ODTÜ

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# Invention Portfolio

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# Materials and Chemistry

# Antimicrobial Zeolitic Materials With Increased Thermal Resistance, Having A Hierarchical Structure, Comprising Essential Oils

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## Hierarchically structured antimicrobial nanopores

**A more effective, more environmentally friendly and highly thermally stable powdered antimicrobial agent has been developed by encapsulating essential oil molecules with organic antimicrobial properties into hierarchical zeolitic materials with low thermal stability.**

## Advantages

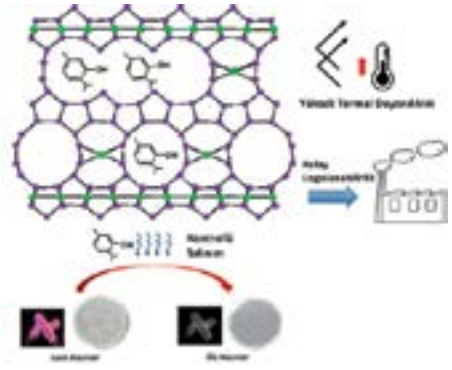
**Thermal resistance:** High thermal resistance due to encapsulation of antimicrobial essential oils in nanomaterials with hierarchical cage structure.

**Controlled release:** Gradual release of essential oils into the environment thanks to nanopore size designed according to antimicrobial essential oil molecules.

**Low cost:** The use of desiccators in the encapsulation method eliminates the use of solvent chemicals compared to liquid mixing methods.

**Practicality:** Ease of process compared to liquid mixing methods with the use of desiccators in the encapsulation method.

**Ease of application:** The prepared powder product can be processed more easily in the industry compared to the direct use of essential oils.



An environmentally friendly and thermally resistant solution with the development of cage structures imprisoned with environmentally friendly essential oil molecules instead of harmful antimicrobial agents such as silver

In this invention, a hierarchical pore structure is provided to zeotype nanomaterials containing zeolite or titanium chains whose nanopores are modified by different chemical methods according to the exact molecular size and structure of the cage material.

Thus, the thermal resistance, antimicrobial activity and the duration of antimicrobial activity of these volatile organic molecules have been increased compared to other environmental agents in the market by enabling the placement of essential oils into these nanomaterials. In the invention, for the first time, volatile oil molecules were encapsulated into hierarchical zeolitic material by gas absorption technique without using any solvent, and this technique provided a more effective retention compared to existing techniques. In this way, the use of organic volatile

molecules, which could not be used in applications due to difficulties in processing until now, has been made possible in various sectors as antimicrobial additives.

**ODTÜ-23**

# Lime-Pozzolan Mortars with Bio-Aggregate for Sound Absorption and Thermal Insulation Purposes

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## Lime-Based Sound Absorptive and Thermal Insulating Mortars

**Lime-pozzolan mortars with bio-aggregate produced for sound absorption and thermal insulation are the mortar products, which have superior breathability, the ability to improve indoor air quality, and self-healing potential. In addition to mentioned properties, these products are environmentally friendly, suitable for local production, and do not contain raw materials harmful to human health.**

## Advantages

**Thermal and Sound Insulation:** Lime-based mortar products with good thermal and sound insulation.

**Indoor Air Quality Enhancement:** elimination of entrapped moisture problem in the building walls and enhancement of indoor air quality provided by high breathability features of the mortar products.

**Self-healing Potential:** Self-repair of micro cracks which may occur in plaster or mortar over time, in other words, self-healing or self-consolidation of microcracks by infiltration of pure lime into the crack cavities (healing by filling).

**Sensitivity to Environment and Living Health:** being mortar products obtained from local resources that do not pose a threat to the environment and human health, being low-cost products suitable for local production and industrial production.

**Application Area Diversity:** They are alternative mortar products that can be used for thermal and sound insulation purposes in new buildings and historical buildings.

It is a mortar product group that offers an alternative product range for new building constructions and renovations as well as historical/traditional building repairs.

By using lime-pozzolan mortars with bio-aggregate produced in various mixtures:
the production of sound absorptive thermal insulating plasters, the production of multi-layered and multi-functional plaster systems and multi-layered insulation board systems for sound and thermal insulation purposes, the production of interior and exterior repair plasters to be used in historic masonry and traditional timber-framed buildings,the production of plasters compatible with timber material that can be applied directly on wooden lath.

The mortar products are obtained from local resources which do not pose a threat to the environment and human health, as well as they are suitable for local and industrial production that can be produced at low cost. Benefitting from the unique properties of pure lime, pozzolanic reactions, and carbonation process, the mortar products which exhibit multi-functional and qualified insulation performances have been produced only with a simple mixture.

# Production of Emulsifiers Suitable for Water-in-Oil (w/o) Emulsion Systems Using Corn Cob, Wheat Bran, Sunflower Plate and Fatty Acids

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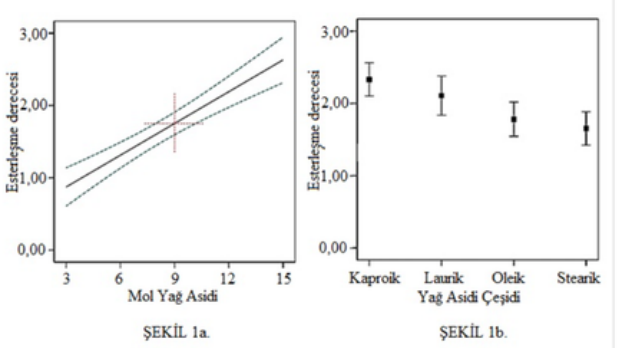
**Emulsifiers suitable for oil-in-water (o/w) emulsion systems were produced using food industry residues and thus high value-added end products were obtained from these residues with high cellulose content.**

## Advantages

**Obtaining Value Added Products:** Emulsifiers with high economic value are produced by utilizing food industry wastes.

**Production Flexibility:** Thanks to the use of different raw materials and production conditions, customized emulsifiers can be produced. Thus, suitable products can be designed for various emulsion systems.




## Production of emulsifiers suitable for oil-in-water (o/w) emulsion systems using food industry residues

As a result of our studies, emulsifiers suitable for oil-in-water (o/w) emulsion systems were produced by using food industry residues containing relatively short fibers and thus high value-added end products were obtained from these residues with high cellulose content. As a result of the studies, different emulsifiers can be produced for emulsion systems with different oil-in-water ratios by using different raw materials and production conditions. In addition, depending on the raw materials and method conditions used in production, the emulsifiers obtained have different rheological and physical effects in oil-in-water (o/w) emulsion systems. Therefore, it has the advantage of providing different rheological and physical properties of the emulsion system. On the other hand, it is also suitable for use with very different raw materials.

**ODTÜ-107**

# Multi-layered And Breathable Insulated Facade System Providing Passive Ventilation By Allowing Air Diffusion

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## An Exterior Facade System

**The invention relates to the idea of a multi-layered and breathable insulated exterior wall that provides passive ventilation in the interior environment.**

## Advantages

Refreshing the indoor air, thus providing more comfortable and healthy indoor environments for users;

It is possible to save energy by reducing the load of natural and mechanical ventilation systems in buildings.

### A breathable, ventilated and insulated external wall system

At this point, our invention proposes a fully breathing, ventilated and insulated exterior wall system that will passively contribute to the freshening of the indoor air by diffusion of the wall wall wall on the inside. This proposal is a new wall system that will passively contribute to the freshening of indoor air through diffusion by drilling millimeter holes in the wall board used on the interior façade from the materials that make up the building wall.

Recent studies have shown that airtight building envelopes have a negative impact on indoor air quality. Our invention is a multi-layered, ventilated and breathable façade system that resists air flow but allows gas diffusion at a slow rate, an exterior wall idea that can reduce natural and mechanical ventilation loads and improve both the energy efficiency and indoor air quality of the building.

# Production of Emulsifiers Suitable for Oil-in-Water (o/w) Emulsion Systems Using Corn Cobs, Wheat Bran, Sunflower Plate and Fatty Acids

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**Emulsifiers suitable for oil-in-water (o/w) emulsion systems were produced using food industry residues and thus high value-added end products were obtained from these residues with high cellulose content.**

## Advantages

**Obtaining Value Added Products:** Emulsifiers with high economic value are produced by utilizing food industry wastes.

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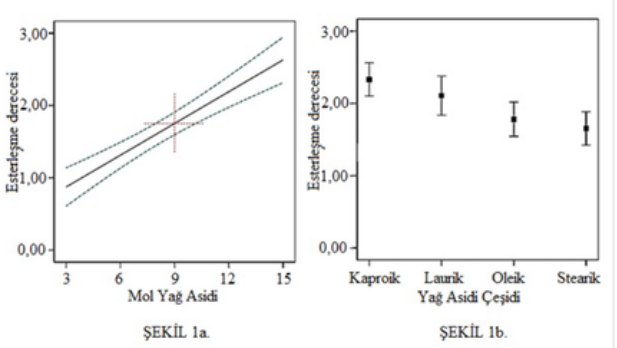


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# Bacteriophage Containing Biopolymer Based Surface Coatings with Antibacterial Activity

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## Ensuring food safety with bacteriophages and biopolymers

**The decrease in the number of bacterial colonies on chicken meat, wrapped with aluminum foil which was coated with bacteriophage incorporated biopolymer based films**

## Advantages

Using two FDA approved biopolymers in the preparation of ultra-thin films.

Deposition of ultra-thin films onto any substrate such as aluminum foil.

Encapsulation of bacteriophages into biopolymer multilayer films.

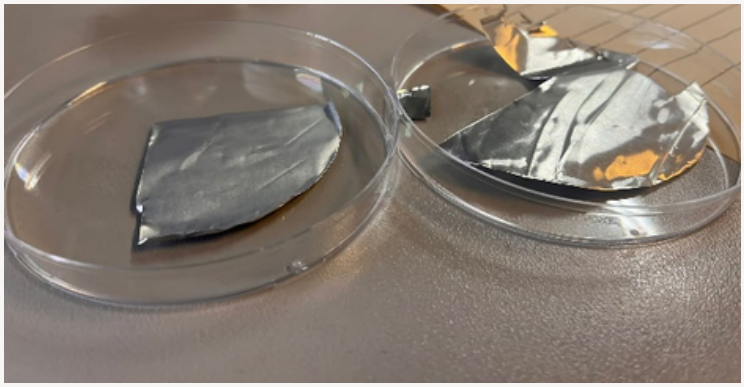
Obtaining antibacterial activity with low amounts of bacteriophages.

The decrease in the number of bacterial colonies on the surface of chicken meat which was wrapped with aluminum foil coated with bacteriophage containing ultra-thin biopolymer film compared to chicken meat wrapped with unmodified aluminum foil.

## Extending the shelf-life of food through smart coatings

The invention relates to the deposition of two FDA-approved biopolymers on an aluminum foil support material by layer-by-layer self-assembly and the trapping of bacteriophages in these ultra-thin films.

Alginate and chitosan are a pair of FDA-approved polymers that are safe for human health in contact with food and suitable for forming ultra-thin films on the surface of a solid support material by layer-by-layer self-assembly. Alginate and chitosan multilayer films enable the attachment of bacteriophages within the layers and on the surface of the films.



On the left, aluminum foil coated with phage-containing multilayer biopolymer-based thin films; on the right, untreated aluminum foil with a shiny surface

**ODTÜ-124**

# On-site Cyanide Leach Solution Producing Reactor System

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## Cyanore

**Ensuring that cyanide is produced as needed, risk-free from simple raw materials, eliminating the costly transportation and storage of dangerious cyanide.**

## Advantages

Common and cheap ingredients such as urea, lye, natural gas/hydrogen.

On-site production avoids high cost risky transportation of cyanide.

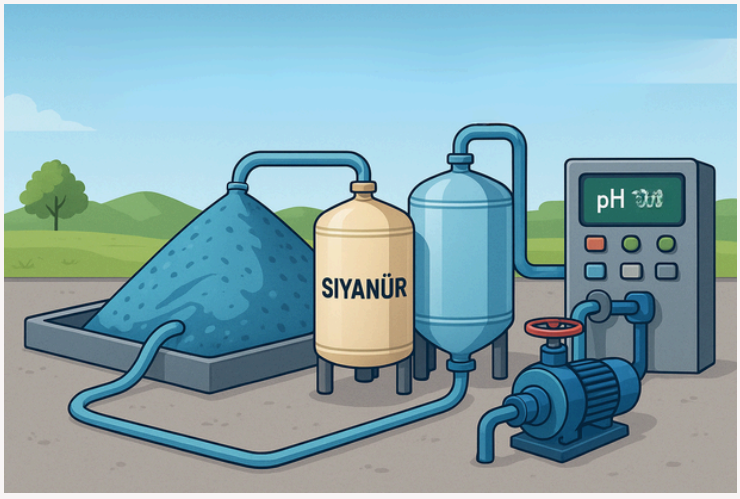
Avoiding the risky storage of high amounts of cyanide and making concentrated solution of it.

With the closed copper reactor that work with siphoning principle, the reactor contents are easily taken into the solution forming tank.

The use of gas as a reducing agent allows the reactor product to be used without the need for an additional purification process such as filtration. Moreover, the option of using green hydrogen as the reducing agent in the reactor opens the way for gold mining to be carried out as carbon neutral.

Make the gold mines able to manifacture required cyanide solution on-site, safely with using common and cheap ingredients.

High temperature reduction of sodium cyanate by a reducing gas agent (i.e. H2,CH4 or CO) , whom was made from urea and sodium hydroxide.




ODTÜ-125

# Recovery of Indium From Waste ITO Coated Glass by Electrochemical Method

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## Green Indium

**Energy efiicient indium recovery was achieved at low temperature by using environmentally benign chemicals.**

## Advantages

-Low energy consumption

-Low temperature process

-Environmentally benign chemicals are used

-Provides high purity recovery

-Fast

-One step process

Recovery of indium metal, which has a high economic value and is included in the list of critical raw materials by the EU and the USA

Indium metal, which has a high economic value and is listed as a critical raw material by the EU and the US, is recovered from electronic waste at low temperature, using low energy and environmentally friendly chemicals, in a single step, with high purity and without damaging the glass substrate.

Using deep eutectic solvents and their aqueous solutions as electrolytes in electrochemical environment, indium tin oxide is obtained from tin oxide layer in one step with high efficiency and high purity indium powder.

# Soft Interface Liquid Crystal Microfluidic Device

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## Intersense

**The invention is a microfluidic device that ise tailorable for diverse range of applications and processes. It is a small sized, low cost device that is applicable to fast and high throughput analytical applications.**

## Advantages

Being a fast and low-cost platform

Can be used for different applications (diagnosis of different species, material synthesis)

It can be easily and quickly adapted to the person, location and situation.

Small size

It is environmentally friendly as it does not have a disposable component.

Can be quickly updated (at zero cost) for different diagnostic or synthesis applications

### Rapid and comprehensive diagnostics, as opposed to current time-consuming methods of individual analysis

It is a platform that, despite the high cost and time-consuming diagnostic applications of critical and rare diseases, enables periodic analysis in a short time and at a low cost, making early diagnosis easy.
At the same time, it is a platform that allows rapid analysis at the point where environmental and public health can be controlled.

It is a continuous process that enables the synthesis of advanced nanomaterials (2D materials, nanostructured materials, etc.) using interfacial chemistry.

# Post-Tensioned Timber Column Frame (PTCF) Earthquake-Resistant Building System

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## QuakeSafe FlexFrame: A Post-Tensioned Timber Structural System for Earthquake-Resistant Buildings

**Earthquake-proof; negative carbon footprint**

## Advantages

Earthquake-proof design that ensures maximum life and property safety; immediate post-earthquake usability.

Environmentally friendly and sustainable; utilizes carbon-sequestering timber to combat climate change.

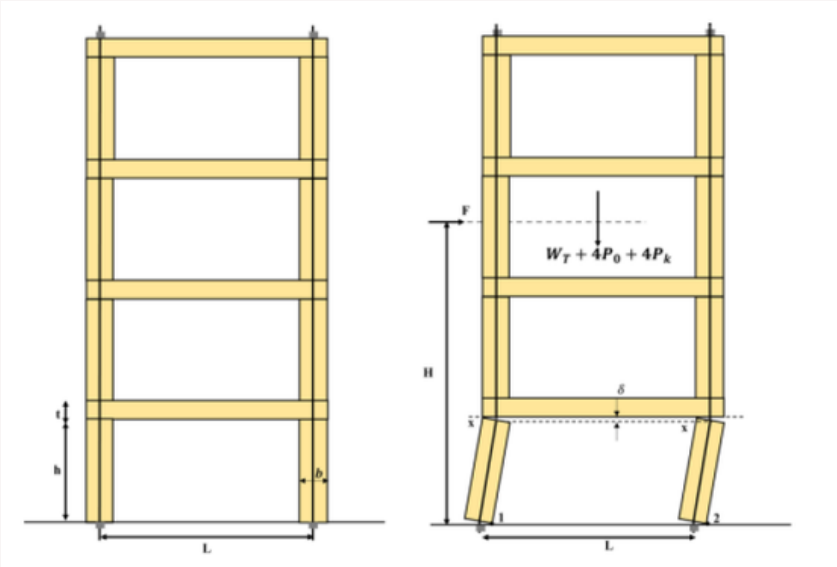
Additional safety walls against extreme earthquake or collapse risk to keep building standing.

Option to add dampers between slabs and safety walls; also fire-resistant with integrated sprinkler system.

Cost-effective; requires smaller foundations on weak soils; unlike seismic isolation systems no need for open space around the building or flexible piping.

Ensures survival during earthquakes; the building remains operational immediately after an earthquake; even under successive earthquakes, the structural load-bearing system remains undamaged.

Use of post-tensioned columns and special connection between rocking columns and slabs-foundation.




ODTÜ-174

# Production Of Substitute Material For Asphalt Binders From Recycled Ship-Generated Petroleum-Derived Wastes

## Asphalt Additive From Ship-Generated Petroleum-Derived Wastes

**The present invention proposes a novel distillation setup and an associated processing method. The proposed method enables the controlled separation of components present in different phases, thereby allowing the production of a systematic and stable product. Through this approach, petroleum-derived ship wastes, which are currently disposed of by incineration in conventional practices, can be transformed into a reliable, standardized secondary product with economic value.**

## Advantages

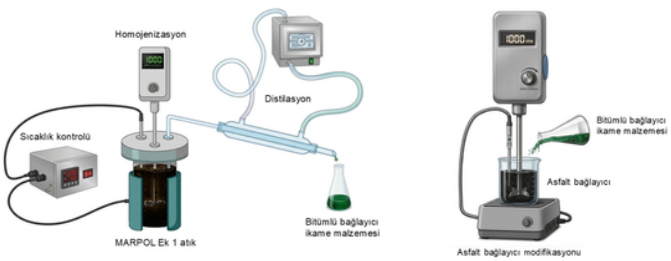
**Sustainability:** Enables the recovery of petroleum-derived ship wastes within the scope of MARPOL Annex I and their utilization as a bituminous binder substitute material.

**Economic efficiency:** Reduces asphalt production costs and decreases the need for imported bitumen by converting low-value bottom residue waste into a value-added product.

**Innovation:** Makes it possible to utilize the bottom residue obtained after dewatering and distillation as a bituminous binder substitute material.

**High performance:** Due to the compatibility of the physical, chemical, and rheological properties of the obtained product with asphalt binders, it exhibits comparable performance when used with commercial binders.

**Environmental benefit:** Reduces the amount of waste disposed of by incineration, thereby lowering air pollution and greenhouse gas emissions, while also contributing to the prevention of marine pollution.




The invention provides a solution that reduces costs and enhances sustainability by enabling the use of petroleum-derived ship wastes, which are conventionally disposed of by incineration, as an alternative bituminous material for asphalt binders.

The technical basis of the invention is founded on the design of a product, obtained from heterogeneous wastes through controlled distillation and homogenization processes, to exhibit physical and chemical properties compatible with asphalt binders. Within this scope, it has been determined that the fundamental properties of the obtained product, such as specific gravity, viscosity, and solubility, comply with the technical specification criteria established for asphalt binders.

Furthermore, according to the SARA fraction analysis results, the asphaltene content of the obtained product was found to fall within ranges comparable to those of asphalt binders. FTIR analysis also revealed that the characteristic vibration bands of the product largely overlap, in terms of wavenumber positions, with those of commercial asphalt binders.

Through this multi-parameter compatibility approach, it has been demonstrated that the developed product can be effectively and reliably used as an asphalt binder or as an asphalt additive.

**ODTÜ-156**

# High-Yield Clean Recycling Method of Polylactic Acid with Supercritical $CO_2$

## Eco-Friendly PLA Recycling

**Lactide, the raw material of PLA, is produced directly from waste PLA in supercritical $CO_2$ with high yield, without a catalyst and without generating waste.**

## Advantages

**Direct lactide production:** Lactide, the monomer of PLA, is obtained directly from waste PLA. The lactic acid-to-lactide conversion step is eliminated.

**No catalyst:** Depolymerisation in supercritical $CO_2$ proceeds without a catalyst, avoiding catalyst cost and catalyst removal steps.

**No costly separation:** Lactide is obtained without costly separation and purification processes, which simplifies downstream processing.

**Shorter process:** Skipping the intermediate lactic acid step shortens the overall recycling route, saving time and energy.

**$CO_2$ recovery:** The $CO_2$ used as the reaction medium can be recovered and reused, and the process generates no waste.

