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Center of Excellence NAMASTE: Advanced Materials for the Future

Center odličnosti
NAMASTE
NApredni nekovinski
MAteriali
S
TEhnologijami prihodnosti

Dr. Alenka Rožaj Brvar, MBA

Sao Paulo, 18. 6. 2012

REPUBLIKA SLOVENIJA
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Advanced Materials for the Future

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CoE NAMASTE is a multi-disciplinary and trans-disciplinary consortium of research institutions and industry, who have decided to merge academic, technological and business expertise, skills, and equipment in order to foster crucial technological progress in selected areas relating to inorganic non-metallic materials and their application in electronics, optoelectronics, photonics, and medicine. This should lead to a substantial increase in added value, research relevance and scientific excellence.

The strategic goals of CoE NAMASTE are: continuity in research excellence, multidisciplinary interconnection, knowledge dissemination and technology transfer. Maintaining and constantly upgrading our excellence in research, technology and business are the important guidelines.

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Research Projects

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The research in the Center is conducted within six projects, which are briefly described as:

- RRP1: Ceramic 2D and 3D structures (dr. J Holc),
- RRP2: Materials for overvoltage and EM protection (assist. prof. dr. S. Bernik),
- RRP3: Materials, micro- and nano-systems for sensors (prof. dr. J.Trontelj),
- RRP4: Soft composites for optical, electronic, photonic and sensor applications (prof. dr. S. Žumer),
- RRP5: Bioactive, biocompatible and bioinert materials (prof. dr. J. Štrancar),
- RRP6: Project of new opportunities, which allows the inclusion of new partners (assist. prof. dr. D. Kuščer).

All of the projects are carried out with partners from the business/private sector.

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Excellent Results

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Some exceptional results, such as

- the large aspect ratio of the dimensions of a buried cavity, which will make possible the fabrication of **highly sensitive ceramic membranes**;
- the new developments in materials for low-doped ZnO varistors for **high-voltage protection** and prototypes for **electromagnetic radiation protection**;
- **being "world champions" in THz field detection;**
- **being first in the world to create a 3D microlaser**;
- **being the leader in studying phenomena in chiral nematic liquid crystals;**
- developing new methods for **investigating the interaction between nanomaterials and living cells.**

Ceramic Pressure Sensors

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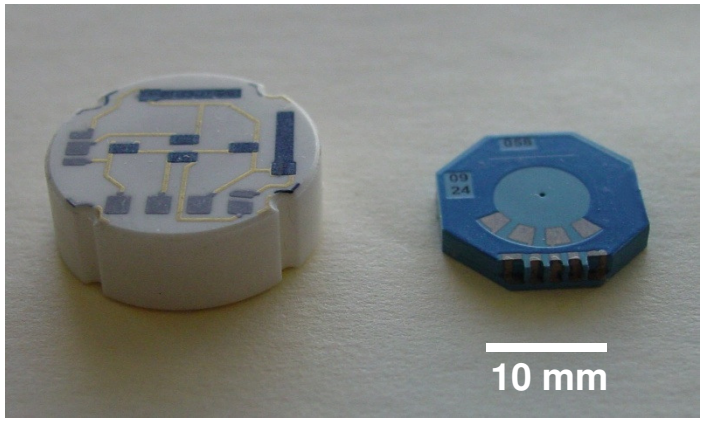
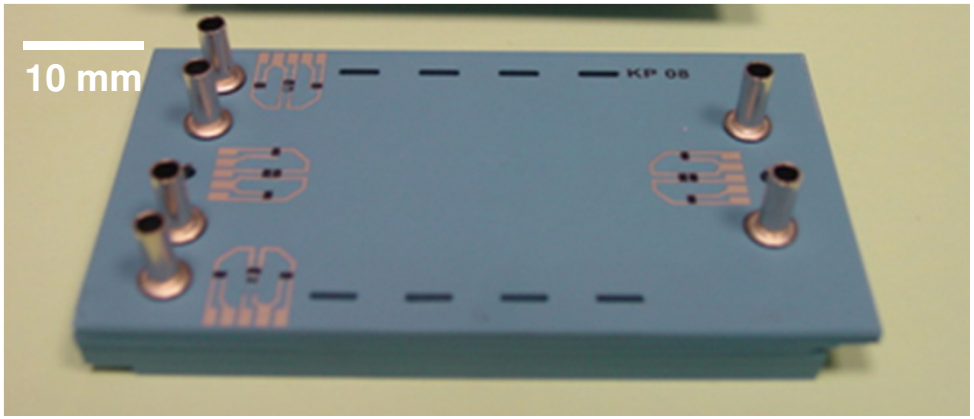
- Ceramic pressure sensors are available for more than 25 years.
- Ceramic pressure sensors, in comparison with silicon sensors, are larger, more robust and have a lower sensitivity.
- Some new technologies offer a feasible solution to increase the sensitivity and design flexibility with the aim to replace the conventional ceramic pressure sensor or even to replace the silicon-based pressure sensors.
- One of these technologies is the Low-Temperature Cofired Ceramics (**LTCC**) technology.
- Some new technologies, like LTCC (=Low-Temperature Cofired Ceramics) offer a feasible solution to increase the sensitivity and design flexibility and thus replace the conventional ceramic pressure sensor or even replace the silicon-based pressure sensors.



Ceramic pressure sensors based on alumina (left) and LTCC (right)



Four pressure sensors integrated into the complex ceramic microsystem (reactor).

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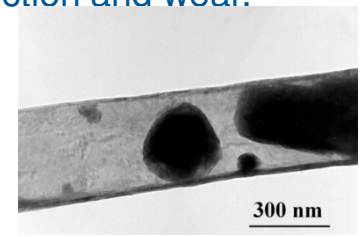
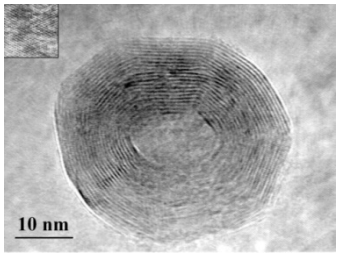
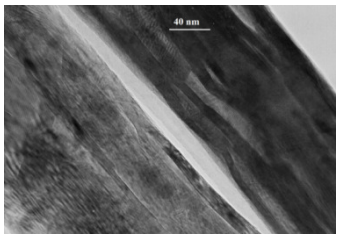
MoS_2 nanotubes used in tribology as: dry lubricant, mixed into oils, greases, and polymers, additive to cooling fluids, and as effective replacement of toxic extreme presure additives (EP), strongly reduce friction and wear.



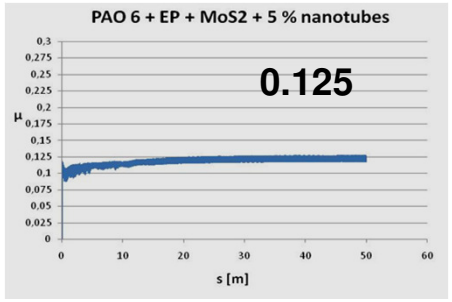
nanopods

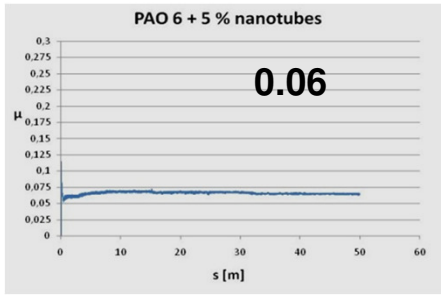


nanoonions

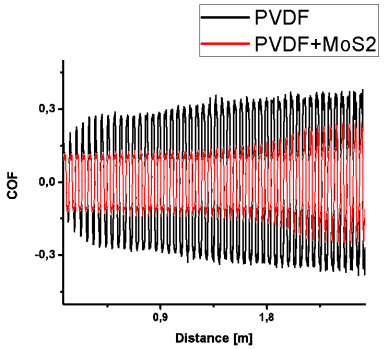


coaxial nanotubes

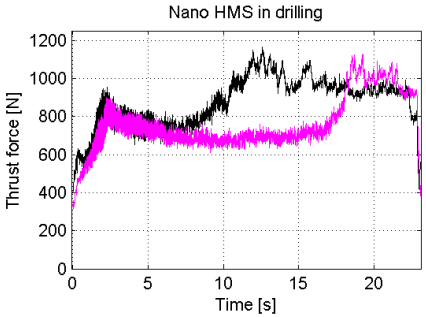




Pin-on-disc test



Reciprocal test



Torque test

NANOTUL d.o.o.
Teslova ulica 30, Ljubljana, Slovenija

www.nanotul.com

Nanotul Ltd. has excluse right on IPR (**US patent 8,007,756) for synthesis MoS_2 nanotubes** owned by Jozef Stefan Institute

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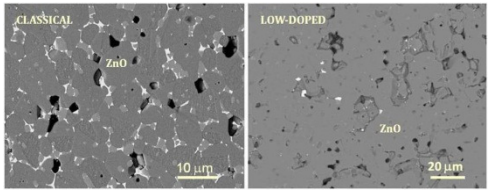
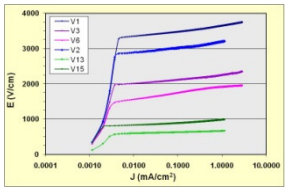
❖ Materials and devices for overvoltage protection

➢New fundamental knowledge enable development of varistor ceramics with up to 4-times lower addition of varistor dopant to ZnO for new generation of varistors.