## Eco-friendly chemical recycling of PLA waste directly into high-purity lactide.

PLA is one of the most widely used bio-based plastics, yet it degrades only slowly under natural conditions, so its waste is a growing problem. Conventional chemical recycling first converts PLA into lactic acid, which must then be turned back into lactide through additional steps.

In the invention, waste PLA is depolymerised in a batch reactor in supercritical or dense $CO_2$, producing lactide directly.
This skips the lactic acid-to-lactide conversion step and requires neither a catalyst nor costly separation processes. At the end of the process, the $CO_2$ can be recovered and reused.

# Self-Healing Composite Material and Production Method

## BiSn NIR Heal TPU

**With core–shell BiSn particles at a low loading (0.5%), the film combines high mechanical strength (~46 MPa) with fast photothermal self-healing of up to 89% efficiency while remaining semi-transparent.**

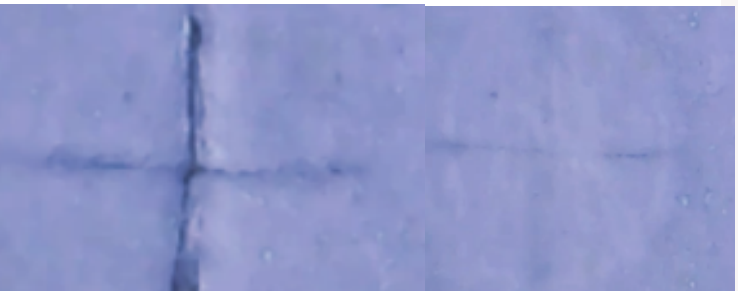
## Advantages

**High mechanical strength:** A tensile strength of about 46 MPa provides sufficient strength for commercial applications.
**High healing efficiency:** Delivers up to 89% self-healing performance in a short time under NIR light.
**Low loading, high yield:** High performance with only 0.5% BiSn brings cost and production advantages.
**Semi-transparency:** Optical transmittance is preserved; suitable for electronic displays, visible surface coatings and packaging.
**Local, contactless healing:** Heals only the damaged area without affecting the whole structure, offering a controlled, safe and practical mechanism.

A coating that heals cracks under NIR light by heating only the damaged area: both strong and fast-healing.

The invention is based on a thermoplastic polyurethane (TPU) composite film reinforced with liquid-metal particles synthesised in a core–shell structure. The core is a BiSn alloy and the shell is a naturally formed SnO-rich oxide layer; the particles are dispersed homogeneously in the TPU matrix by solution mixing and cast into a semi-transparent film by solution casting.

Under near-infrared light, the high photothermal conversion capability of the BiSn particles causes a local temperature rise in damaged areas. This increases chain mobility and closes the cracks, and the film reaches 89% healing efficiency in about 10 minutes.
The system can be triggered without contact, allowing local and controlled healing.



ODTÜ-192

# Heatable Fabrics Coated with Metal Nanowires

## Nanowire-Coated Heatable Fabric

**Silver nanowires are coated three-dimensionally onto fabric by dip coating, producing a structure that can be heated by an applied current while preserving the breathability and flexibility of the fabric.**

## Advantages

**Breathability:** Fabric surfaces are not covered, so the fabric stays breathable.
**Minimal material:** Thanks to nanotechnology, only a very small amount of active material is used.
**Suited to mass production:** Produced with a simple method such as dip coating.
**Low power consumption:** The high electrical conductivity of the nanowires allows operation at low currents with low power use.
**Fast, high heating:** The high thermal conductivity of the nanowires enables high temperatures at low operating currents.

## Fabrics that heat efficiently with low power consumption.

With the invention, fabrics are coated with metal nanowires, and the nanowires are used as heating elements.

The coating lets the fabric breathe, does not impair its flexibility and does not restrict its areas of use.
It reaches the maximum of 60 °C required in many wearable products repeatably and very quickly, holds a constant temperature for as long as needed, and easily returns to room temperature when the direct current is switched off.



TTO-74



# Medical Technologies

# Design Of Alcohol Dehydrogenase 2 (ADH2) Promoter Variants By Promoter Engineering

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## Ethanol-Induced Hybrid-Architecture ADH2 Promotor Variants

**Engineered ADH2 promoter variants for use in P. pastoris cell-factory design**

## Advantages

**High performance protein production platform:** Engineered ADH2 promoter variants relative to the naturally occurring strong ADH2 promoter enable enhanced gene expression and therefore increased production;

**Fermentation with ethanol:** Engineered ADH2 promoter variants are controlled by non-toxic ethanol instead of toxic methanol in P. pastoris cells;

**Modular:** Engineered ADH2 promoter variants can be used in the production of therapeutic proteins, profitactic proteins, enzymes, peptides and vaccines;

**Providing well-designed bioreactor system control:** Engineered ADH2 promoter variants are regulatable (inducible) promoters and provide efficiently controlled fermentation processes through control of bioreactor operating conditions;

**Low-cost production:** The use of ethanol, an inexpensive and non-toxic carbon source, simplifies the production process and subsequent sanitization, thereby reducing plant set-up and operational costs, as well as increasing production and productivity.

## Enhanced recombinant protein production

The most commonly used promoter for recombinant protein production with P. pastoris is the PAOX1 promoter, which is strong and tightly regulated. However, toxic methanol poses risks in the production environment and requires more intensive post-production sanitization and more difficult risk assessment and regulatory documentation steps before the protein can be used in the pharmaceutical and food industries. P. pastoris PADH2 is regulated by the non-toxic carbon source ethanol and has the same productivity as PAOX1. P. pastoris is a popular host for industrial recombinant protein production and this invention provides engineered ADH2 promoter variants that are more potent than the native PADH2 and PAOX1 promoters and can be used in the design of ethanol-regulated enhanced recombinant protein production platforms. The engineered ADH2 promoter variants can be used for the production of industrially important therapeutic proteins, prophylactic proteins, enzymes, peptides and vaccines.

# Reinforced AOX1 Promotor Variants for Production with or without Methanol

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## Modified AOX1 Promotor Variants

**The invention relates to the design of enhanced AOX1 promoter variants that can produce higher yields than bioprocessing systems developed with the natural AOX1 promoter for P. pastoris yeast, which is becoming more and more widely used in industry, and can be controlled with a safe carbon source that has been used for centuries.**

## Advantages

Higher quantities can be produced from the natural and already powerful AOX1 promoter.

Controllable with safer carbon source instead of toxic methanol.

Can be used for the production of therapeutic and prophylactic proteins and all other proteins of industrial importance The amount and duration of R-protein production can be controlled by determining the induction conditions.

By using a cheap and safe carbon source, high amounts of product can be produced in a short time.

### Production of r-protein in high quantity and yield

Promoter genes are one of the most important tools of recombinant protein (r-protein) production processes. With this invention, promoter variants of the most widely used AOX1 promoter of Pichia pastoris yeast in industrial biotechnology applications have been developed that are more potent and can be controlled by methanol-free fermentation media. The enhanced AOX1 promoter variants allow higher yields of r-protein production than the native promoter in methanol or non-methanol (with a safer carbon source) media.

The developed technology enables the production of the desired therapeutic protein or industrial enzyme in a shorter time, in higher quantities and using a carbon source that is safer for human health.
The inventive amplified AOX1 promoter variants can be used in bioprocess development studies for the production of all therapeutic and prophylactic proteins and enzymes of industrial importance.

# A System to Obtain Higher Quality and Resolution Images from 2-Dimensional Ultrasound Images

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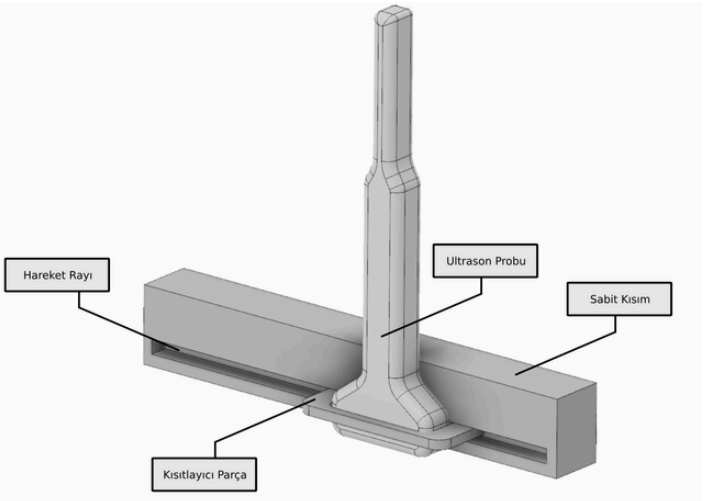
## A System to Get High Quality and Resolution Images from 2D Ultrasound

## Advantages

**Easily Adaptable:** It can be adapted to common 2D ultrasound devices used in clinics with the help of a video card or any protocol that supports video.

**Fast Application:** Application can be extremely accelerated with the use of GPU

**Increase in Detail:** Good results are obtained according to objective image quality evaluation methods. As the edge sharpness is improved, the speckle pattern is reduced.




Increasing the image quality of 2D Ultrasound, which is one of the most important devices for diagnosis in many fields such as radiology, obstetrics and cardiology

A system that uses Bayesian, multi-image, super-resolution, correlated Gaussian model to produce higher resolution images, reducing the negative effects of speckle pattern in ultrasound images, is presented.

Statistical and model-based image processing methods, which are prominent in the literature, are brought together for medical ultrasonography to increase image quality. The correlated Gaussian speckle pattern model was studied specifically for ultrasound and combined with multiple super-resolution restoration. Optionally, the probe movement can be made more controlled with the help of an apparatus.

# MEMS Airborne Ultrasonic Transducer System for Detecting Brain Haemorrhage

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## Brain Haemorrhage Detector

**This invention focuses on the fast and affordable detection of brain haemorrhage. This detection uses ultrasensitive impeditive ultrasonic detector, which via frequency sweeping collects thermoacoustic generation of ultrasound wave caused by the RF-induced volumetric expansion of blood in the brain.**

## Advantages

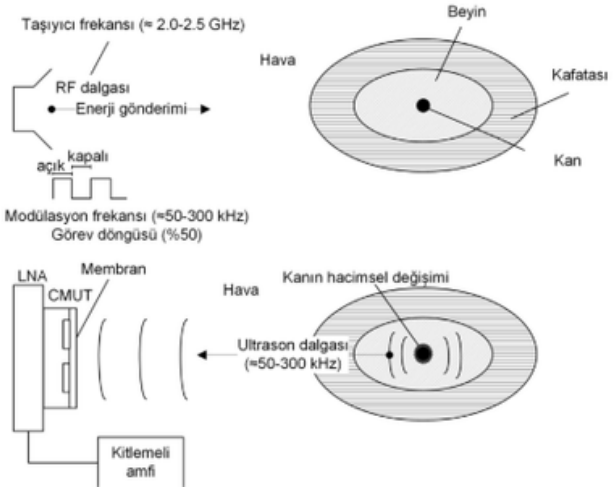
**Unique approach:** Spectral scanning and collection of signals with ultimate signal-to-noise ratio (SNR)

**Sensitive:** unique ultrasensitive ultrasound transducer

**Fast:** whole brain data collection at once enabling detection in minutes

**Affordable:** basic system having RF-transmitter and ultrasound-receiver based system reducing cost compared to expensive MRI, CT systems

**Portable:** compact prototyping solution possible




### Fast, affordable, portable system for detecting brain haemorrhage

Detection of cerebral haemorrhage within the first 1.5 hours after the onset is paramount for effective recoverable healing and prevention of permanent brain damage. However, detection using magnetic resonance imaging (MRI) or computed tomography (CT) can hardly be completed in this time frame due to high cost and complexity of the equipment limiting their readiness and availability. This invention relates to MEMS airborne ultrasonic transducer system to detect thermoacoustic generation of ultrasound wave caused by the RF-induced volumetric expansion of blood in the brain. The potential of thermoacoustic imaging method is based on 2.5-fold difference of volumetric heat expansion of blood and brain. Ultrasensitive detection of the ultrasound wave is achieved by a novel design of an airborne capacitive micromachined ultrasonic transducer (CMUT) that operates in collapse mode with electrical contact resistance (ECR) featuring capacitive and resistive sensing, hence acting as an impeditive micromachined ultrasonic transducer (IMUT). Unlike volumetric scanning systems for brain tomography, this system with the sole purpose of detection performs spectral scanning of the whole brain at once by sweeping modulation frequency, and collecting specific signals with a lock-in amplifier to determine constructive and destructive patterns caused due to the size of accumulated blood in the brain.

**ODTÜ-38**

# Active Thermal Imaging with Multi-Frequency Current

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## Medical Electro-Thermal Imaging

**For breast tumour diagnosis, the method increases the temperature contrast of thermal images depending on the frequency of the applied electrical current.**

## Advantages

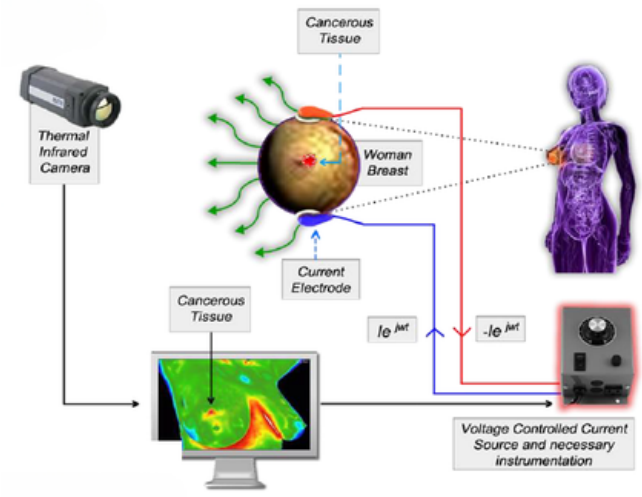
**Reliable:** Provides high spatial-resolution temperature distribution images with enhanced thermal contrast.

**Harmless:** Safe for the body, as it involves no ionising radiation.

**Painless:** Contactless imaging with no breast compression.

**Early Diagnosis:** Enables diagnosis of millimetre-sized deep tumours.

**Suitable for Screening:** A low-cost, portable, fast and real-time imaging method.




### Electrical conductivity and thermal imaging combined

Mammography devices widely used in breast cancer diagnosis can give false-positive or false-negative results. The breast is compressed during mammography, causing discomfort, and a low dose of ionising radiation is applied.

As there is no gold-standard imaging technique for breast cancer diagnosis, alternative imaging methods are needed.

The invention images the temperature distribution produced in tissue by two different heat sources: external (electrical currents) and internal (metabolic heat generation, blood perfusion).
By using three different physical properties of tissue (electrical, thermal and diffusive), images with higher contrast than passive thermography are obtained.

# Powering System for Constant Current Neural Stimulators

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# Adaptive Powering System for Longer Operation Periods Between Charges

**It is an invention that is aimed to be used in devices that perform constant current neural stimulation. It generates the correct supply voltage for the stimulator, reducing the average power consumption.**

## Advantages

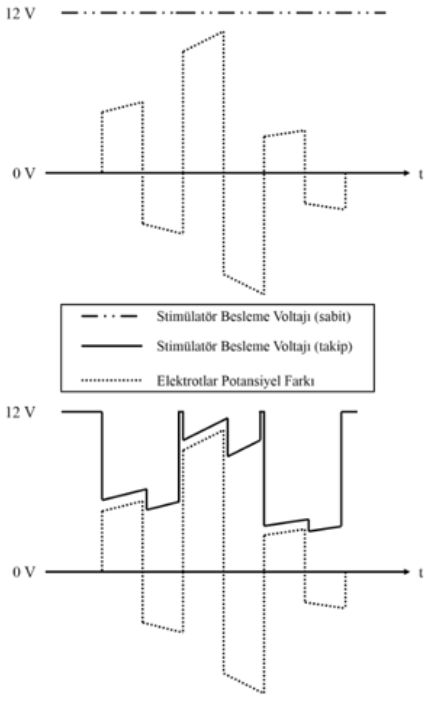
**Efficient:** Operation aimed to reduce power consumption

**Battery:** Ability to operate with variable battery voltage

**Recharging:** Longer periods between charging time

**Piezoelectric:** Ability to operate with piezo energy harvesters.

**External Components:** Least number of external components




## Powering system that enables longer periods of battery usage.

Constant current neural stimulators stimulate neurons with constant current with the help of electrodes. Said neuron-electrode interface may show high impedance characteristics. For this, the stimulator circuit needs a high supply voltage. However, this is not always the case. If the neuron-electrode interface has a low impedance value or the current flowing through the electrodes is reduced in direct proportion to the amount of charge that must be transferred to the neurons, the supply voltage required for the stimulator will also decrease. In this case, if the stimulator circuit continues to be driven with a high supply voltage, unnecessary power loss will occur.

The invention creates the correct supply voltage for the stimulator by tracking the voltage of the neuron-electrode interface through which a constant current is passed, thus preventing unnecessary power loss. This way, the system aims to increase the low efficiency, which is a problem of constant current stimulators.

**ODTÜ-48**

# Electroactive Chemiluminescence Compounds For Blood Detection In Forensic Science

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## Chemiluminescent molecules for latent bloodstain and metal ion detection

## Advantages

**Useful:** High sensitivity toward iron ions, thereby certain and convincing proof of bloodstain traces in crime scene.

**Visible:** High chemiluminescence quantum yield.

**Efficient:** Easy synthesis with the smaller number of steps

**High performance:** The potential for the detection of bloodstain, metal ions as well as trace amount of hydrogen peroxide in biological processes.

**Sensitive:** Quite high sensitivity.

### National, fast, on-site and reliable detection platforms

This invention focuses on the easy synthesis of new chemiluminescent molecules with the potential use for lateral bloodstain detection in forensic, metal ion detection in analytical chemistry and trace hydrogen peroxide detection in biological processes.

This invention defines facile two-step synthesis of new chemiluminescent molecules to overcome the poor solubility and low chemiluminescence efficiency disadvantages of luminol. In the case of responding towards iron ions, the resulting chemiluminescent molecules provide more reliable and certain proof for bloodstain detection in crime scene investigation.



ODTÜ-54

# Single PDMS Layered Pumpless Microfluidic System

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## Personalized Cellular Treatment Based Microfluidic System for Childhood Infertility

**This invention focuses on a new technology offering high quality image in micro sizes with single PDMS layer; and pumpless flow via resistance circuit.**

## Advantages

**High image quality:** Ability to be examined under microscope during culture due to single PDMS layer

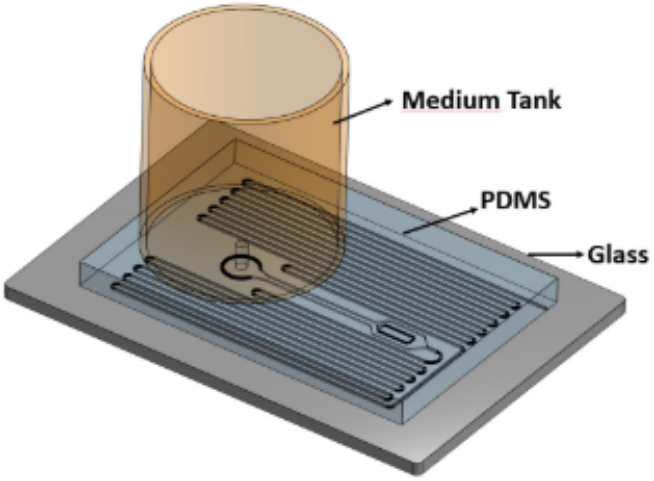
**Pumpless Flow:** The feature of providing the flow rate in required speed range by resistance circuit

**Convenient:** Design in which secretory factors of supporting cells can be integrated

**Visible:** Monitorability of changes in size of testis and condition in organ chamber during in vitro culture

**Useful:** Small size takes up less space in the incubator

**High performance:** The potential to expand the spermatogonial stem cell pool within a low volume of testis




### Mobile, cheap, reliable, personalized treatment-based organ culture platform

This technology is based on the contribution of the secretory potential of the supporting cells in immature testicular biopsy strips in vitro. This invention aims to maintain and differentiate the sperm precursor stem cells in the testis by providing an appropriate flow rate by resistance circuit, obtaining high quality images during organ culture and ensuring a proper diffusion via 750 µm wide organ chamber.

Microfluidic testicular organ culture systems are in vitro testicular maturation-based platforms which aim to find a solution to permanent infertility in male patients due to gonadotoxic cancer treatments such as childhood chemo-radiotherapy. One important problem in these platforms is that the width of the organ channel prevents the diffusion of the medium to the central regions of the organ. Also, the systems do not have the features of providing high image quality and pump-free fluid flow at the same time during culture. With this invention, the 750 µm wide organ chamber, which is fed through the medium channel on both sides, is defined as a new testicular organ culture platform with the presence of resistance circuit that can provide the required fluid flow rate on a single PDMS layer. This new system can be used for in vitro maturation of the prepubertal testis and induction of spermatogenesis in vitro.

**ODTÜ-60**

# Fiber Loop Ringdown Spectroscopy (FLRDS) Fiber Optic Sensor And Sensor Applications For The Detection Of Sars-cov-2 Viruses From Human Breath

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## Sars-cov-2 Fiber Optic Breath Sensor

**Detection of SARS-CoV-2 viruses with high precision simultaneously and non-destructive**

## Advantages

Non-desructive and simultaneous measurement

Real time measurement

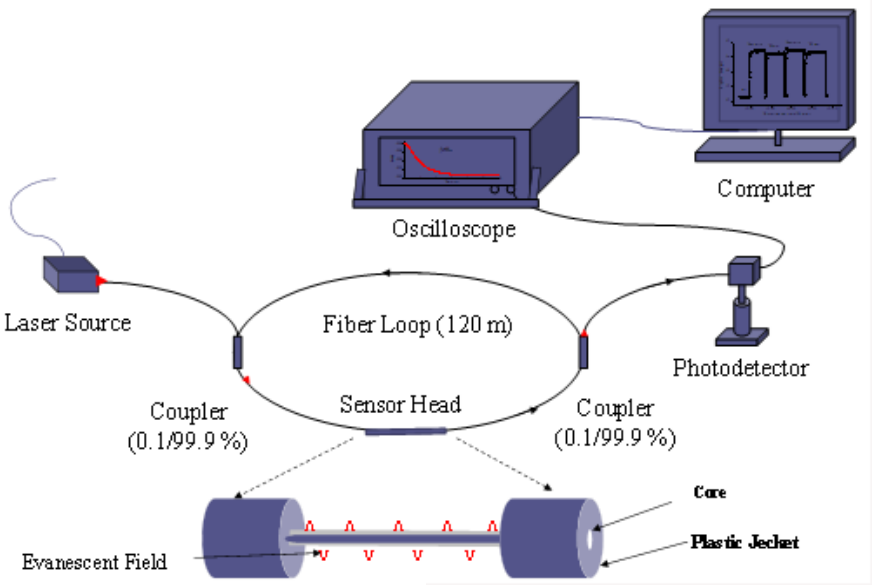
High precision

Immunity to electrical interference

High sensitivity

It will provide detection of SARS-CoV-2 viruses deadly effective all around the World with simultanous and high precision measurement

A piece of fiber from the fiber loop will be etched and high sensitive sensor heads will be fabricated. Followingly, this sensor heads will be coated by using several chemicals. The refractive index around the sensor head will be change due to interactions of coated chemicals with SARS-CoV-2 viruses. This ultra high sensitive technique is based on sensitive measurement of the chenage of evanescent field around the sensor head.




ODTÜ-68

# Membranes and Functional Films of Aligned Nanorods via Tangential Flow Deposition

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## An easily scalable method of forming anisotropic films of aligned nanorods

## Advantages

Tunable and controllable functional properties: Film properties can be controlled using easily adjustable fabrication parameters.

Scalable production: Films via flow deposition can be formed in various geometries and scales.

Material variety: Any nanorod shaped material that can form a stable sol in water or an organic solvent can be used in formation of aligned nanorod films.

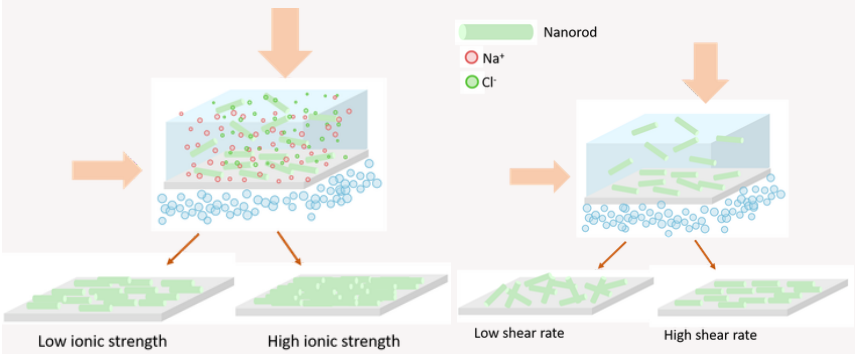
Economical: The fabrication method is low-cost as it merely relies on liquid flow and filtration.

Benign for water and human health: The method allows fabrication using aqueous sols only, thereby avoiding use of potentially harmful or toxic organic solvents and high energy consumption.

### Fabrication of funcitonal films or layers with a controllable, designable and scalable technique

Nanorod shaped materials (e.g. cellulose nanocrystals, metal hydroxide nanotubes, etc.) in suspension can show alignment in shear direction under flow.
Factors such as flowrate, nanorod concentration, surface charge and ionic strength can be used to control the extent of alignment and the distance between the nanorods.

Nanorods are filtered through a porous support under tangential flow and aligned in the flow direction, and later can be physically or chemically stabilized. In this manner, supported of free-standing anisotropic films can be formed and their mass transfer, optical, magnetic, electrical properties can be adjusted through the extent of alignment.




ODTÜ-72

# Induced Current Magnetic Resonance Electrical Impedance Tomography (ICMREIT) Pulse Sequence Based on Bipolar Gradient Pulses

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## Induced Current Impedance Tomography

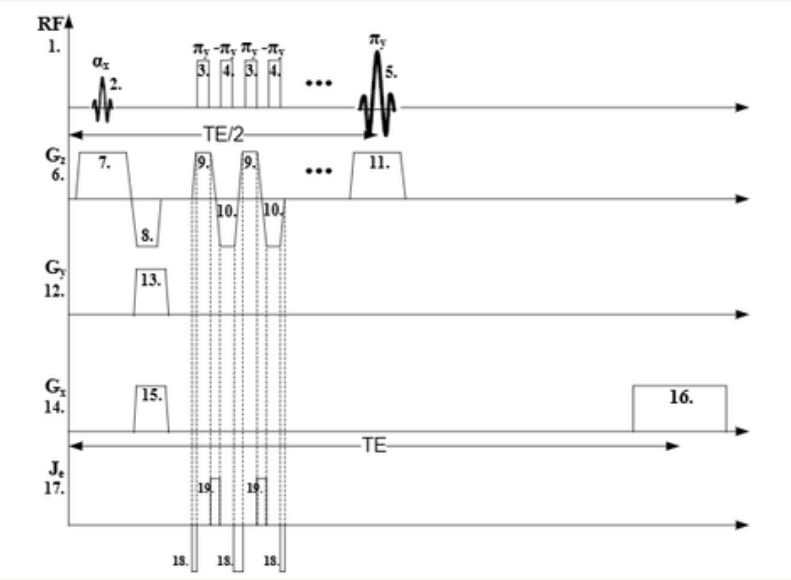
**ICMREIT is realized by using the readily available gradient coils of magnetic resonance imaging (MRI) scanners without the need of additional equipment.**

## Advantages

- Realization of ICMREIT with gradient coils of MRI scanners.
- Realization of ICMREIT without the need of additional equipment.
- Contactless induction of eddy current in the body.
- Overcoming application diffculties of classical MREIT due to electrodes.
- A remedy for imaging tissues with high impedance.

### Realization of ICMREIT with MRI gradient coils

Gradient coils are excited with time varying electrical current which induces eddy current in the object to be imaged. The secondary magnetic field created by the eddy current accumulates phase in MR images. Using the secondary magnetic field measurements, current density and conductivity images could be reconstructed.



# A Nano/Micropatterned Cellular Nucleus Deformation Based Cancer Diagnostic System

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## Micropattern Induced Nuclear Deformation for Diagnosis (MINDD)

**This diagnosis system is based on a simple physical surface design which is able to discriminate healthy and cancerous cells without use of any chemicals or expensive equipment.**

## Advantages

Easy: The application is easy and needs no expertise to operate.

Accessible: The target consumer group is small, hospitals and primary care physicians.

Fast: Takes 4-24 hours to get the result.

Mobility: Has the potential to be converted into mobile form coupled with an intelligent phone.

Affordable: Plastic chip and polymer substrate allows low cost production of the detection chips.

### Mobile, simple, fast, on-site, and cheap cancer diagnosis platform

The invention is about a cellular diagnostic system which is composed of micro/nano patterned surfaces that can be integrated into a microfluidics device which reveals the nuclear shape deformability of the cells; which can be imaged with the help of an optical system and can be quantified with a software algorithm.

In this system, nano/micropatterned polymer surface leads to nuclear deformation of cells due to the following factors and it enables a non-expert to discriminate cancerous and healthy cells using an algorithm developed.

# Smart Active Counter and Online Monitoring System

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## IVMERAD

**Ability to display the measurement of the device that measures ionizing radiation in an online traceable system**

## Advantages

Personal dosimeter, handheld detector, patient follow-up detector for discharge process control, etc. combining the features of devices in a single device.

Easy data tracking with database and mobile application support.

With its portable and light structure, it does not interfere with the freedom of movement of the actively working personnel (Nurse, radiology specialist, etc.).

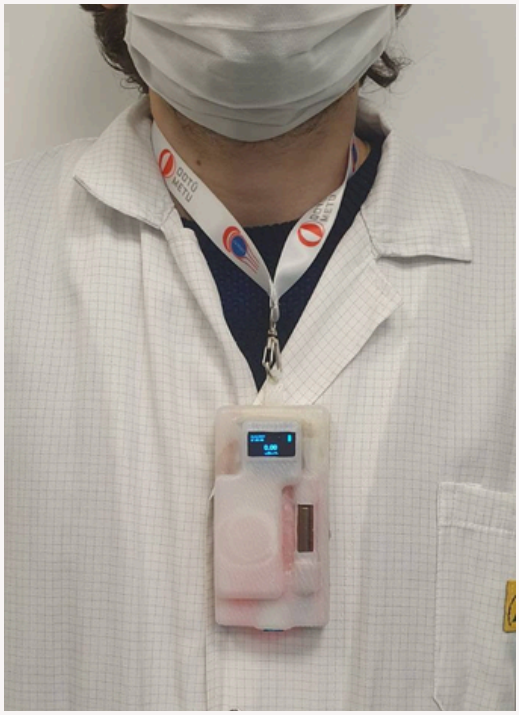
Fast adaptation for both corporate and individual use without the need for infrastructure installation.

Up-to-date and low cost thanks to the selection of widely used electronic parts and Technologies with a proven history.

### Carried the internet of things technology to the field of radiation safety.

The most critical technical feature behind the invention is that it carried the internet of things technology to the field of radiation safety.

The radiation meter, which has the ability to use flexibly with an affordable cost, can share the radiation measurement with both individuals and institutions without the need for a new infrastructure setup.



**ODTÜ-128**

# Colorectal Cancer Tumor Segmentation and Grading

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## SEG-Grade-Cancer

**The invention is the first system capable of automatic tumor segmentation and grading in colorectal cancer histopathology.**

## Advantages

Detecting and locating tumors at the pixel level

Estimating the grade of the detected tumors

### Tumor segmentation and grading system in colorectal cancer histopathology

The input of the method is a whole slide image acquired with a digital scanner, and the output is a pixel-level segmentation of the tumor regions detected on the image and their grades (grade 1, 2 and 3).

Once the digital image of the biopsy sample is acquired, it is scaled and segmented to make it processable. Each segment is fed into a deep artificial neural network (DPN) model. The DPN model detects tumors and their grades at the pixel level on the input image. The results obtained from each segment are combined to produce a segmentation and grading result for the whole image.

# The Design of Hybrid-Architectured Promoter Variants Through The Integration of Activation Elements in Coordination with the HAP1 And HAP2/3/4/5 Transcription Factors to Alcohol Dehydrogenase 2 (ADH2) Promoter Variant

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## The Design Of Alcohol Dehydrogenase 2 (ADH2) Promoter Variants

**Providing a basis for glycerol or ethanol inducible safe-clean-green r-protein production processes**

## Advantages

- Sustainability
- Low toxicity
- High efficiency
- Regulatable
- Low cost

### Development of highly efficient recombinant protein production under strong promoters

The distinct integration of the DNA sequences of the first and second upstream activation elements of S. cerevisiae CYC1 promoter that are in coordination with the HAP1 and HAP2/3/4/5 transcription factors, respectively, to P. pastoris ADH2 promoter variant




ODTÜ-155

# Unipolar Slice-Selective Gradient Pulse-Based ICMREIT Pulse Sequence

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## Induced MR Impedance Tomography

**The invention enables ICMREIT to be performed in an optimised way using selective 180-degree radiofrequency pulses and a slice-selective unipolar gradient waveform.**

## Advantages

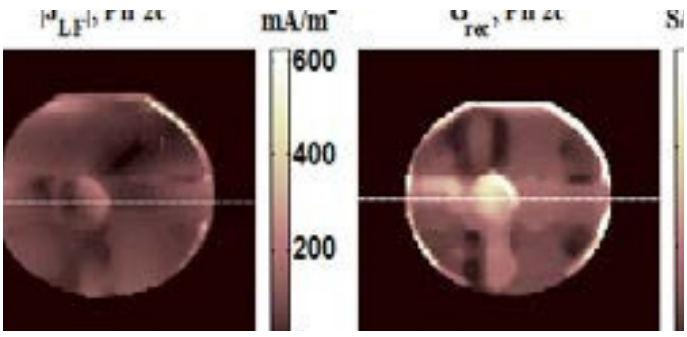
**Slice-selective excitation:** ICMREIT is performed via slice-selective gradient coils.

**Targeted signal:** Only spins in the excited slice are used.

**Optimised excitation:** Unipolar excitation provides optimised imaging.

**Low artefacts:** Artefacts caused by RF and gradient pulses are reduced.

**No extra hardware:** Applied without adding hardware to MR scanners.




### ICMREIT optimised with a slice-selective gradient

With the developed technology, the slice-selective gradient is excited with a unipolar current, inducing eddy currents in the imaged object. Using 180° RF pulses applied in sync with the gradient current, the phase related to the eddy current is accumulated in the MR images. Current density and conductivity images are then reconstructed from the MR phase images. The method uses hardware already present in MR scanners, with no additional hardware required.

# Position Detection in Surgical Branches with Fiber Bragg Grating-Based Optical Sensors

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## 3D Optical Surgical Navigation

**The exact coordinates of the target region are determined in real time with Fiber Bragg Grating-based optical sensors and overlaid on CT/MRI images for monitoring in 2D or 3D.**

## Advantages

**Safety:** Greatly reduces C-arm fluoroscopy shots and thus the radiation exposure of patients and staff.

**Speed:** Continuous real-time feedback shortens operation time.

**High success:** Instrument coordinates are known even in tissue or bone areas invisible to the eye.

**Uninterrupted tracking:** Position tracking is unaffected by changes in tissue or body position.

**Visual flexibility:** Data can be presented in 2D/3D on a monitor or special glasses.

### Real-time navigation with continuous feedback to the surgeon

Fiber Bragg Grating-based optical fibers, whose reflectivity changes with strain, are integrated into surgical instruments to obtain the position and orientation of the instrument in space. This real-time data is registered with the patient's CT, MRI or other imaging data using a dedicated algorithm. The registered data is transferred in real time to a monitor or 3D glasses via a computer interface, giving the surgeon continuous feedback and immediate guidance to the target point and direction of advance during surgery and biopsies.

# Amperometric Determination of Lactate Dehydrogenase with an Electrochemical Sensor

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## LDH-Sense – Rapid LDH Sensor

**An electrochemical sensor enabling rapid and sensitive amperometric determination of lactate dehydrogenase (LDH) using a gold electrode modified with the conductive polymer PANI-b-PAA.**

## Advantages

**Rapid detection:** Amperometric determination of LDH significantly shortens analysis time.

**High sensitivity:** The PANI-b-PAA-modified gold electrode enhances the NADH signal for reliable detection.

**Point-of-care analysis:** Measurements can be made at the bedside, reducing the need for central laboratories.

**Low cost:** Economical, user-friendly measurement without expensive spectrophotometric analysers.

**Clinical applicability:** Usable for diagnosis, progression monitoring and evaluating treatment response.

### Point-of-care LDH measurement without expensive devices

The sensor has a three-electrode structure consisting of a gold working electrode, a silver reference electrode and a counter electrode. The working electrode surface is modified with the conductive polymer PANI-b-PAA, synthesised by RAFT polymerisation, to increase electrochemical activity and signal sensitivity. NAD, lactate and LDH solutions are applied to the modified electrode, and the NADH oxidation signal is monitored at constant potential. The amperometric response allows the LDH concentration in the sample to be quantified. The sensor is suited to clinical diagnosis, disease monitoring and cancer biomarker detection.

# Self-Powered Cochlear Implant

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## Next-Generation Cochlear Implants

**A cochlear implant that can be fully embedded in the skull and generates its own energy; inspired by the ear's natural working principle, it reduces battery dependence and aesthetic concerns.**

## Advantages

**Low cost:** An economical solution based on inexpensive MEMS technology.

**Fully implantable:** No external device; all components can be embedded in the skull.

**Energy harvesting:** The system generates its own energy from acoustic vibrations.

**Sound quality:** Mimics the ear's natural working principle for better hearing.

**Simple structure:** More compact, as no processor or microphone is needed.

### A cochlear implant that generates its own energy

Today, hearing is restored for people with hearing loss using cochlear implants, which consist of an external sound processor worn behind the ear, an implant placed in the skull and electrodes stimulating the nerves in the cochlea. Daily battery changes interrupt continuous hearing, and the external unit causes aesthetic discomfort. The invention converts eardrum vibrations at different frequencies into electrical signals that stimulate the relevant nerves, eliminating the need for a separate sound processor and implant unit. The required energy is harvested from the kinetic energy of the vibrations, so no battery is needed; and because the system sits entirely inside the body, aesthetic concerns are removed.

# Encapsulation of Genetic Molecules in a Mesoporous Silica/PEG Hybrid Structure

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## Nucleic Acid Carrier Nanoparticles

**Developed for the treatment of cancer and genetic diseases, the hybrid vector structure and single-step production process enable efficient use of mesoporous silica vectors in RNAi.**

## Advantages

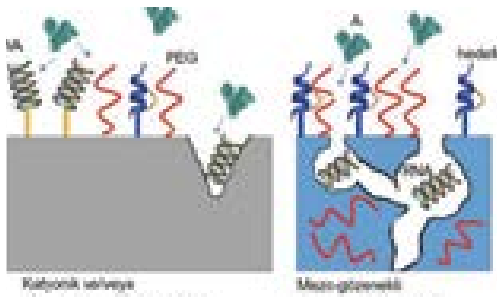
**Simple production:** Simplifies RNAi vector production: controlled, efficient production with less material in a short time.

**Targeting:** Surface active groups are used only for targeting and required functionalisation.

**High stability:** Homogeneous PEG and PEI distribution improves resistance in blood and cell-membrane passage.

**Controlled loading:** Pore volume and nucleic acid amount are tunable; drug molecules can be co-delivered.

**pH-controlled release:** Nucleic acid release is controlled by pH change without complicating the material.



### Hybrid silica/PEG vector produced in a single step for RNAi

The invention is a carrier nanoparticle system in which genetic molecules (nucleic acids) are encapsulated in a hybrid structure of mesoporous silica and polyethylene glycol (PEG). Because PEG and PEI are distributed homogeneously throughout the structure, the vector's resistance to degradation in the bloodstream increases and passage through the cell membrane becomes easier. The single-step process simplifies RNAi vector production. Pore volume and the amount of loaded nucleic acid can be controlled, drug molecules can be co-delivered with nucleic acids, and release is controlled by pH change.

# Photosensitizers Absorbing in the Near-Infrared (NIR)/Red Region

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## Targeted Photodynamic Therapy Agents

**Next-generation photodynamic therapy agents that absorb in the near-infrared (>700 nm) and are decorated with groups targeting specific cancer types.**

## Advantages

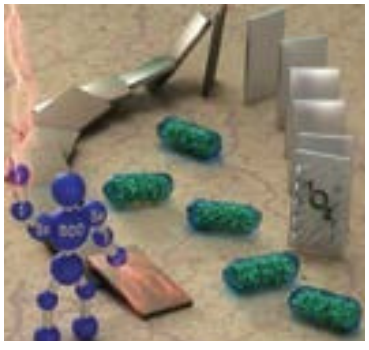
**Targeted:** Agents functionalised with targeting groups can be activated in specific cancer types.

**Deep tissue penetration:** NIR absorption allows the agents to reach deep tissues.

**High efficiency:** High singlet oxygen generation efficiency.

**Minimal side effects:** Non-toxic in the dark, so effects on healthy tissue are minimal.

**Biocompatibility:** Water-soluble and photostable.



### Non-toxic, water-soluble and photostable PDT agents

Photodynamic therapy (PDT) is used to treat various cancers thanks to its minimally invasive nature and far fewer side effects than current treatments. However, its clinical use is limited by the poor tissue penetration of the light that triggers singlet oxygen generation and by a lack of selectivity for cancer cells. The invention provides photosensitizers that absorb in the near-infrared, offer high singlet oxygen generation efficiency and are decorated with groups targeting specific cancer types. Near-infrared light enables deeper tissue penetration, as it causes no autofluorescence and minimal interference from biomolecules.

# Biodegradable and Bioactive Implant for Craniofacial Bone Defects

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## Resorbable Craniofacial Implant

**A porous implant produced by rapid prototyping or lyophilisation that gradually dissolves in the body and is replaced by new tissue, eliminating the need for a second surgery.**

## Advantages

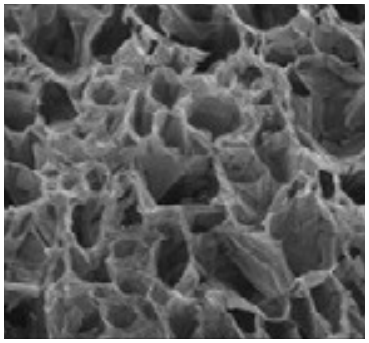
**Biodegradable:** Gradually dissolves in the body and is replaced by new tissue.