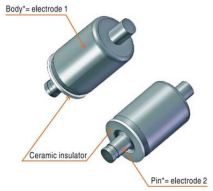
Both materials have a break-down voltage at 200V/mm and a nonlinearity coefficient of 40.



Low-doped varistor ceramics with broad range of break-down voltages.

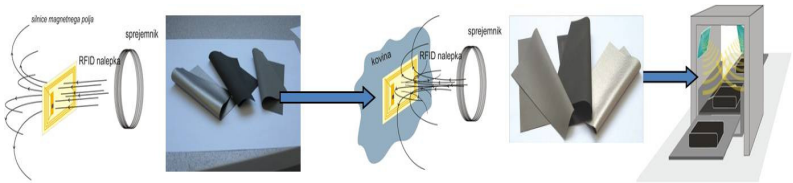
➢ZnO-based varistors with high stability under DC field for overvoltage protection of solar panels and wind turbine generators.

➢New patented construction of miniaturized and self-extinguishing gas-discharge tubes (GDT).

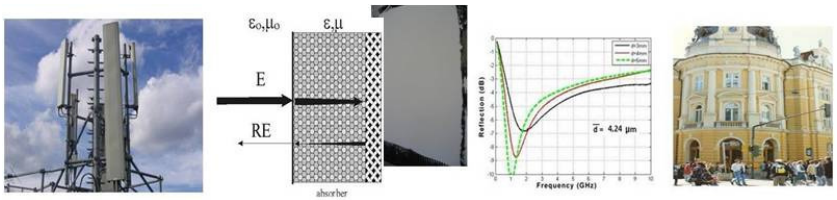


❖ Development of m*agnetic nano- and micro-powders for foil and composite absorbers of electromagnetic (EM) waves.*

➢Composites magnetic materials (foils) for HF in UHF radiofrequency identification (RFID)



➢*Composite facade coating systems for EM absorption.*



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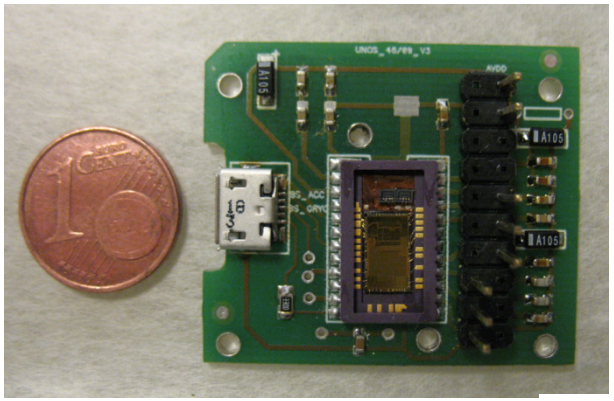
Electronic Detection of Hazardous Substances in the Air



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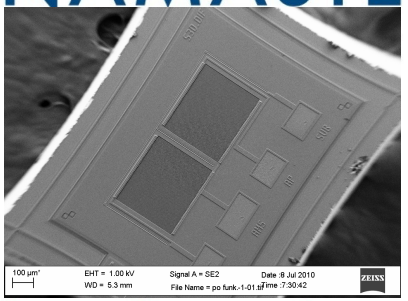
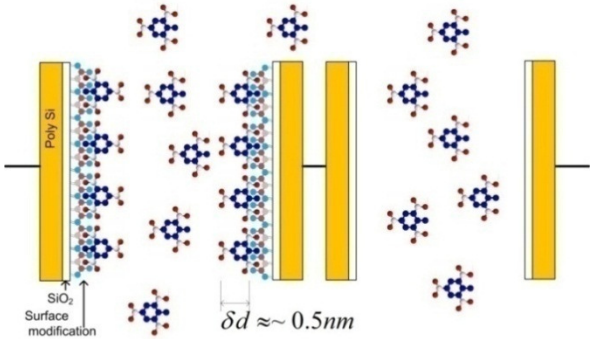


Goal: To build a miniature electronic sensing system for a specific type of molecules (TNT, DNT, RDX and others in a future) with maximum possible sensitivity and selectivity.

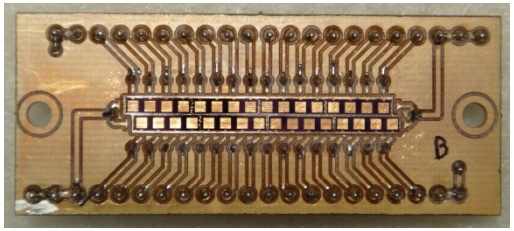
Detection level : <=0,5 aF/√Hz (1aF = 10^{-18}F) corresponds to much less that 1 layer of adsorbed molecules.