**Porous structure:** Porous architecture supports tissue ingrowth.

**Antibiotic-loaded:** Loaded antibiotics reduce the risk of infection.

**Growth factor:** Accelerates tissue integration and healing.

**No revision surgery:** Eliminates the need for a second operation.



### An implant that accelerates tissue healing with growth factors

The invention relates to a porous implant, produced by rapid prototyping or lyophilisation, that closes craniofacial defects, fractures and cracks and gradually dissolves in the body as new tissue forms. It offers an alternative to metallic, non-resorbable implants and can be produced by two different methods. Antibiotics loaded into the structure prevent infection, while growth factors improve integration with the tissue. As no revision surgery is needed, the risks, trauma, pain and cost of a further operation are avoided.

# Reducing Electrical Crosstalk in CMUT Arrays

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## Diamond-Shielded CMUT

**A capacitive micromachined ultrasonic transducer (CMUT) that reduces electrical crosstalk with an individually addressable Faraday cage for each array element and a self-discharging diamond lightning rod.**

## Advantages

**Crosstalk suppression:** Up to 6.7 dB lower crosstalk in transmit mode.

**Receiver performance:** Up to 51% lower parasitic capacitance for higher SNR.

**Dielectric protection:** The diamond lightning rod discharges accumulated charge for reliable operation.

**Mechanical strength:** A diamond (BNCD) membrane offers a more responsive, robust structure.

**Manufacturing yield:** XeF2 dry etching suits industrial mass production.

### Faraday cage grounded in transmit, floating in receive

The invention dynamically switches the state of the Faraday cage of each CMUT array element: the cage is grounded in transmit mode and floating in receive mode. This suppresses crosstalk while preserving receiver sensitivity. Hazardous charge that builds up in floating mode is safely discharged by a diamond lightning rod with high field-emission efficiency. XeF2 dry etching prevents membrane stiction without damaging diamond/oxide materials.

# Microparticles Capturing Bacterial Cells with High Capacity

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## Bacteria-Capturing Microparticles

**Functional microparticles with the highest known bacterial capture capacity that selectively separate bacterial cells from blood and other biological fluids.**

## Advantages

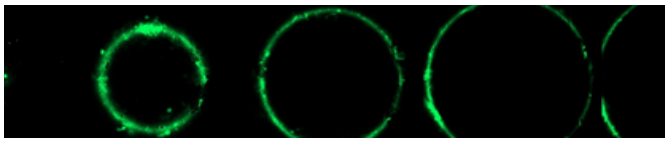
**Universal capture:** Selectively captures many different bacterial species.

**High capacity:** Among the highest bacterial capture capacities of any material.

**Selectivity:** Selectively separates bacteria from complex matrices such as blood.

**Easy access:** Scalable production from inexpensive microspheres via simple chemistry.

**Low cost:** The materials used are relatively low cost.



### A material that facilitates the diagnosis and treatment of bacteremia

The invention is based on coating the surfaces of micron-scale, non-porous microspheres with synthetic affinity ligands for bacterial cells using simple chemical methods. The microsphere size enables selective separation of bacteria from complex matrices such as blood. A capture capacity of $10^9$ CFU/g is achieved for 200 µm microspheres. The invention can separate bacteria from blood and other aqueous fluids where bacterial contamination is a concern, for both diagnostic and therapeutic purposes.

# Multilayer Acoustofluidic System and Manufacturing Method

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## Stackphore Acoustophoresis Chip

**Multiple microchannel layers connected in series and/or parallel, produced monolithically in a single print together with actuator slots and drain channels, without adhesives.**

## Advantages

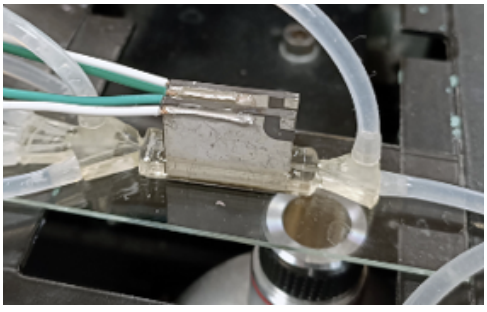
**Short production time:** Single-print production with no bonding or assembly.

**Low cost:** No modular parts, adhesives or extra processing.

**Repeatable production:** Self-aligned actuator slots prevent misalignment.

**Short analysis time:** Parallel layers increase sample throughput.

**Easy integration:** Multi-step processes combine on one chip; tubing ports are built into the body.



### A multilayer acoustophoresis chip produced in a single print

The invention shortens chip length by stacking channels on top of each other. In series, separation, focusing, trapping, washing and concentration run sequentially on one chip; in parallel, throughput increases or different samples are processed simultaneously. The body is printed in one step by stereolithography (SLA). A self-aligned pair of piezoelectric actuators generates acoustic radiation force in all layers, and conical drain channels empty uncured resin during printing. Applications include cell separation, diagnostics and removing microplastics from water.





# Defense and Security



# Accountable Subgroup Multi-signature Scheme with Verifiable Group Setup

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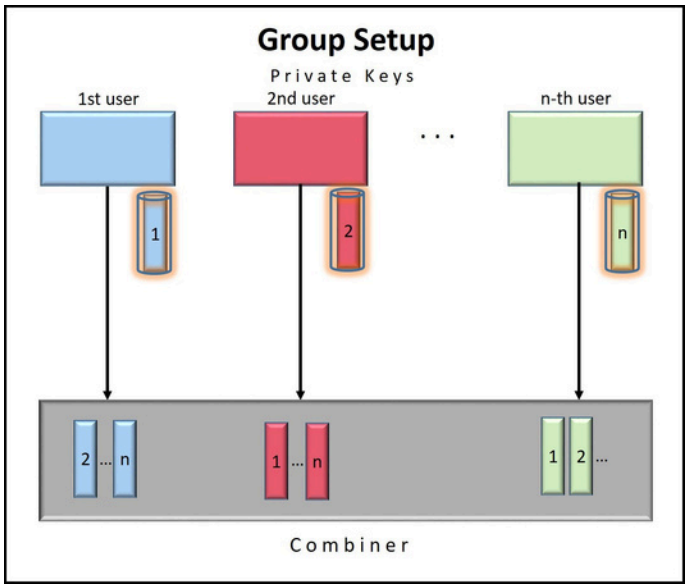
## H2CI-3: Fast & Accountable Multi-Signature-3

**Thanks to its unique group setup, the invention has the fastest signing and verification and the smallest signature size among known pairing-based ASM schemes.**

## Advantages

**Fast signing:** Requires 1 elliptic curve scalar multiplication.
**Fast verification:** Requires 2 elliptic curves pairing and n elliptic curve scalar multiplication operations.
**Accountability:** Signatures are computationally binding, hence they cannot be repudiated.
**Constant signature size:** Consists of only 1 elliptic curve group element, independent of the number of signers.
**Flexible number of signers:** The number of signers can be 1 to n.
(*) n: number of potential signers




The generated signature can be verified with public keys and identities of the signers.

Potential signers, authorized on behalf of an organization, can sign in a fast, secure and accountable fashion with the membership key they obtained following the group setup that they performed jointly with their private keys. This signature can be verified very quickly by anyone given signers' public identities.
Each potential signer in the organization signs the others' public identities individually with their private key and sends them to the combiner. She stores her own identity signature. Later, when she wants to sign a message, she signs it with her private key and add the identity signature she has recorded. She sends it to the combiner. The combiner aggregates the signatures he receives. Then, he combines the previously recorded identity signatures of the signers and aggregates it to the signature he has already created.

# Doppler Shift Based Distributed Drone Detection System

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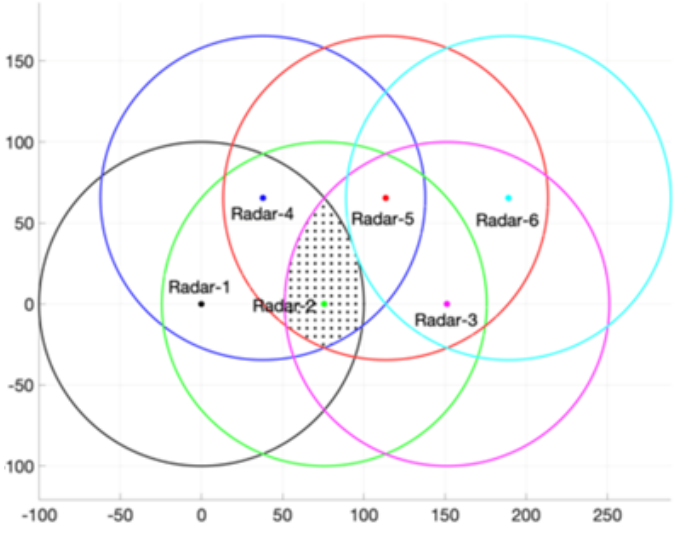
## Distributed Drone Detection System

**This invention focuses on a new method to detect drones in target dense environments. This method is based on using the Micro-Doppler signals caused by the motion of the propellers of the drones to detect drones and filtering other targets.**

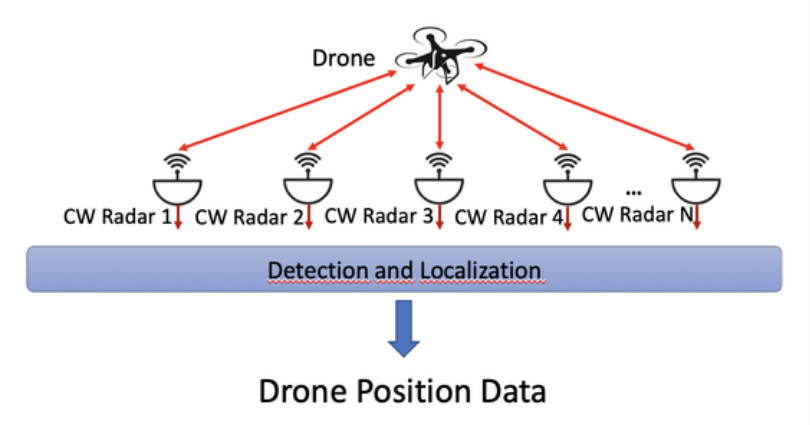
## Advantages

**Cost effective:** Cost effective in radar coverage limited regions
**Scalable:** System architecture can be scaled according to the surveillance region
**Graceful degradation:** High reliability due to the usage of multiple distributed radars
**Easy deployment:** Easy deployment of multiple small radar systems compared to single conventional radar system
**Operation in target dense environment:** Operate in target dense environment using drone specific filtering.




## Radar drone detection in radar-coverage limited and target dense environments like urban areas.

It is a challenging task both in terms of cost and performance for conventional radar systems to detect drones in radar-coverage limited and target dense environments. This invention defines a distributed, low power and cost effective radar drone detection solution. With this method, fusion of the data generated by distributed radar systems is used to detect and localize drones. With this distributed structure, radar blind zones can be prevented using proper deployment of radars.




ODTÜ-89

# Gunshot Detection From High Noise Multichannel Acoustic Data on Unmanned Aerial Vehicles

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## Noise resistant gunshot detection on a drone

## Advantages

Emphasizing the distant gunshot sounds instead of the noise close to the microphone array

Adaptive to different firearm types and nonstationary ego-noise without apriori information

Precise resolution in time and frequency, ability to tune / focus different signal characteristics

Support for different microphone array sizes and geometries

Low computational complexity for real-time processing.

Robustness even if some microphones in the array mulfunction.

Adaptive detection and imrovement of different muzzle blast and shock waves despite varying drone noise for gunshot localization.

Detecting impulsive event / gunshot in an adaptive way, taking advantage of multi-channel's coherence so as to improve SNR performance.

The offered Array Corelation Map (ACM) uses cross-correlations of array signals. The adaptivity feature is achieved by a specific selection method of the known CWT's scales.

# System For Detection Of Non-Organic Object Transition In Shallow Waters Using Muons

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## Emins

**Unlike its counterparts, It does not see organic objects with low false alarm rate.**

## Advantages

Detection with a low error margin.

Organic objects (for example, a pod of dolphins) cannot be seen by EMINS.

Being a passive system.

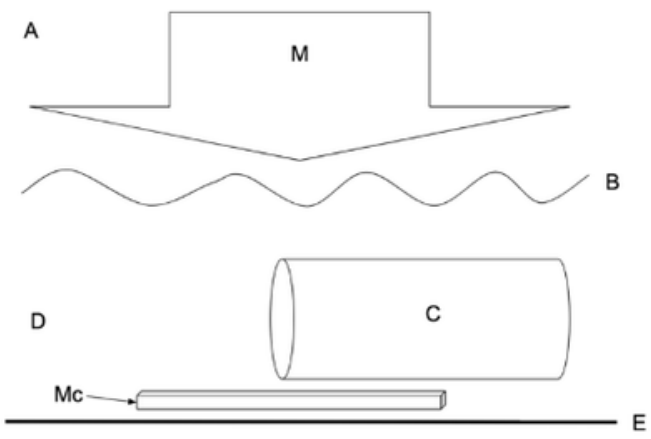
Measurement of parameters such as length, diameter and speed of the object that may be required for the identification of the object.

The system can be installed up to 70 meters sea depth.

It can be used as a warning system for secret submarine passages, especially in shallow waters such as the Straits.

The invention relates to a muon flux measuring device placed on the bottom or on a platform underwater for the detection of the passage and/or presence of non-organic objects (e.g. submarines) standing or moving underwater or on the water surface in shallow waters, and to a system that will give a live alarm as a result of a decrease in the instantaneous muon flux caused by the presence of the object.

It is possible to detect a decrease in the number of high-energy cosmic muons that can enter water, due to the high stopping power of steel.




**A.** Atmosphere

**B.** Surface of the sea, ocean, strait, river or natural or artificial lake

**C.** Non-organic object, e.g. submarine

**D.** The sea, ocean, strait, river or natural or artificial lake

**E.** Bottom of the sea, ocean, strait, river or natural or artificial lake

**M.** Atmospheric muon flux

**Mc.** Muon flux measuring device

**ODTÜ-145**

# Naval Task Group Defense Planning Algorithm

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## NADP Algorithm

**The invention is an algorithm that can produce an effective solution in a short time so that it can be used in real time.**

## Advantages

Real-time and effective (near-optimal) solutions can be obtained

Increasing the survival probability of platforms

Efficient use of defense resources

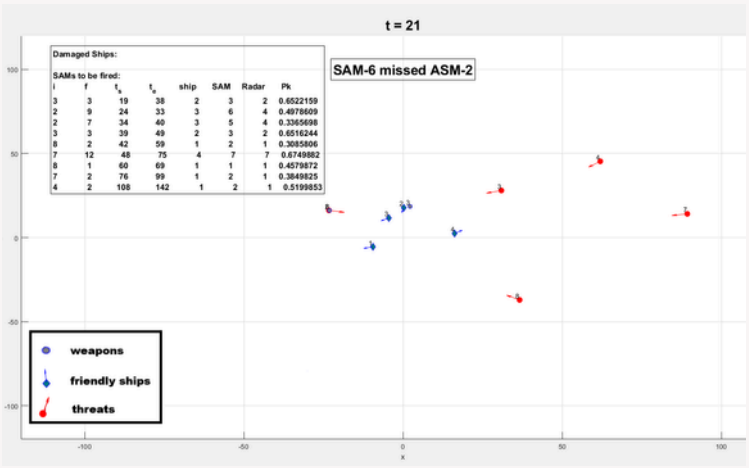
Scalability of the solution approach

Easy implementation

### Providing engagement scheduling and ship routing decisions within the scope of naval task group air defense planning

The invention, Naval Air Defense Planning (NADP) Algorithm, comprises a solution approach developed for use in combat management systems to effectively protect naval task group platforms from air threats.

The NADP algorithm is an algorithm that optimizes and automates naval air defense planning. The algorithm covers the planning of defense resources in a very short time, including maneuver decisions of ships, assignment and timing of weapons and sensors against threats.




ODTÜ-146

# Quantum-Resistant Lattice-Based Accountable Subgroup Multi-Signature Scheme

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## Quantum-Resistant ASM Scheme (vMS2)

**The first quantum-resistant Accountable Subgroup Multi-Signature (ASM) scheme in the literature, securing signatures against quantum computers with a lattice-based design.**

## Advantages

**Quantum resistance:** Provides quantum-computer security that no existing ASM scheme offers.
**Accountability:** The identity of every signing subgroup member can be verified.
**Flexible number of signers:** No fixed threshold; any subgroup can sign together.
**Wide application:** Usable in finance, authentication, e-voting, blockchain and military systems.
**Standards-compatible basis:** Built on MS2, an extension of NIST PQC finalist Dilithium.

### The first ASM solution to bring digital signatures to a quantum-resistant platform.

Existing classical ASM schemes (DLP/DHP-based) are vulnerable to quantum computers. vMS2 extends the MS2 multi-signature scheme with Verifiable Secret Sharing (VSS) and the Rejection Sampling protocol.
During group setup, each user selects a random polynomial based on their secret key, and membership keys are shared via VSS. Accountability is ensured by using the membership key in signature generation. Security relies on the Module-LWE and Module-SIS assumptions.



# Information and Communication Technologies

# Energy-Efficient Scheduling Method for Non-Deterministic Traffic in IEEE 802.15.4e TSCH

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## Long Battery-Life Network Device for Industrial IoT Systems

**The invention is based on a scheduling method that minimises the device's energy consumption, and thus extends battery life, for low-density, irregular and delay-sensitive traffic.**

## Advantages

**Compatibility:** Compliant with industrial IoT standards and works alongside other standard-compliant solutions.
**Low complexity:** Predictions rely on an empirical model and need little processing power.
**Energy efficiency:** Finds the most efficient solution to maximise battery life.
**Self-adaptation:** The model is updated taking environmental factors into account.
**Scalability:** The distributed algorithm maintains performance in networks with many devices.

### A network device with user-adjustable performance

The network device developed in the invention operates in IEEE 802.15.4e TSCH mode. Its scheduling method is based on an empirical model that the device uses to make performance predictions, and the model is updated according to current measurements.

Using predictions based on this model, the algorithm finds the network configuration with the lowest energy consumption that meets the delay and reliability constraints set by the user.

# A Semiconductor Photodiode Functioning In A Wide Band Range And Obtaining Method Thereof

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## Low-cost Broadband Silicon Infrared Detector

**Our invention is about the design and production of a low cost and effective photodetector that can operate in a wide band range from the visible to wide infrared wavelengths, that is, at a wavelength range of 0.4 μm to 9 μm.**

## Advantages

**Useful:** surveillance, military, and energy device applications. It can be used in a variety of fields, including telecommunication, environmental sensing, bio-medicine, monitoring equipment's. ect.

**Efficient:** Large worldwide sales market.: regional analysis for the Photoelectric Sensors (highest) Market:
-North America (USA, Canada and Mexico)
-Europe (Germany, France, England, Russia and Italy)
-Asia Pacific2 (China, Japan, Korea, India, and Southeast Asia)
-South America (Brazil, Argentina, Colombia etc.)

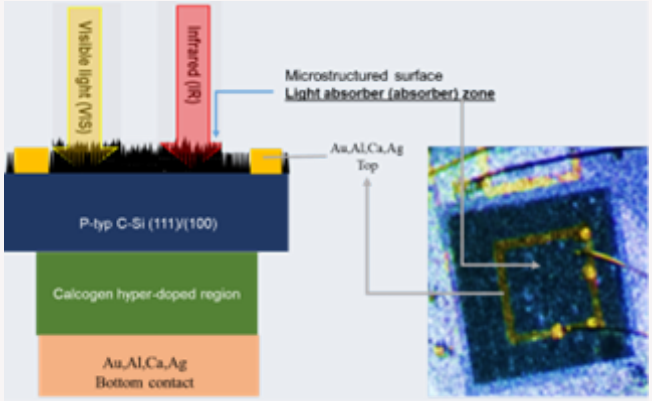
**Cost performance:** The proposed method offers an approach to fabricate low-cost broadband silicon-based photodetectors

**High performance:** High IR photoresponse of Si hyperdoped photodiodes at room -and cryogenic temperature. In other words, the invention covers a wide range of bands from visible to longwave infrared.

**Sensitive:** Higher sensitivity

The highly doped black Si allows the production of a new generation of photo-detectors that can operate in the near and mid-infrared region as well as in the visible region

Our invention enables the silicon to be active in the IR region by forming a new band in the forbidden band gap by doping the Si crystal with a high concentration of Se, Te, S atoms by ion implantation method. In addition, due to its compatibility with micronelectronic technology, its integration into complex CMOS circuits constitutes an important advantage.
The simple idea of our invention is that we dope semiconductors and their microstructures beyond the solubility limit of chalcogen dopants (sulfur, selenium, tellurium atoms) by processing the laser-assisted -doping and microstructuring separately on both sides of the Si; i.e., doping one side by ion implantation and microstructuring the other side




**ODTÜ-24**

# Two-Stage Detection in One-Bit Massive MIMO Systems with Pseudo-Random Quantization

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## One-Bit Newton-Hamming Detector (OBNHD)

**A new quantization method and a new detection algorithm for massive MIMO systems equipped with one-bit ADCs**

# Advantages

The invention proposes a new quantization scheme for systems that are equipped with low-resolution ADCs, that can help overcome the negative effects of the stochastic resonance phenomenon on detection performance.

The dithering effect is obtained by changing the quantization thresholds of the ADC units and does not require additional oscillators.

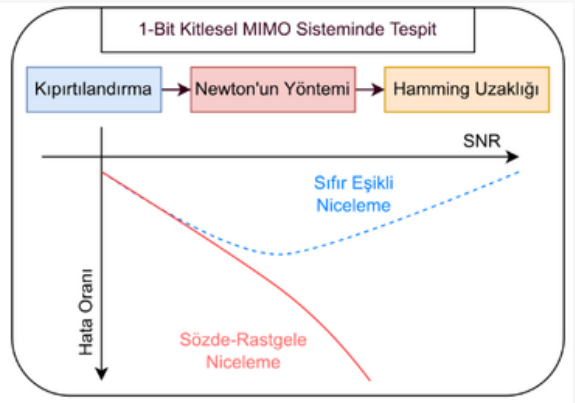
The proposed method in the invention outperforms the existing detection algorithms from the literature.

By utilizing one-bit ADCs, the proposed scheme provides exponential decrease in the power consumption compared to the systems that are equipped with high-resolution ADCs.

Due to the simple circuitry of the one-bit ADC units, important reductions in the base station construction costs can be obtained.

The invention can support higher order modulation schemes in a multi-user massive MIMO system that is equipped with one-bit ADCs and offers superior detection performance compared to that of the existing detectors from the literature.

The invention compensates for the negative effects of the stochastic resonance phenomenon on detection performance by creating a dithering effect with the help of the pseudo-random quantization scheme. The proposed detection algorithm utilizes Newton's method with an appropriate cost function created for detection purposes in the first stage and applies ML detection on a reduced candidate set formed by taking the one-bit quantized observations as binary codewords in space with a criterion based on the Hamming distance.




**ODTÜ-116**

# Quasi-Newton Detection in One-Bit Massive MIMO-OFDM Systems with Pseudo-Random Quantization

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## One-Bit Quasi-Newton Detector (OBQND)

**A new quantization method and a new detection algorithm for massive MIMO-OFDM systems equipped with one-bit ADCs**

## Advantages

The invention proposes a new quantization scheme for systems that are equipped with low-resolution ADCs and can help overcome the negative effects of the stochastic resonance phenomenon on detection performance.

The dithering effect is obtained by changing the quantization thresholds of the ADC units and does not require additional oscillators.

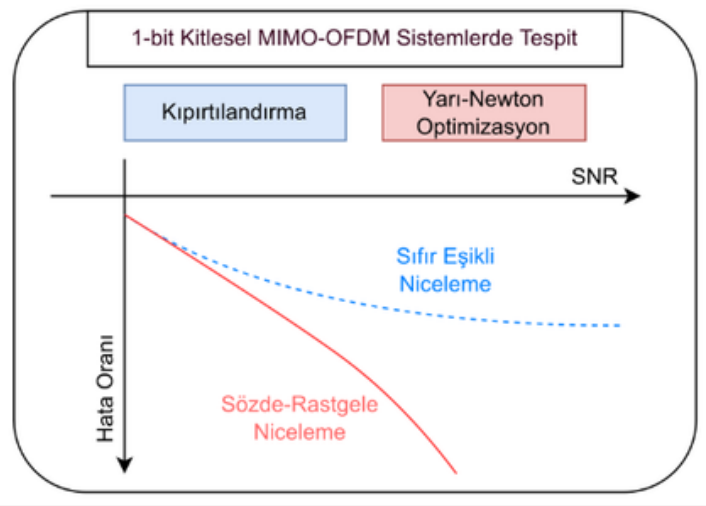
The proposed method in the invention outperforms the existing detection algorithms from the literature and offers low computational complexity as a frequency domain equalizer for wideband systems.

By utilizing one-bit ADCs, the proposed scheme provides exponential decrease in the power consumption compared to the systems that are equipped with high-resolution ADCs.

Due to the simple circuitry of the one-bit ADC units, important reductions in the base station construction costs can be obtained.

The invention can support higher order modulation schemes in a wideband multi-user massive MIMO-OFDM system that is equipped with one-bit ADCs and offers superior detection performance compared to that of the existing detectors from the literature.

The invention compensates for the negative effects of the stochastic resonance phenomenon on detection performance by creating a dithering effect with the help of the pseudo-random quantization scheme. The proposed detection algorithm utilizes a Quasi-Newton optimization technique constructed for detection purposes.




**ODTÜ-120**

# MEMS Neuristor

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**The invention focuses on an alternative approach by replacing the memristor-capacitor pairs in state-of-art memristor-based neuristors with an electromechanical device, CMUT.**

## Advantages

**Energy-efficiency:** Capacitive mode provides a minimal energy dissipation and maximized energy efficiency during operation with charge conservation during collapse-snapback.

**Adjustable delay behavior:** MEMS neuristor provides optimizable delay feature by applying a proper combination of AC signals and DC bias, resulting in a versatility in applications.

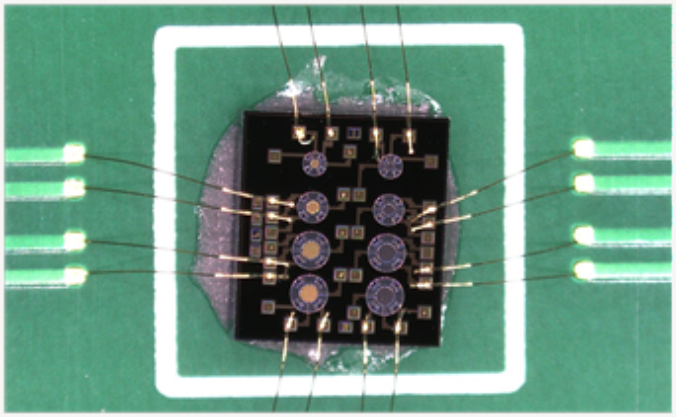
**Reliability:** MEMS neuristor provides a consistent and predictable behavior, free from such variability seen in memristor-based devices, ensuring greater reliability.

**Compatibility with industrial microfabrication:** Neuristor functionality is achieved with a single compact CMUT element, MEMS-based devices, eliminating the need for additional memristive components or specialized materials and bringing about inherent compatibility with existing CMOS processes, simplifying industrial fabrication and integration.

**Frequency-dependent operation:** Frequency-dependent spike generation provides adjustable sub- and super-threshold reponses in MEMS neuristor according to frequency of applied signal benefiting from spring softening effect of CMUTs.

A newly developed MEMS neuristor designed to meet the industrial demand for a reliable, high-performance, CMOS-compatible neuristor prototype to power next-generation neuromorphic electronics.

A paradigm shift from traditional analog/digital electronics to brain-inspired neuromorphic hardware has the potential to address the massive waste of energy, time, and materials. This transition can be realized by replacing transistor-based systems with neuristor-based hardware.
Memory and processing functions of a neuristor are achieved without relying on any memristive element thanks to the hierarchically layered mechanical and electrical features of the CMUT.
CMUTs, as units of MEMS neuristor, featuring collapse-snapback events present hysteresis characteristics in their capacitance and membrane deflection between their collapse-snapback voltages, offering memory feature.
Utilizing Fowler-Nordheim tunneling mechanism in CMUTs instead of insulation layer provides capacitive and resistive operation modes of CMUTs offering threshold-based spike generation.



**ODTÜ-152**

# High-Sensitivity MEMS and Fiber-Optic Microphone Immune to Electromagnetic Waves

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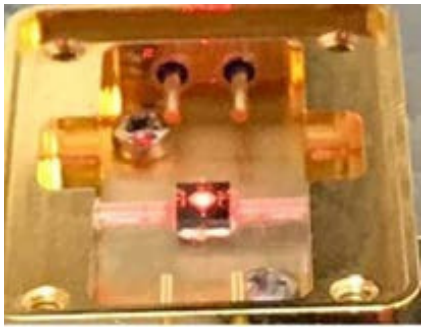
## Fiber-Optic MEMS Microphone

**Thanks to its optically tunable flexible membrane design, the invention offers superior microphone performance compared with other fiber-optic MEMS microphones.**

## Advantages

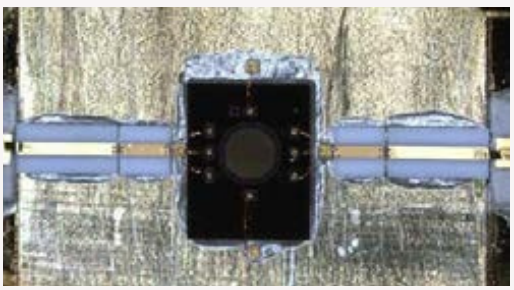
**Reliable:** Delivers stable, dependable microphone performance.
**Long-lasting:** Robust structure provides a long service life.
**High sensitivity:** Tunable MEMS membrane enables precise sound detection.
**EM immunity:** Unaffected by electromagnetic waves.
**Harsh-environment resistance:** Operates outdoors and in harsh conditions.



### A reliable, sensitive, outdoor-resistant microphone

Fiber-optic MEMS microphones combine a passive MEMS diaphragm with optical fibers. This invention replaces the passive diaphragm with an electrically tunable MEMS membrane.

A photodiode chip generates electrical energy from the laser light passing through the membrane; the energy of the light carried in the optical cable is converted into a voltage on the membrane via a photodetector. This removes the need for electrical transmission along the fiber and significantly reduces the cost of large-scale use.



# A Method For Direct Resonance Computation Of Nonlinear Structures By Using Response Dependent Nonlinear Normal Modes (RDNMS)

## RDNM DRC

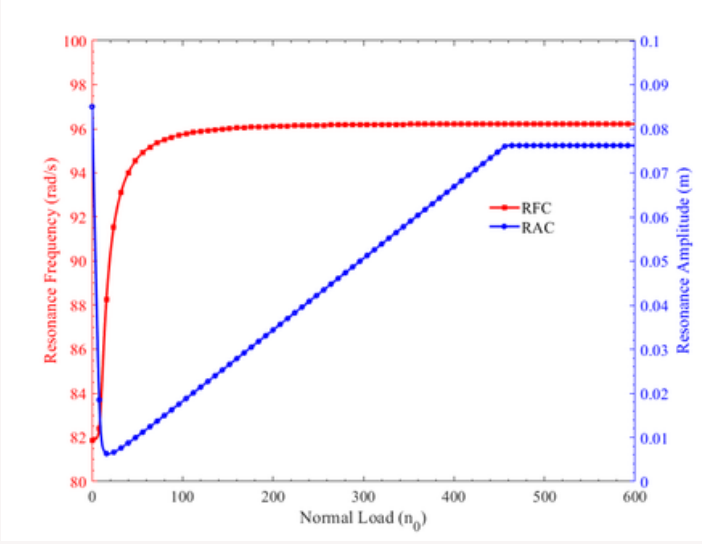
**The present invention enables the direct computation of the resonance response of nonlinear systems by employing Response-Dependent Nonlinear Modes (RDNMs). The RDNM-DRC approach calculates the resonance response as a function of variations in both the excitation amplitude and the nonlinear parameter. Furthermore, the method is applicable to systems exhibiting complex nonlinear behaviors, such as internal resonance or modal coupling.**

## Advantages

- **Computational Efficiency:** Direct calculation of the resonance response and a significantly reduced number of required mode shapes substantially decrease the overall computational time.
- **Direct Resonance Characterization:** Resonance amplitudes and nonlinear natural frequencies can be directly determined with minimal computational effort using analytical or numerical methods.
- **Wide Parametric Capability:** Resonance amplitude and frequency can be evaluated as functions of both the excitation amplitude and various nonlinear parameters.
- **Low Computational Cost:** The total time required to generate resonance characteristics is merely on the order of computing a single frequency response curve (FRC).
- **High-Fidelity Applicability:** The method's efficiency makes it highly suitable for use with high-fidelity finite element models while maintaining strict accuracy.

The invention enables the direct, fast, and highly accurate computation of the resonance responses of nonlinear systems over a wide parameter range.

In the current state of the art, Frequency Response Curves (FRCs) are commonly used to analyze nonlinear systems. However, such approaches require the computation of a large number of FRCs, which leads to high computational cost and does not allow accurate determination of the resonance response. In contrast, the present invention first determines the nonlinear natural frequency of the system and subsequently computes the vibration amplitudes directly at this frequency. As a result, the need for conventional frequency-sweeping-based methods is eliminated.




**ODTÜ-172**

# A New Computationally Efficient Method for Direct Determination of Flutter Speed for Linear and Nonlinear Structures

## DNFSD: Direct Nonlinear Flutter Speed Determination

**This invention presents a novel frequency-domain computational method that directly and efficiently determines the flutter speed of both linear and nonlinear structures. Unlike existing methods (p-k, k-method), this approach computes flutter speed in a single step without requiring a flow speed sweep, and is directly applicable to nonlinear aeroelastic systems.**

## Advantages

**Direct Solution Without Speed Sweep:** Flutter speed is computed directly without iterating over flow speed values, reducing both computation time and risk of missing the flutter point.

**Applicability to Nonlinear Systems:** The method determines flutter speed and post-flutter characteristics for nonlinear structures in the frequency domain a capability absent in all current commercial aeroelastic tools.

**No Time Integration Required:** The high computational cost of transient time-domain solutions is eliminated; the method reaches the steady-state solution directly.

**Suitability for Design Optimization:** Its computational efficiency makes the method compatible with optimization algorithms that require repeated evaluations of the same problem for varying design parameters.

**High Accuracy:** Since flutter speed is obtained by directly solving for the condition of zero net damping rather than detecting a sign change during a speed sweep superior accuracy is achieved.

The invention enables the direct, fast, and highly accurate determination of flutter speed and post-flutter characteristics for linear and nonlinear aeroelastic structures without time integration using a frequency-domain formulation.

Existing methods (p-k, k-method) require repeated eigenvalue computations across a range of flow speeds to detect a sign change in equivalent damping; nonlinear systems additionally require costly time-domain integration. The proposed method reformulates the equations of motion in harmonic form using the Harmonic Balance Method (HBM), integrates flow speed, vibration frequency, and amplitude as unknowns into a single nonlinear algebraic system, and directly solves for the flutter condition (net damping = zero) as a constraint. This eliminates the flow speed sweep entirely and naturally accounts for amplitude-dependent nonlinear effects.

# Design and Manufacturing Method for Surface-Deformed Passive Reflectors for mmWave Mobile Communication

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## Passive Reflector for mmWave Coverage

**A design and manufacturing method for single-piece, energy-free reflectors with shaped conductive surfaces that reflect signals from a source to predefined areas with low loss in millimetre-wave mobile communication.**

## Advantages

**Steerable reflection:** The surface shape reflects the signal in the desired directions at the desired power.
**Easy design:** Only the problem requirements are needed for a design.
**Requirement-driven:** The method generates a structure that meets the requirements.
**Time saving:** Saves time in the design phase.
**Low cost:** 3D printing and coating reduce infrastructure and production costs.

### Single-piece passive reflector for 5G mmWave

The reflector is designed in a computer environment. Unlike existing passive reflectors for 5G millimetre-wave mobile communication systems, the invention realises single-piece conductive structures.

Manufacturing involves two simple steps: 3D printing and conductive coating. Independent reflector surfaces can be produced without infrastructure upgrades, and coating a printed structure instead of machining metal blocks reduces cost.

# Age-of-Information Threshold Mini-Slotted Random Access

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## MuMiSTA Random Access Protocol

**A random access protocol that adds Age of Information (AoI) control thresholds to slotted ALOHA, which has long been used in computer networks.**

## Advantages

**Age threshold:** An AoI threshold keeps transmission focused on fresh data.
**Mini slots:** Multiple mini slots are used for access control.
**New access scheme:** Introduces a new mini-slot access structure.
**Optimised parameters:** Protocol parameters are optimised for AoI.
**High speed:** Up to 53% faster, with AoI reduced to about one third.

### Faster and fresher data transmission

Existing random access protocols were not designed around AoI, so their channel control mechanisms ignore it and perform far from optimal. Efficiency remains at 18% for ALOHA and 37% for slotted ALOHA.

MuMiSTA optimises AoI while preserving the random access structure. The protocol is up to 53% faster and reduces AoI to about one third.

# High-Performance Object Detection Using HDR Images from LDR Cameras in Autonomous Vehicles

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## HDR-Assisted 3D Object Detection

**An integrated solution that uses low-cost cameras to automatically detect people, vehicles and objects that cannot be seen by eye in dark areas or under strong glare.**

## Advantages

**Recognition performance:** Joint training of sub-blocks increases system performance.
**Cost advantage:** Low-cost LDR cameras replace expensive HDR cameras.
**Difficult lighting:** Objects can be recognised in tunnels and at sunrise or sunset.
**Integrated solution:** Image enhancement and object detection in one system.
**Safety:** Helps prevent unwanted accidents in autonomous vehicles.

### HDR-quality detection with low-cost LDR cameras

Current autonomous vehicles mostly use LDR cameras, so objects cannot be separated and recognised under high-contrast lighting such as tunnels, sunrise or sunset.

The invention offers a high-performance object detection system using HDR images obtained from LDR cameras. By transferring the most informative parts of the HDR image into detail-rich images, the system improves automatic object detection and helps prevent accidents.

# High-Speed Network Packet Classification on GPUs

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## BVGPU

**GLAS is a software technology that runs the multi-dimensional associative search used in packet classification on general-purpose GPUs, reaching about 8.98 billion classifications per second with 1K rules and 3.83 billion with 10K rules.**

## Advantages

**Highest throughput:** 8–27× faster with 1K rules and 4–8× faster with 10K rules than competitors.
**Low latency:** 10–20 µs lookup latency suits time-critical applications.
**Fully programmable:** Software-based, so rules update without hardware changes.
**Cost-effective:** Runs on standard GPUs; cheaper than FPGA/ASIC or TCAM.
**Comprehensive matching:** Prefix/ternary, range and exact matching in one framework.

## Packet classification on GPUs without special hardware

GLAS performs classification, the most critical and resource-intensive stage of the packet processing pipeline, with an associative search method that exploits the massive parallelism of GPUs. Packet header fields (IP addresses, ports, protocol) are compared with the rule set simultaneously across thousands of GPU cores.

Prefix/ternary matching for IP addresses, range matching for ports and exact matching for protocols are supported. Running above 200 Gb/s with 10–20 µs latency, it offers a flexible, low-cost solution for firewalls, data centres, 5G/6G core networks and next-generation routers.

# Image Alignment through Deep Feature Matching

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## DFM – Deep Feature Matching

**An integrated architecture that uses any pre-trained deep network to find point correspondences between two images with high precision, following coarse geometric alignment with a coarse-to-fine strategy.**

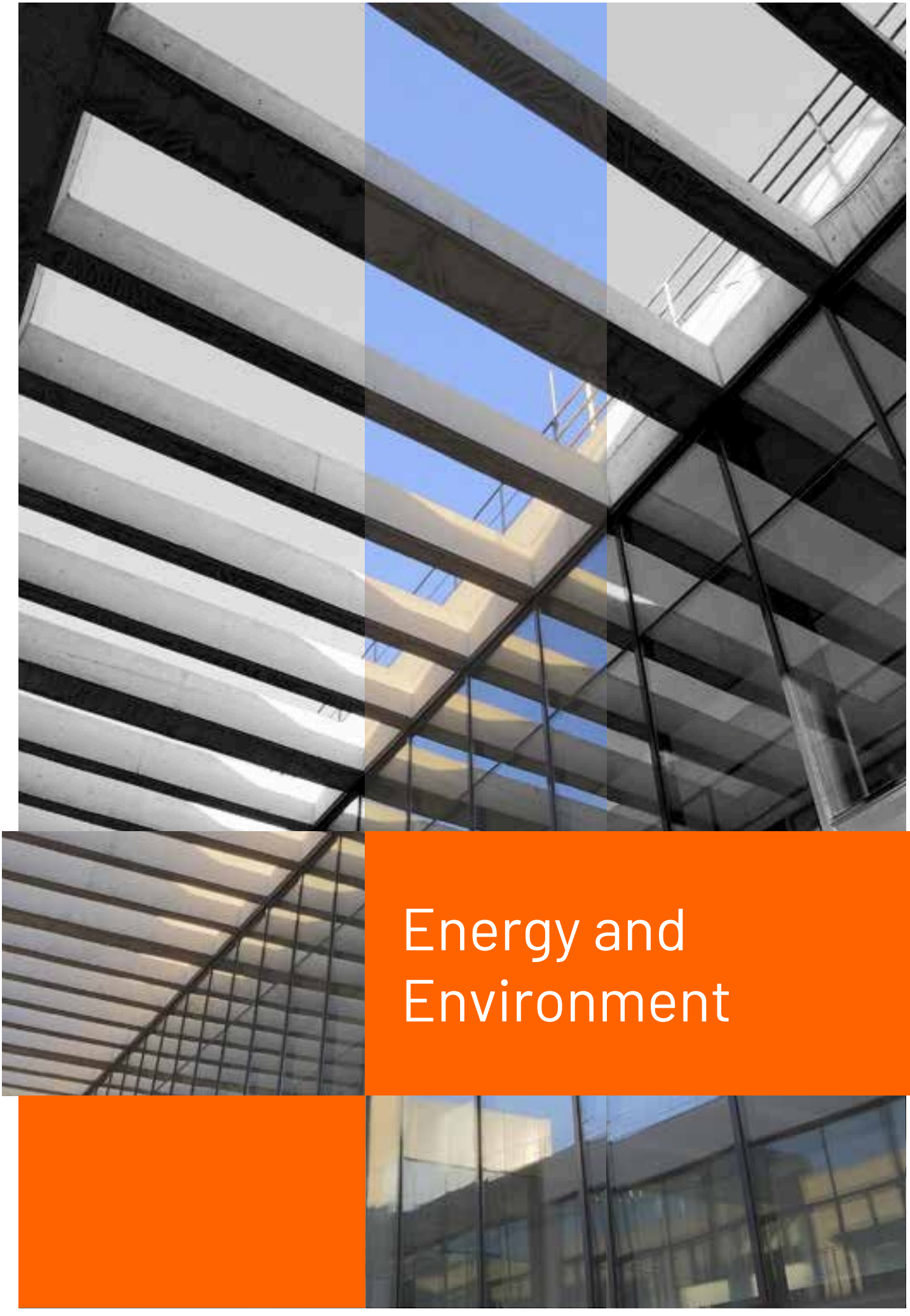
## Advantages

**No training required:** Features of any pre-trained classification network can be used without dedicated training.
**High localisation accuracy:** Matches are refined up to the original image resolution.
**Viewpoint robustness:** Coarse alignment ensures reliable matching under large viewpoint changes.
**Modular design:** No retraining needed when the feature-extractor backbone changes.
**Speed and accuracy:** High match counts and precise localisation suit real-time use.

### Matches images from different viewpoints in a single framework

The invention solves the matching problem between images taken from different viewpoints in a single framework, without the classical sequential pipeline in which detection, description and matching stages constrain each other.

In the first stage, a coarse geometric transformation is estimated with Dense Nearest Neighbour Search (DNNS) on final-layer feature maps and the second image is aligned. In the second stage, the Hierarchical Refinement Algorithm (HRA) refines the matches up to the original resolution.



# Energy and Environment

# Viscoelastic Vibration Damping Device for Wind Turbine Towers

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## ViscoLink-Wind

**It is a vibration control system/device for wind turbine towers that can potentially occupy less volume inside the tower, add a lesser weight to the total weight of the tower while achieving similar vibration mitigation performance compared to dynamic mass dampers, which are frequently used to reduce vibration in wind turbine towers.**

## Advantages

**Vibration Control Efficiency:** The wind turbine tower has the potential to increase the amount of vibration damping on both longitudinal and lateral vibration modes simultaneously.

**Wide frequency range:** Conventionally used dynamic mass dampers have to be designed separately for each vibration mode. With the invention, damping effect can be created simultaneously in all critical vibration modes of the tower.

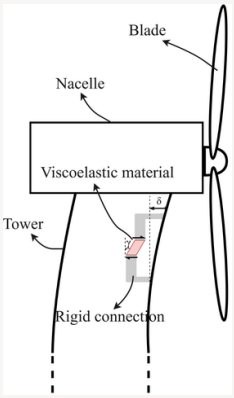
**Compact design:** It is expected to take up less space in the radial direction in the tower section compared to conventional dynamic mass dampers, which are often used to reduce vibration in wind turbines. Dynamic mass absorbers are placed in one or two locations within the tower, while ViscoLink-Wind has the potential to not occupy much volume locally as it is applied in a distributed manner along the length of the tower.

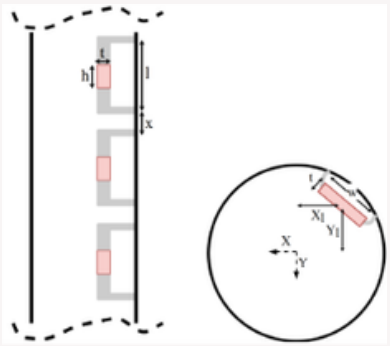
**Lightweight:** Since the vibration damping effect is not created by using resonance behavior such as conventional dynamic mass dampers, which are often used to reduce vibration in wind turbines, the same vibration damping effect can be achieved by increasing the tower weight less.

**Ease of Construction:** The vibration dampers, which are the subject of the invention, which will be attached to the inner surface of the tower, can be mounted during the production of the components of the tower and the need for assembly in the field can be eliminated.

A novel design that prolongs fatigue life of wind turbine towers by supressing wind-induced resonant vibrations in wind turbine towers.

The present invention consists of a viscoelastic material component with a specially determined geometry in the wind turbine tower and rigid fasteners to connect this material into the tower. The basic working principle of the invention is that while the wind turbine tower vibrates horizontally or vertically (dynamically changing shape) in critical vibration modes under the action of wind or sea induced loads, the parts of the vibration damping device made of viscoelastic material, which is the subject of the invention, make use of the relative displacement difference of two points in different places on the tower and damping tower vibrations by converting the dynamic tension energy resulting from this displacement difference into heat energy. The viscoelastic material to be selected can be connected to the wind turbine tower with rigid connections in different ways as determined in the invention and can show desired amount of vibration damping performance. Using multiple viscoelastic fasteners throughout the tower will provide more effective vibration damping performance.



ODTÜ-44

# Energy Storing Modular Building Elements

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## Concrete Battery

**It is an invention for both strengthening the structural system and promoting the use of renewable energy sources in housing.**

## Advantages

**Use of Renewable Energy in Houses:** It provides uninterrupted energy production in houses.

**Economic:**Energy storage with concrete, which is one of the cheapest known building materials, has very economical results.

**Efficient:**A more efficient system is obtained by using the concrete material, which is already used in houses, in heat storage at the same time.

**Compatible with Housing Architecture:** Since the invention is a reinforced concrete element, it is no different from any other element in buildings.

**Environmentally Sensitive:** Unlike lithium-ion batteries, when the battery life is over, it can be used as a filler material without the need for a special recycling process.

## It is possible to store the energy obtained from renewable energy sources in concrete structural elements

The energy storing modular elements can either be built into the framing system of new buildings or integrated into the external frames of existing buildings for retrofitting or switching to renewable energy sources by means of anchors. The invention is made up of nested layers. The innermost layer will contain high temperature resistant concrete heat stores for storing heat energy.

The intended use of the invention is to store the energy obtained from renewable energy sources in concrete structural elements and to realize energy production from this battery when the renewable energy source is not accessible. In addition, it can be used both for retrofitting existing buildings with inadequate earthquake performance and for new buildings to provide earthquake performance.

Thanks to its modular structure, it has the ability to be replaced when the battery is damaged or its life is over. In addition, its modular structure also allows it to be applied to existing buildings.

# Privacy Camera System Algorithm and Design

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## PrivCam-HDR

**Balance between security and privacy**

## Advantages

Reversibility: The ability to reconstruct the original face data in case of authorized criminal investigation situations

Smart privacy filters: The ability for an operator to understand the content of the video without revealing the identity of individual faces

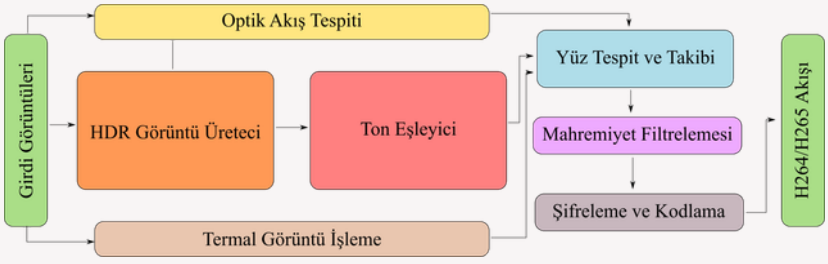
High performance under difficult lighting: The ability to perform surveillance and privacy protection under difficult lighting situations (including intense backlighting) due to the use of HDR imaging and video processing techniques.

Automatic face detection and tracking: The ability to automatically detect and track human faces, which can be extended to other objects such as human bodies, vehicles, and tag plates

Real-time performance: The ability to perform the entire processing in a real-time manner for a full-HD (1920x1080) resolution video

To allow security cameras perform surveillance without compromising visual privacy

Automatic detection of faces that enter the camera view by using state-of-the-art deep learning face detectors. The ability to perform face detection under difficult lighting conditions thanks to the use of HDR imaging techniques. Automatic filtering and privacy protection of faces based on user controllable smart filters. Storage of the original face data in a compressed and encrypted manner, which is reversible in case of criminal investigation situations. Fast and accurate face detection thanks to the usage of stereo and thermal video processing techniques.




ODTÜ-100

# Water-Harvesting, Self-Cleaning Anti-Reflective Aerogel Coating on Glass for Solar Panels

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## Water-Harvesting and Self-Cleaning Anti-Reflective Aerogel Coating

**Water harvesting, self-cleaning, anti-reflection**

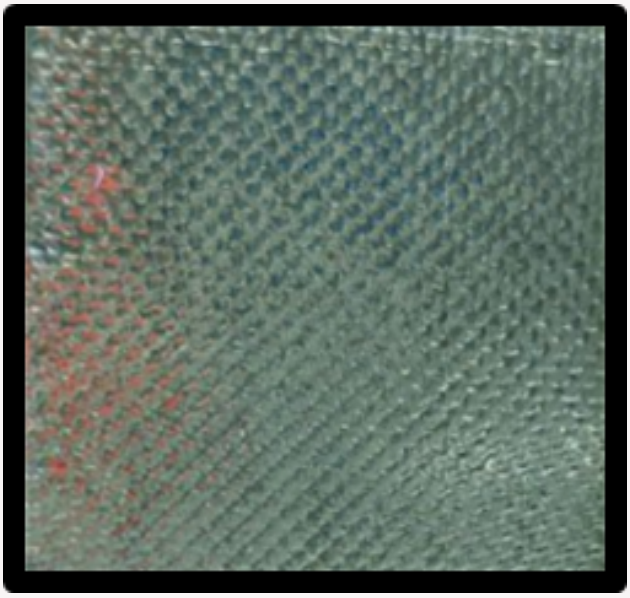
## Advantages

- Low cost
- Easy production
- Scalable to industrial size
- Multifunctional
- Adaptable to different materials



Combines three functions with low-cost production

A low-refractive-index aerogel coating with hydrophilic/hydrophobic patterns created using a UV-blocking photomask



ODTÜ-127

# Monolithically Series Connected Solar Modules Formed by Using P1 and P3 Scribes With No Additional P2 Scribing Operation

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## P2'less Thin-Film Solar Module

**Interconnection between the cells without use of P2 scribes**

## Advantages

Fabrication time decreases owing to the cancellation of one scribing step.

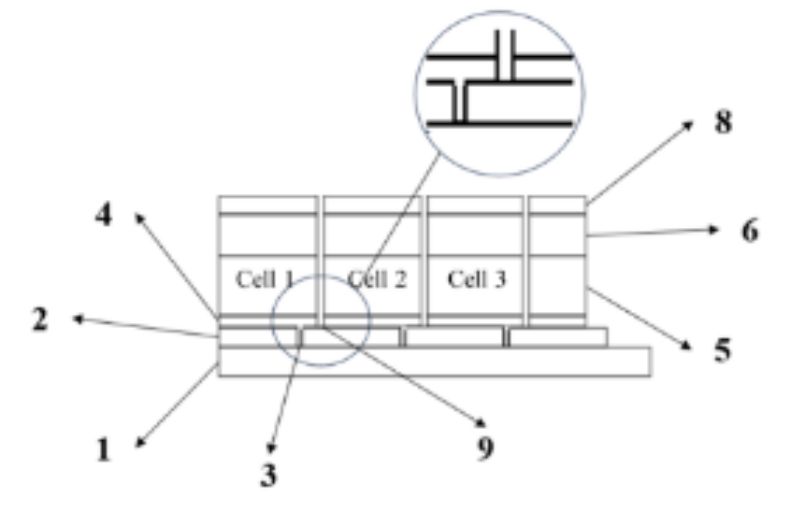
Avoiding the exposure of possibly toxic vapours (Pb, Cd, metals etc.)

Enhancing the stability of especially organic-based solar cells since the direct contacting of metals to photoactive layers through P2 scribes may accelerate degredation in the photoactive layers.

Providing serial interconnection between cells without the need for P2 line

Enabling the interconnection of the adjacent cells in thin-film solar modules without the need for P2 scribes

Conversion of solar cells at interconnection region into resistors by reverse breaking down under reverse biasing



# IBC Silicon Solar Cell Fabrication Facilitated by Ion Implant and Screen Printing

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**Simplification of IBC manufacturing complexity**

## Advantages

Process simplification of IBC production

Reduced workload

Potentially lower production cost for IBC

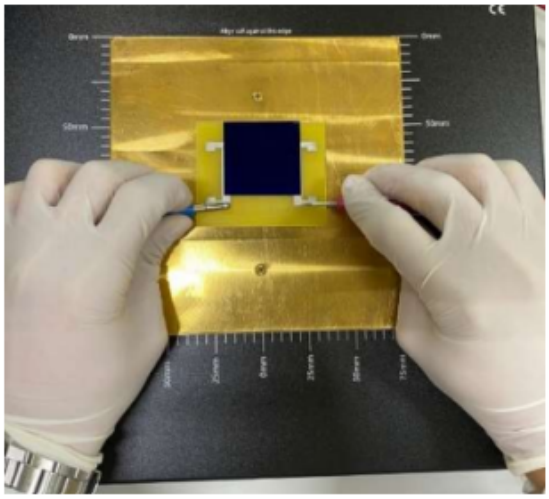
IBC has a big advantage for higher efficiency than other designs due to lack of metal at the front side.

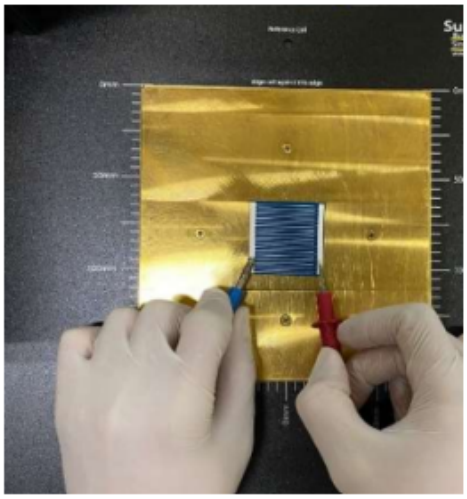
Porposed method can be adapted to PV lines by including ion implnater only.

Single side and patterned metallization by screen printing in the same process flow.

Using the ion implantation method at least for doping one polarity since it provides single side and patterned doping. Also, screen printing will be in the same process flow for further simplification of the entire production.

Single side and patterned doping by ion implantation for n+ and p+ regions, or at least one of them. Single side and patterned metallization by screen printing in the same process flow.





# A Screen Printing Based Patterning Method for the Fabrication of Interdigitated Back Contact (IBC) Solar Cells

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**This invention makes it possible to produce low-cost IBC cells in industrial lines**

## Advantages

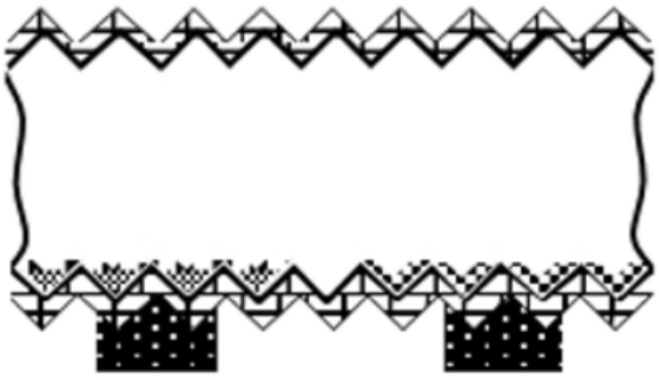
It is easily adaptable and applicable for the currently available industrial lines

No need for an additional investment

Its being an alternative method against two other IBC production methods

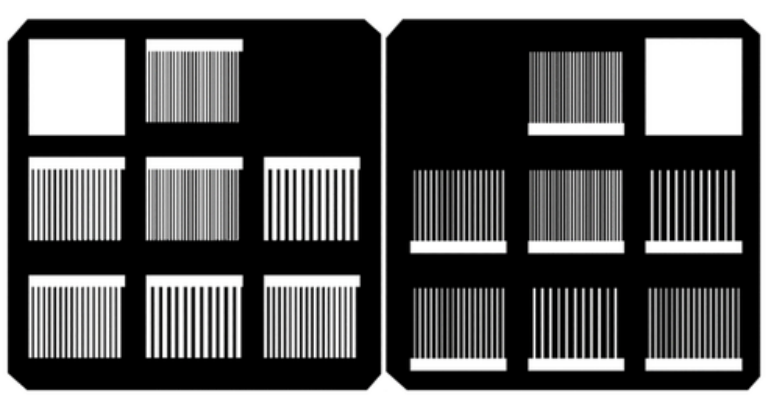
Its being relatively cheaper and easier production mehtod

Its high throughput capability



## Screen printing-based patterning step

This invention offers a simple and easy-adaptable production method for IBC cells



# Metallization Screen Design For Si Based Solar Cells

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## Metallization Screen

**In nested IBC cells, joints are provided at the ends of the cell to ensure the connection between the metallic regions and wide solder points are designed to allow flexibility in cell measurements.**

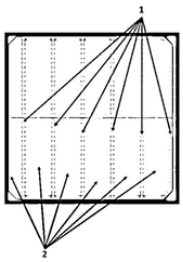
## Advantages

Insulation material used to prevent the contact areas of different polarities from contacting each other is not required

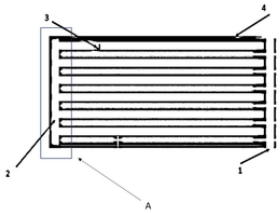
Making it suitable for industrial production with screen printing

Shortening the distance of the current that the metals must carry

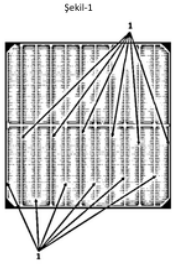
Reducing the series resistance



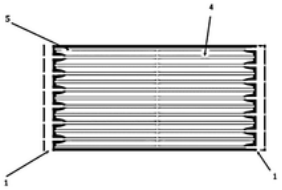
Şekil-1



Şekil-2



Şekil-3



Şekil-4

## Highly efficient and inexpensive cell production without the use of insulating material in the metallization process

A screen designed for high efficiency and cheap cell production without the use of insulating material in the metallization process, which is the last link in the production of IBC type solar cells.

In nested IBC cells, joints are provided at the ends of the cell to ensure the connection between the metallic regions and wide solder points are designed to allow flexibility in cell measurements.

# Novel Front and Back Passivating Contact Crystalline Silicon Bottom Structure for Two-Terminal Perovskite/Silicon Tandem Solar Cells

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## Crystalline Silicon Bottom Structure for Two-Terminal Perovskite/Silicon Tandem Solar Cells

**The invention aims to solve the problems and provide a novel bottom cell structure based on p-type crystalline silicon for Perovskite/Silicon tandem solar cells.**

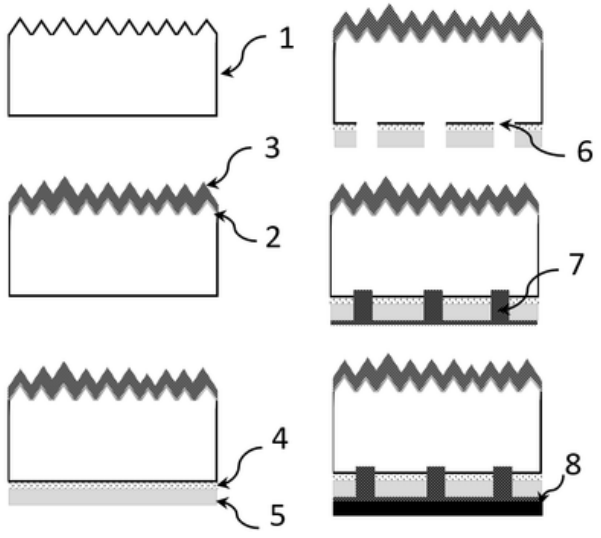
## Advantages

Reduce number of process steps to realize bottom silicon structure for silicon/perovskite tandem

Reduce material used (water, chemicals, silicon)

Eliminate the need of one high temperature process

Eliminate direct metal-silicon contact




Unlike available Patents and literatures with p-type bottom cell structure with either diffused phosphorus emitter and/or direct local metal at the back and/or screen-printed Aluminum its associated high temperature process to create the back surface field and metal electrode, the hole-selective and passivation layer is prepared at room temperature. The back electrode is prepared at room temperature. The hole-selective and passivation layer as well as the back electrode can be prepared in sequential processes in a single fabrication tool and a single step. The presence of hole-selective and passivation layer in contact with the p-type crystalline silicon at the back side will prevent direct metal contact with the silicon and therefore passivate the local opening in the silicon (lead to high Voc compared to direct metal-silicon contact), reduce process steps including the need of wet-chemical processes so reduce water and chemical consumption, eliminate one high temperature process and therefore reduce the cost and the need for thick polycrystalline silicon on the front side (reduce silicon material).

The bottom cell comprises from top to bottom is sequentially a heavily phosphorus doped polycrystalline silicon (3), ultra-thin tunneling layer (2), planar or micro textured or nano textured crystalline silicon surface of a gallium-doped or boron-doped p-type crystalline silicon (1), dielectric passivation layer (A) touching the p-type crystalline silicon (4), dielectric passivation B (5), contact opening (6) though the dielectric passivation layer, hole-selective and passivating contact (7), and back metal electrode (8).

# Full Recycling of Perovskite Solar Cells

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## PVK Loop

**A full recycling method that recovers all valuable components of end-of-life perovskite solar cells in a single process without harming the environment.**

## Advantages

**Full recovery:** All valuable components are recovered in one process, reducing waste.

**Safe lead management:** Toxic lead is converted into the $PbI_2$ precursor and safely separated.

**Precious metal recovery:** Gold, silver and copper electrodes are recovered at high purity.

**Halogen and precursor recovery:** Iodine, bromine and methylammonium precursors can be reused in production.

**Environmental sustainability:** The closed-loop solvent system reduces environmental risks.

A sustainable solution to the toxic lead problem of perovskite solar cells

The method uses pure methylamine, condensed under pressure and operated in a closed loop, as the solvent. It selectively separates the perovskite layer and other components, and metal electrodes such as gold, silver and copper are recovered at high purity.
Toxic lead compounds are converted into $PbI_2$ and safely separated. Critical halogens such as iodine and bromine, as well as methylammonium components, are also recovered.
Using the solvent in a closed loop reduces chemical consumption and environmental risk, and recovered materials can be returned directly to new perovskite cell production.

# Well-Type Solar Collector

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## HexaSolar

**A solar collector that traps solar energy in a small volume using flat mirrors, producing medium temperatures of 60–200 °C without expensive optics.**

## Advantages

**Easy manufacturing:** Built from flat mirrors and a simple geometry, with no special equipment.

**Low cost:** Standard flat mirrors replace curved mirrors and costly optics.

**Easy to use:** Its simple design makes installation and operation easy.

**High efficiency:** The well geometry prevents rays escaping and concentrates energy on the target.

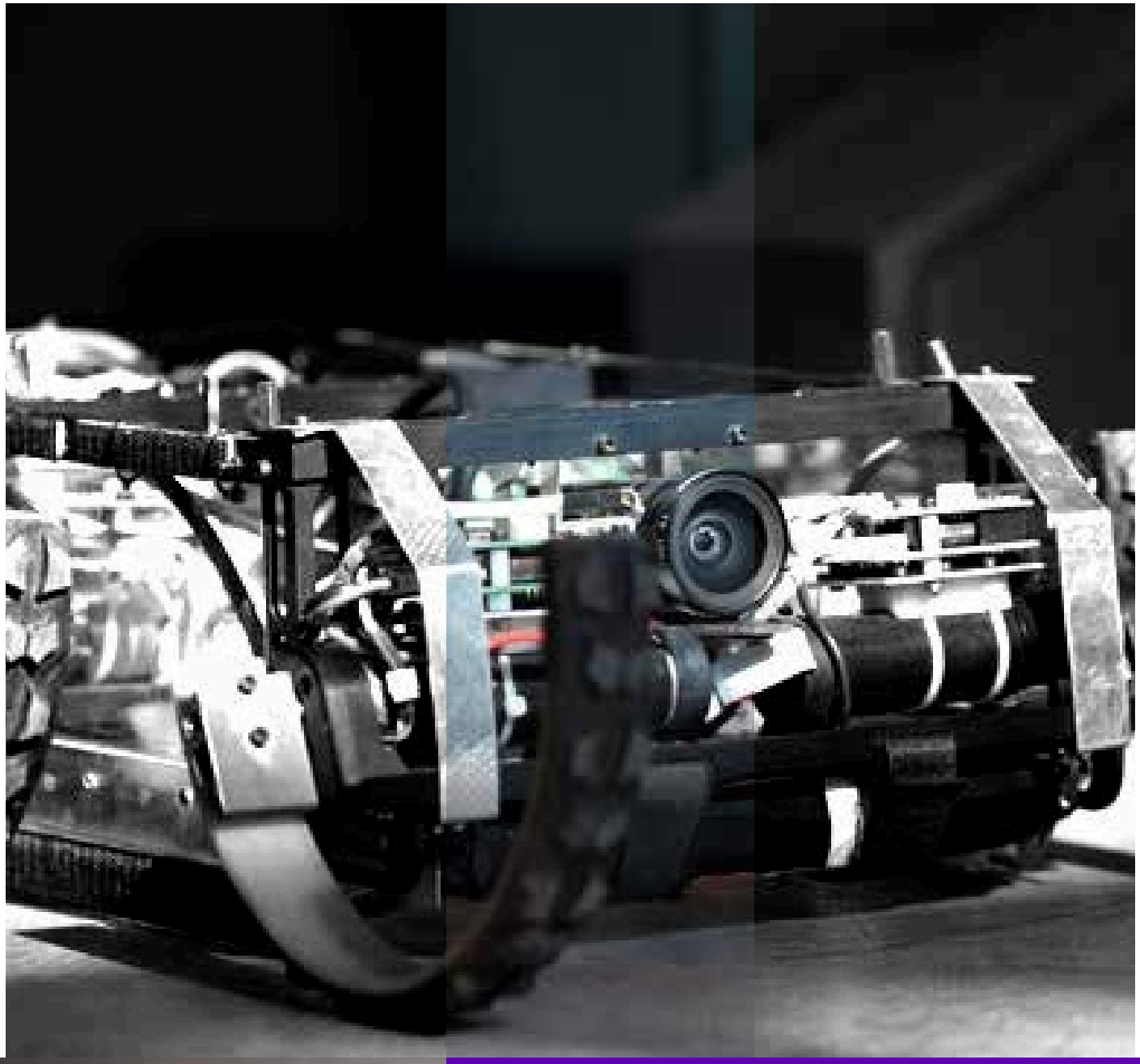
**Wide range of uses:** Water heating, drying, cooking and process heat at 60–200 °C.

## A low-cost, efficient heat source for medium-temperature applications

The collector has a well-shaped geometry whose inner surfaces are lined with flat mirrors. Sunlight entering through the aperture is directed downwards to the target volume by successive reflections on the well walls.

This geometry largely prevents rays from escaping. Using flat mirrors eliminates the precise and costly manufacturing required by curved concentrators.

The concentrated energy heats the working fluid to 60–200 °C for applications such as water heating, drying, cooking and industrial process heat.



# Machinery and Manufacturing

# A Novel Modal Superposition Method Using Response Dependent Non-Linear Modes for the Periodic Vibration Analysis of Large Non-Linear Structures

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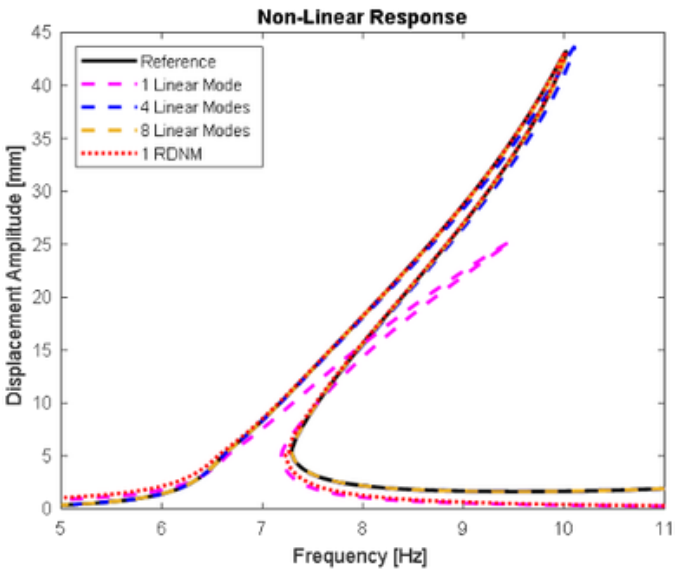
## Fast and Accurate Dynamic Solutions of Non-linear Engineering Structures

## Advantages

Speed: It enables faster analyses than those in the literature
Accuracy: It gives high accurate results
Feasibility: It can be applied to realistic large structures
Usability: It can be used for different types of non-linear elements
Outputs: It enables to compute frequency response functions (displacement vs frequency plots) and different outputs such as nonlinear resonance frequencies of the system.




Development of Response Dependent Non-Linear Modes (RDNM), which reduce the high computational burden in dynamic response analyses of realistic non-linear systems.

Minimizing the number of nonlinear algebraic equations in periodic solutions of non-linear systems with a modal superposition method developed by using RDNMs.
RDNMs are new modes obtained by modifying the underlying linear system at every solution point. They change with the system response so that they create a more accurate basis in the dynamic solutions of non-linear structures.

They are calculated by solving the eigenvalue problem in different modal domains for complex and large systems. This enables to perform fast analyses without sacrificing the response accuracy. Thus, design iterations of industrial applications can be carried out in a more efficient and rapid manner.

# Compact Holographic Spectrometer Using a Spatial Light Modulator

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## A Compact Spectrometer System With High-resolution And High Signal-to-noise Ratio

**High-resolution spectrum analysis with a compact system**

## Advantages

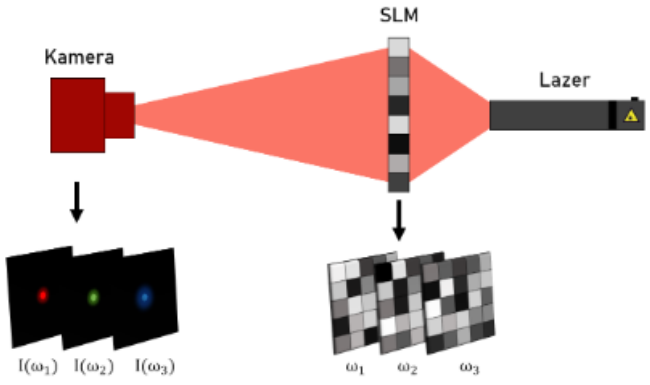
Compact design: Ability to analyze the spectrum with increased degrees of freedom achieved with a single SLM, independent of the detector distance

High-resolution: Detection of tiny wavelength differences by using an SLM with a high number of pixels

High signal-to-noise ratio: Less signal loss due to fewer optical elements

Broad bandwidth: Detection of the whole spectrum by increasing the degrees of freedom of the spatial light modulator

Lower costs: Cheaper production costs compared to the equivalent systems offering similar resolution and bandwidth




A new method, which does not require the prisms or gratings used in conventional spectrometers, has been developed, and with the help of a single spatial light modulator (SLM) it has become possible to build a high-resolution spectrometer.

To achieve high resolution in conventional spectrometers, high-cost diffractive optical elements (prisms, gratings, etc.) that are more sensitive to different wavelengths or large system designs that increase the detector distance are needed. In these types of spectrometers, the signal-to-noise ratio decreases as the number of optical elements increases. In addition, when spectrum analysis of a broadband light source is desired, a very large area must be scanned in the detector region.

This invention presents an innovative broadband spectrometer design having high-resolution, high signal-to-noise ratio, where a spatial light modulator (SLM) is used instead of a diffractive optical element. The invention also presents a measurement technique in which the desired results can be obtained. By increasing the pixel number (degrees of freedom) of the spatial light modulator, it is possible to reach the promised high-resolution, high signal-to-noise ratio and broadband scanning capability without the need of adding extra optical elements or changing the distances in the design.

# Optical Spectrometer Based On Alternating Diffractive Optical Elements

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## Compact Optical Spectrometer With High Spectral Resolution

**Compact, high sensitive, low photon requiring and broad-band operating optic spectrometer**

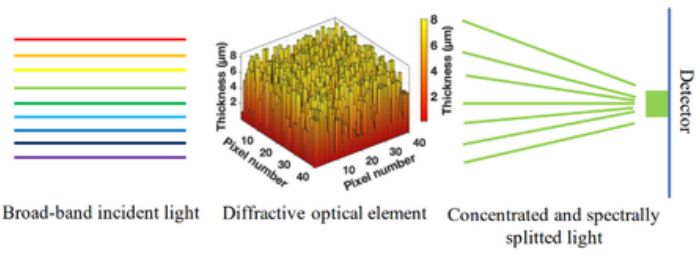
## Advantages

**Compact:** No requiring heavy and bulky optical items.

**Efficient:** High throughput sample/analyte detection.

**High performance:** High S/N ratio measurement.

**Sensitive:** Trace amount of sample detection.




Spectral splitting of broad-band light using diffractive optical elements designed for individual wavelength of light.

In this study, for time to our knowledge, an optical spectrometer is developed with diffraction optical elements designed for each wavelength and placed on a moving part. Compared to optical spectrometers constructed with a single prism or diffraction grating and operating in narrow-band, our spectrometer can operate under broadband light. In addition, the decrease in the number of photons seen after the prism and diffraction grating is reduced/eliminated by this invention. With this study, in addition to the increase in the number of photons, a high signal/noise ratio can be obtained, and sample/analyte detection will be performed in a shorter time. The diffraction optical elements used provide the concentration of light as well as spectral separation. With this feature, our invention reduces the need for focusing optical elements (lens, etc.) used in the system.

# A Winding Method for Electrical Machines

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## An Electric Machine Winding Made Of Thin Electrically Conductive Sheet

**The invention relates to a winding method used in electrical machines, which is obtained by various cutting and bending processes of an electrically conductive sheet in the form of a U or V shape, using planar cutting tools such as a water jet, laser etc.**

## Advantages

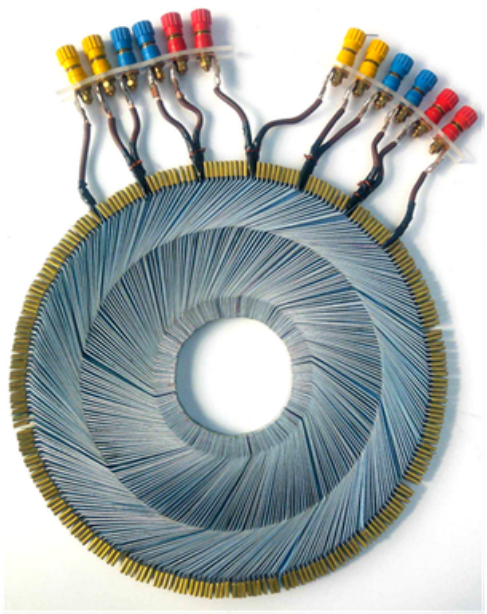
**Ease of manufacturing:** Obtained by cutting and bending processes from the plate without the need for winding machine

**High efficiency:** High efficiency thanks to shortened end winding lengths

**Low cost:** Low cost due to ease of manufacturing compared to conventional windings

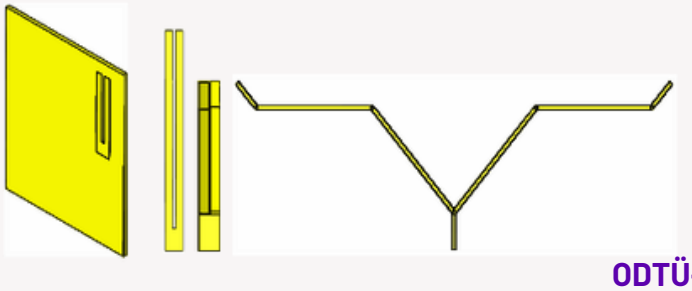
**High current:** Capable of meeting high current demands thanks to large cross-sectional area

**High fill factor:** High fill factor compared to conventional windings thanks to the rectangular cross-section



A low-cost, easy-to-manufacture winding method for electric machines, which can meet the requirement of high current ratings and increase the machine performance

The thin electrically conductive bendable sheet is cut in U or V shapes with planar cutting tools, such as water jet or laser to obtain an unbent electrical machine winding. The obtained part is bent from at least one bending point, such as lower, middle and upper bending points. The parts obtained in this way are placed around a circle, and electrical connection is provided by joining them at the ends of the windings. Electrical isolation of adjacent electrical machine windings is provided by the electrical insulation material placed between them. The electric machine winding, which is the subject of the invention, is combined in different combinations according to the requirements of the electric machine, such as the number of poles, the number of phases, voltage or current ratings.



**ODTÜ-61**

# A New Test Stand for Micro Unmanned Aerial Vehicles

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## MAV Test Stand

**The presented test stand design represents a vertical link model for flapping wing micro air vehicles with adjustable stroke plane, being aerodynamically efficient, enabling force and moment measurement in wind tunnels.**

## Advantages

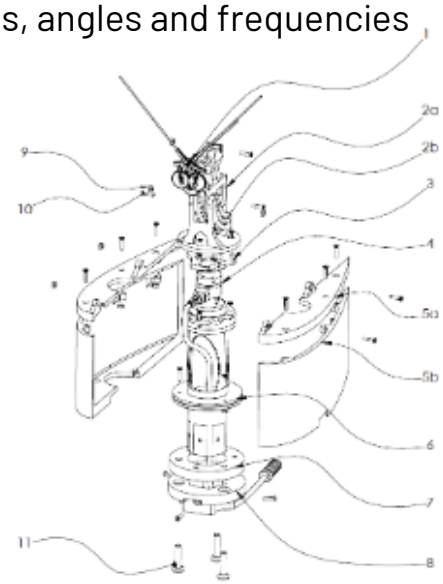
**Useful:** Ability to test different Micro Air Vehicles (MAVs) and to be revised according to the required size

**Functional:** Testing inside the wind tunnel at different flapping stroke planes

Efficient: Aerodynamically efficient as a result of covering the vertical fixing part with a symmetrical airfoil section

**Easy assembly and adjustment:** By use of the connectors, it can be easily mounted both to the wind tunnel and to the MAV and can be adjusted according to the desired height.

**Parametric measurement capability:** Time-dependent force and moment measurement at different wing flapping motions, angles and frequencies




The invention is a wind tunnel mountable test stand developed for micro-air vehicles belonging to the class of unmanned vehicles that have attracted attention in recent years.

In this invention, it is aimed to design an economical and rapidly accessible test fixture that is resistant to system loads in order to accurately perform the wing characterization studies of any micro air vehicle studied. The present invention represents an aerodynamically efficient vertical linkage with an adjustable flapping stroke plane. In this framework, a new angle adjustment apparatus with 5 degrees sensitivity, consisting of two different "u-profile" parts that can be inserted into each other, is used. Thus, the presence of any connection element under the wing is prevented. To make the preferred vertical link pattern aerodynamically efficient, the sensor is covered with a symmetrical wing section that wraps the connecting cables and the vertical fixing beam.

# An Integrated Si-based Platform For Observation Of Micro-nanoscale Radiative Transfer

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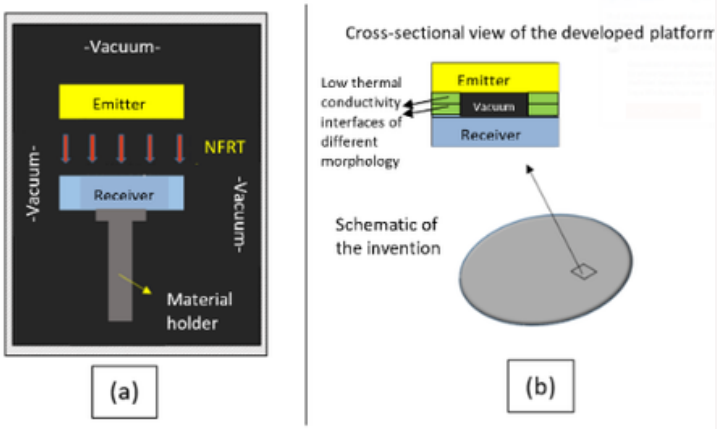
## An Integrated Si-based Platform For Micro-nanoscale Radiative Transfer

**The integrated platform of this invention has the potential to clear off the requirements of highly controlled and complicated vacuum conditions and laboratory environment.**

## Advantages

**Environment conscious:** Waste heat input of proper temperature and quality.
**Efficient materials and processes:** Proper selection of material and system configuration.
**Functional:** Operation outside of the controlled laboratory environment.
**High sensitivity:** Can be achieved by this integrated device or its variations.
**Efficient:** The possibility of obtaining useful energy output.




The integrated platform of this invention covers two parallel aligned objects located in a way that near-field radiative transfer (NFRT) between them is possible.

The novelty behind this invention is that it enables conversion of the NFRT into useful energy (e.g., electric energy) outside of the laboratory environment.
In the literature, systems developed for investigation of NFRT typically require vacuum environments (Figure (a)). In these systems, materials exchanging NF thermal radiation are located separately (i.e., not in an integrated way) using high-precision micro-nano positioners to ensure the suitability of the configuration for NFRT. In spite of that, this invention (Figure (b)), since it is an integrated platform, and its possible variations have the potential to be used under standard operating conditions once the materials are held at the required temperatures.

# Cost Effective Fiber Optic Pressure And Strain Sensors By Fiber Loop Ringdown Spectroscopy (FLRDS) Technique With 1550 Nm LED Light Source

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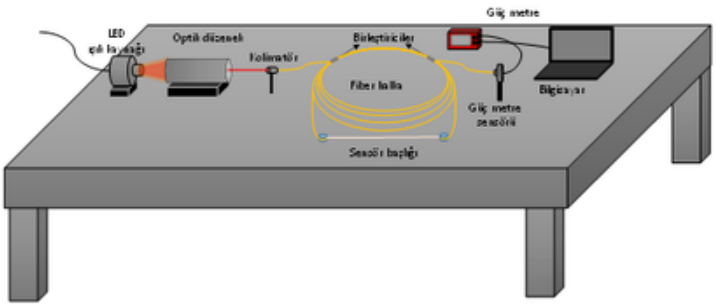
## LED based FLRDS fiber optic pressure and strain sensors

**Fabrication and applications of highly sensitive, cost effective fiber optic pressure and strain sensor by keeping FLRDS features and using LED light source**

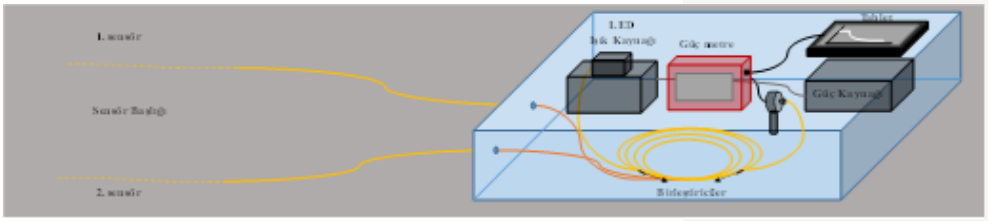
## Advantages

High sensitivity
Real time measurement
Continuous monitoring
Immunity to electrical fluctuations
Portability
Possibility to be used in fully closed structures
Use in structural monitoring such as buildings, bridges etc.




This invention with implementation of a LED source provides simplification of a system without loosing advantegous features of FLRDS technique, and provides cost effective portable new design making it readily avaliable for many applications in greater numbers such as structural monitoring.

A light pulse is trapped into a single mode fiber loop and travels very many round trips until it fades. Since the light loss in the fiber system changes only on the sensor region once the system is set, the system becomes highly sensitive to interaction of light with the environment at the sensing region, thus technique allows to very sensitively monitor pressure and strain changes around the fiber.



# Detachable Anchors with Bolted Corners for Steel-Concrete Composite Structures

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**The invention proposes a removable anchor with a completely new geometry.**

## Advantages

The most important advantage of the inventive anchor is its low cost.

First of all, by reducing the length of the high strength bolt used, the material usage is reduced.

In addition, an anchor that can be produced quickly using standard cornice elements has been obtained.

The advantages of the anchor are that it is removable, has high strength and can be used with precast reinforced concrete slabs.

Thanks to the developed anchorage, the use of sustainable building systems will increase.

The invention relates to a detachable anchor with a bolted cornice for steel-reinforced concrete composite structures with a new geometry.
A demountable anchor that will improve the behavior of existing demountable anchors and reduce cost and labor has been developed and mechanical tests of the anchor have been completed. This product, which is called bolted anchor with 30 corners, is formed by combining standard elements that are easily available in the market.
No lathing process is required.
The sliding problem can be minimized as a result of the holes to be drilled in the cornice and steel beam head can be drilled close to zero tolerance.
A frictional interaction joint can also be obtained by giving pre-pull to the bolts.
The developed anchor is superior to existing anchors in terms of capacity and stiffness.

# Thorax Impactor To Be Used In Pedestrian Protection Tests

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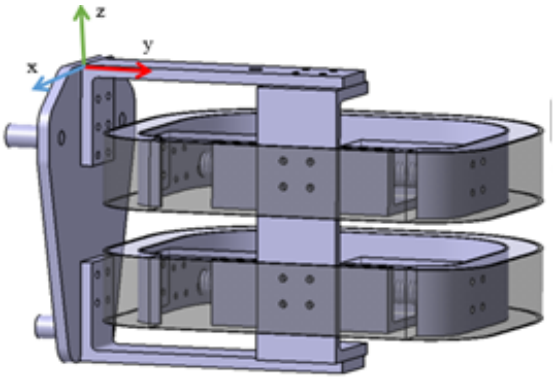
## Pedestrian Thorax Impactor

**The invention is an impactor that represents the thorax regions of pedestrians and that enables the evaluation of pedestrian injuries with tests which are caused by flat front vehicles.**

## Advantages

**Novel:** This invention will enable to perform tests in order to evaluate pedestrian thorax injuries.
**Reliable:** The reliability of the test results obtained by using this impactor is validated with several Finite Element Analyses and pyhsical tests.
**Robust:** Pedestrian protection tests are very severe. This invention is designed such that it will be used without getting damaged in the tests.
**Low Cost:** The test dummies and impactors used in this field are supplied from limited number of companies abroad and they are very expensive. This invention is designed such that it can be manufactured with low cost.
**Producible:** The impactor is designed such that it can be produced by local manufacturing sites with a low cost and the production is already completed.




### Reliable, robust, affordable impactor to evaluate pedestrian thorax injuries with tests

Pedestrian protection standard tests are defined to evaluate the injuries that are observed in different parts of the pedestian bodies in vehicle-pedestrian accidents. In the present case, pedestrian protection tests are being performed with standard test impactors that only represent the head, upper leg and lower leg regions of the body. However, no standard impactor that represents the thorax region of pedestrians is available and no tests can be performed to evaluate the injuries in this region. Therefore, the thorax impactor in this patent, which represents the thorax region of pedestrians and which is designed to be used with linear impactors in pedestrian protection tests, is novel and does not have an equivalent in the World. The thorax impactor in this patent will enable the automotive companies to validate their vehicle front designs with physical tests in terms of pedestrian thorax injuries.

# Fast and High Resolution LIDAR with Multi-axis and Multi-surface Polygon Scanner

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## MultiScan-LIDAR

**The multi-surface scanner is equipped with optical guides at different angles. Each optical guide can scan in both horizontal and vertical planes.**

## Advantages

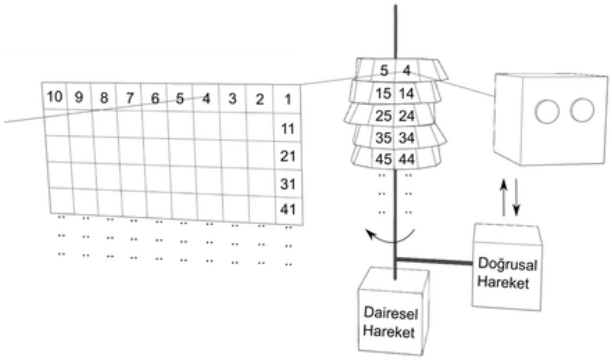
It provides the advantage of using the speed advantage obtained with circular motion linearly.

It is a system that can be easily produced with a 3D printer or CNC

Scanning in both horizontal and vertical axis with a single polygon

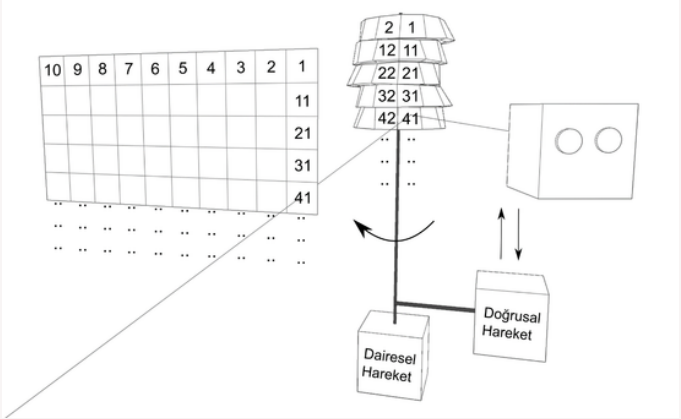
Multi-axis and multi-surface polygon design provides fast and high resolution.

Since there is no need for a second polygon, it provides an advantage in automation between units.




Polygon and mirror-based LIDAR systems scan with two polygons positioned for the vertical and horizontal axis.

With our invention, we make it possible to perform two-axis scanning quickly with a single polygon. In this way, we have significantly reduced the size of the product and eliminated the costs arising from the production and synchronization of the second polygon.
The biggest advantage of our invention is that by placing the optical guiding elements used in polygons at different angles, it is possible to perform high-resolution spatial scanning in both horizontal and vertical axes with a polygon. Our invention differs from existing systems with this feature.



# A Neck Model Where Neck Injuries Can Be Examined

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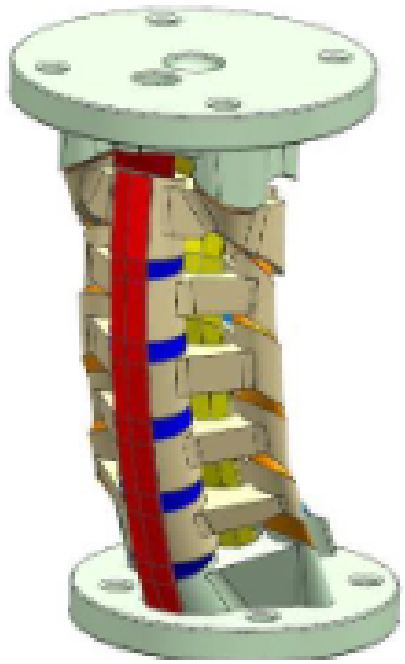
## A cheap and directly applicable new neck model for neck injury crash tests

## Advantages

**Practical:** Directly applicable to the available crash test dummies
**More realistic results:** More similar results to the human movements
**More Data:** More data can be gathered with the new sensors wrt to the original Hybrid III neck
**Cheap:** A very cheap solution wrt the available complex and special dummy solutions
**Scaleable:** The design can directly to be applied to the 5th and 95th percentile Hybrid III dummies by scaling.



Cheap, fast and more realistic neck injury crash test results and applicable to the available dummies.

Hybrid III 50 percentile male crash test dummies are the most commonly used test devices of the crash test centers all over the world. This invention which is directly applicable to these test dummies provides more realistic test results with respect to the original Hybrid III dummy neck. Additionally, it is a way cheaper and faster solution with respect to the other available dummy solutions for neck injury research tests.

Available Hybrid III 50 % crash test dummies neck model is an old design and it behaves in an unrealistic way especially for low speed neck injury tests. This invention is based on the real human cadavear data in both geometry and material wise. The steel cable and neck jacket addition for the muscles behaviour provides more realistic movements under crash conditions.

# A Method For Fabrication Of A Substrate For Surface Enhanced Raman Spectroscopy

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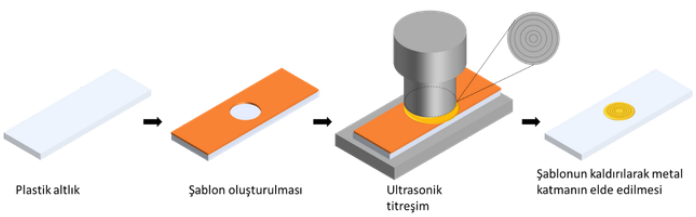
## A method for fabricating SERS substrates

**This invention relates to fabrication of a plastic based substrate comprising a metal film with controlled surface properties developed for detection of target molecules by using surface enhanced Raman spectroscopy.**

## Advantages

Fast and cost-effective production: The gold film can be produced within approximately 10 seconds using an ultrasonic welding device, which is a relatively low-cost equipment. Obtaining the gold film on a plastic surface can further reduce the cost.

Controllable surface roughness and pattern: The method used in the substrate production allows for direct control of the surface roughness and micro-pattern on the gold film. Therefore, it is possible to obtain SERS substrates according to specific needs.




### Fabrication of a plastic-based substrate with a metal layer with controllable surface properties for target molecule detection by Raman spectroscopy

Surface-enhanced Raman spectroscopy (SERS) substrates, which are used for molecular identification, are known to increase the Raman signal when their surfaces have a regular roughness. Invented SERS substrate consists of a gold film with a specific micro-pattern and controllable surface roughness on a plastic substrate. The pattern and roughness on the film contribute to the enhancement of the Raman signal.

The gold film used as the SERS substrate is obtained by pressing gold nanoparticles onto a plastic substrate with the aid of a sonotrode under ultrasonic vibration. The duration of ultrasonic vibration directly affects the surface roughness, while the micro-pattern on the sonotrode can be transferred onto the metal film. This allows for the creation of gold surfaces with the desired roughness and a specific micro-pattern.

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# Swirl-Assisted Chip Collection System Operating with Vacuum and Compressor

## Chip Collector Apparatus

**Effectively collecting chips emitted during machining operations through the combined effect of high-pressure air and vacuum.**

## Advantages

**High Quality Surface:** Removing heat generated during machining with airflow reduces surface roughness and prevents material degradation caused by high temperatures.

**Long Tool Life:** In dry operations, tools naturally heat up and lose efficiency. Air-cooled tools can machine more material compared to hot conditions.

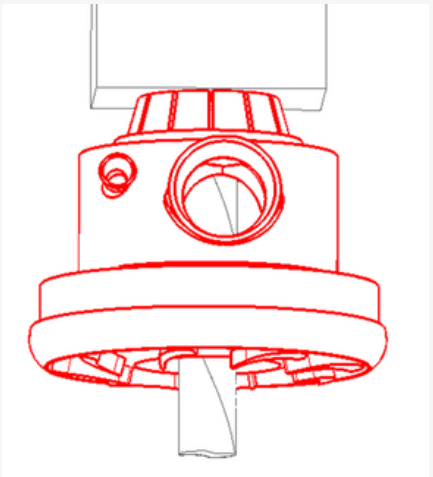
**Clean Working Environment:** Collecting chips at the source prevents discomfort and protects the operator, ensuring a cleaner workspace.

**Easy Recycling Separation:** Chips collected directly in sterile bags reduce the need for cleaning before recycling.

**Increased Recycling Efficiency:** Instant chip collection significantly improves recycling performance.

Preparing the chips for recycling with minimal impact from external factors (dust, dirt, etc.), providing cooling during processing to ensure higher quality part production, and maintaining a longer lifespan for the cutting edge.

The vacuum power alone is not sufficient for collecting chip particles; with the assistance of high-pressure air, the chips are aerated in a controlled manner and transported to areas where the vacuum is strong, allowing for the collection of much larger chip particles. The airflow that is effective in collecting chips in the area where they are generated also cools the tool and the machined surface at high speeds through convective heat transfer.



**ODTÜ-115A**

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# A Head, Device, and Method For Vacuumed Machines

## Dual-Pressure Chip Collection Head

**The invention effectively collects the chips generated during machining by combining the effects of the high pressure obtained through the rotational energy of the spindle and the external vacuuming system.**

## Advantages

**High Quality Surface:** Removing heat generated during machining with airflow reduces surface roughness and prevents material degradation caused by high temperatures.

**Long Tool Life:** In dry operations, tools naturally heat up and lose efficiency. Air-cooled tools can machine more material compared to hot conditions.

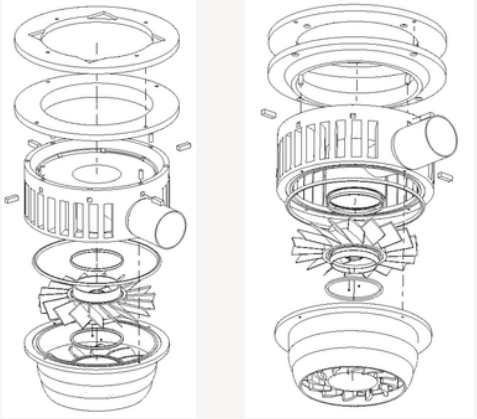
**Clean Working Environment:** Collecting chips at the source prevents discomfort and protects the operator, ensuring a cleaner workspace.

**Easy Recycling Separation:** Chips collected directly in sterile bags reduce the need for cleaning before recycling.

**Increased Recycling Efficiency:** Instant chip collection significantly improves recycling performance.

During machining, chips that cannot be collected solely by vacuum power are removed by the high-pressure air stream generated from the spindle's rotational energy. Thus, no additional compressor is required, the vacuum efficiency is enhanced, and the power demand is reduced.

Chip particles that cannot be collected solely by vacuum power are directed to the vacuum region by the high-pressure air flow generated by the spindle's rotating impeller. This allows larger chips to be collected and improves the overall vacuum efficiency. In addition, the blades in the central vacuum region create a counterflow that supports the airflow of the external vacuum, further enhancing suction performance.



**ODTÜ-115B**

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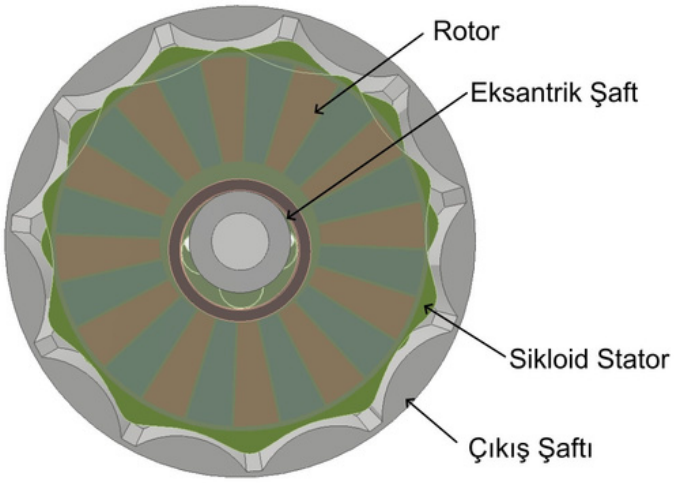
# Cycloid Integrated Axial Flux Actuator

## CycloMotor

**The cycloid gear element also serves as the stator in the axial flux motor, and due to the absence of axial displacement, the air gap remains constant.**

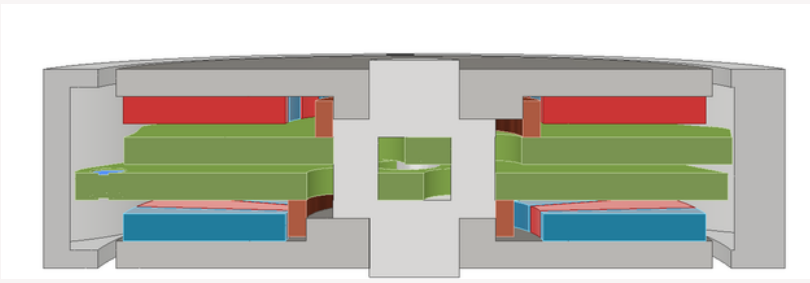
## Avantajlar

- Emsallerine göre yüksek tork yoğunluğu
- Emsallerine göre yüksek güç yoğunluğu
- Tahrik sisteminde daha az sayıda bileşen içerme
- Kompaktlık
- Dişli entegrasyonu




It reduces the number of components in the drive system, offering a more compact design while providing high torque and power density for increased system efficiency.

The cycloid disk used as a gear element also functions as the stator, containing the windings in the axial flux motor. Since the cycloid disk does not perform axial displacement, the air gap remains constant. The gear-integrated system increases torque density.



# Self-Starting Dual-Speed Synchronous Reluctance Motor

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## Dual-Speed Synchronous Reluctance Motor

**Two-speed operation and self-starting**

## Advantages

Two speeds: Operation at two different speeds by changing the connection

High efficiency: Higher efficiency than equivalent motors

High power density: Higher power density than equivalent motors

Simple production: No changes required to the stator or rotor

Self-starting: Starts without a drive thanks to the squirrel cage

The synchronous reluctance motor is connected using dual-speed winding schematics so that it can run at two separate speeds, and a squirrel cage is added so that it can start by itself.

Synchronous reluctance motors stand out for their high efficiency and simple structure, but they usually run at a single speed and need a drive to start.

In the invention, the motor can be used at two different speeds simply by changing the connection, without any modification to the stator or rotor. Thanks to the squirrel-cage structure added to the rotor, the motor can also start by itself.

# REHBER: Electric Wheelchair

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## Stair-Climbing Electric Wheelchair

**Climbs stairs without extra apparatus**

## Advantages

Stair climbing: Climbs stairs on its own, without ramps or additional apparatus

Easy manoeuvring: Moves on its steering wheels with the front wheels lifted on flat ground

Ergonomic and safe: The balance element keeps the user parallel to the ground while climbing

Independent range: Battery power lets the user move between floors without external equipment

Cost and time savings: Buildings do not need ramps at stairs

Removes the need for ramps at stairs, allowing wheelchair users to overcome stairs independently in existing buildings.

The invention is an electric wheelchair that moves on flat ground and climbs stairs without any extra apparatus, while keeping the user parallel to the ground at all times.

On flat ground, the front wheels are lifted and the wheelchair moves on its steering wheels, which makes manoeuvring easy. When a staircase is reached, the front wheels touch down and the steering wheels are lifted, so that the wheelchair can climb the stairs.

Throughout this motion, a balance element keeps the seat and the user parallel to the ground. The wheelchair is battery-powered and needs no external apparatus to climb stairs.

# Electrode-Feedback Bee Feeding Spoon

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## Smart Bee Feeding Spoon

**Feeding with real-time electrode feedback**

## Advantages

Less solidification: Food is exposed to air only during feeding, then retracted

Electronic verification: Electrodes confirm that the food has reached the spoon

Reliable feeding: Real-time position feedback controls each feeding cycle

Easy cleaning: Retracting the food keeps the spoon and channel clean

High-viscosity ready: The syringe-pump drive suits highly viscous food that is hard to dispense

Viscous bee food solidifies when exposed to air. In the invention, the food is held in the spoon only during feeding and then retracted, while electrodes electronically confirm that it has reached the spoon.

The device consists of a spoon body connected to a syringe pump that drives the viscous food through a flow channel.

Rear, middle, front and ground electrodes placed along the channel are read by a microcontroller, which detects the position of the food in real time.

Using this feedback, the system operates in standby, filling and retraction modes: the food is advanced to the spoon for feeding and drawn back afterwards to limit its contact with air.

# Full Touch-Mode Capacitive Pressure Sensor

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## Intrinsic Touch-Mode Capacitive Sensor (ITMCS)

**Touch-mode operation even at zero pressure**

## Advantages

Linear response: Intrinsic touch mode gives a more linear capacitance-pressure relationship

Zero contact threshold: The sensor works in touch mode from zero gauge pressure

High sensitivity at low pressure: Effective sensing even near zero pressure

Flexible design: With no contact-threshold constraint, diaphragm geometry can be chosen freely

Easy calibration: The linear relationship reduces the need for complex signal processing

A capacitive MEMS pressure sensor that keeps its diaphragm in permanent contact through controlled stiction, operating even at zero pressure for more linear measurement and fewer design constraints.

ITMCS is based on a MEMS structure consisting of a diaphragm positioned over the bottom electrode and a gap between two insulating layers. Its key feature is that, thanks to controlled stiction during fabrication, the diaphragm adheres permanently to the bottom electrode.

Because the diaphragm is in contact even at zero pressure, the device operates directly in touch mode without needing a pressure-induced contact threshold. When pressure is applied, the diaphragm deflects elastically and widens the contact area; capacitance changes through the growing contact area rather than a shrinking gap. This provides a direct capacitance-pressure relationship even near zero pressure.