Measured result : 3.5 ppt (3.5 molecules in 10^{12} moelcules of N_2)



$$C_{pt} = \frac{\varepsilon A}{d_{pm} - 2\delta d} \qquad C_n = C_0 + \Delta C = \frac{\varepsilon A}{d_n}$$

THz Sensor System (300GHz – λ=1mm)

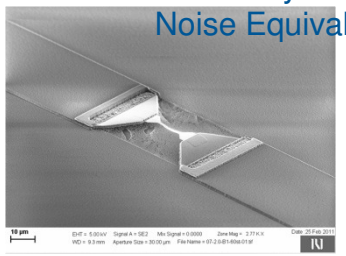


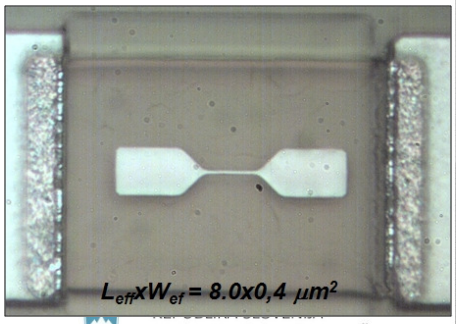
THz Vision Demonstrator
1024 pixels, 1Hz frame repetition rate
up to 5m distance

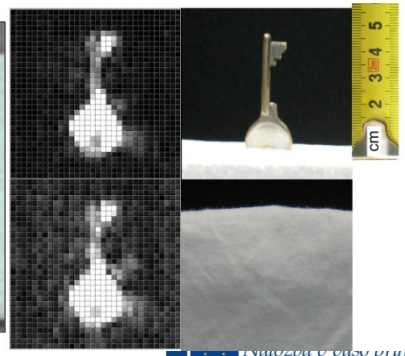
Properties of THz sensor
- Room operating system
- Antenna-bolometer system on the Si-nitride membrane
- Titanium bolometer floating in the air

Room Temperature Antenna-Sensor array

Operating frequency	0,3THz
Sensitivity	Se ≈ 981V/W
Noise Equivalent Power	NEP ≈ 5pW/√Hz







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INTERNATIONAL PATENTS

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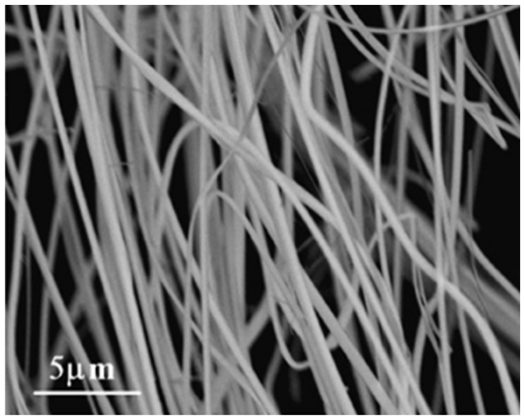
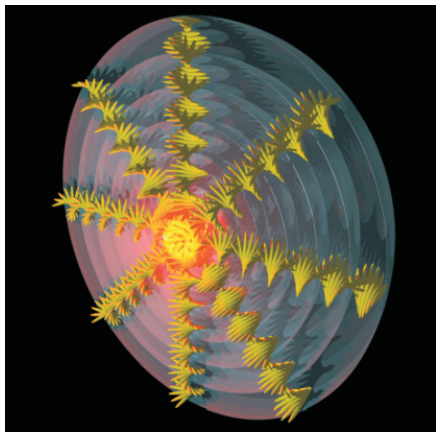
- Remškar Maja, Viršek Marko, Kocmur Miha, Jesih Adolf. *Procedure for synthesis of threadlike tungsten oxide* W_5O_{14} : 2011patent EP 2114827 B1.



- Mrzel Aleš, Remškar Maja, Jesih Adolf, Viršek Marko. *Process for the synthesis of nanotubes and fullerene-like nanostructures of transition metal dichalcogenides, quasi one-dimensional structures of transition metals and oxides of transition metals:* 2011patent US 8007756B2.
- Muševič Igor, Škarabot Miha, Žumer Slobodan, Ravnik Miha. *Metamaterials and resonant materials based on liquid crystal dispersions of colloidal particles and nanoparticles* : 2011 patent EP 1975656 B1.



- Rasing Theo, Lazarenko Sergiy, Muševič Igor, Škarabot Miha, Uplaznik Marko. *Multistable liquid crystal device :* 2011patent EP 1927885B1.
- Muševič Igor, Humar Matjaž. *Spherical liquid-crystal laser*: 2011patentna prijava PCT/EP2011/005607.

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3 HIGH IMPACT PUBLICATIONS

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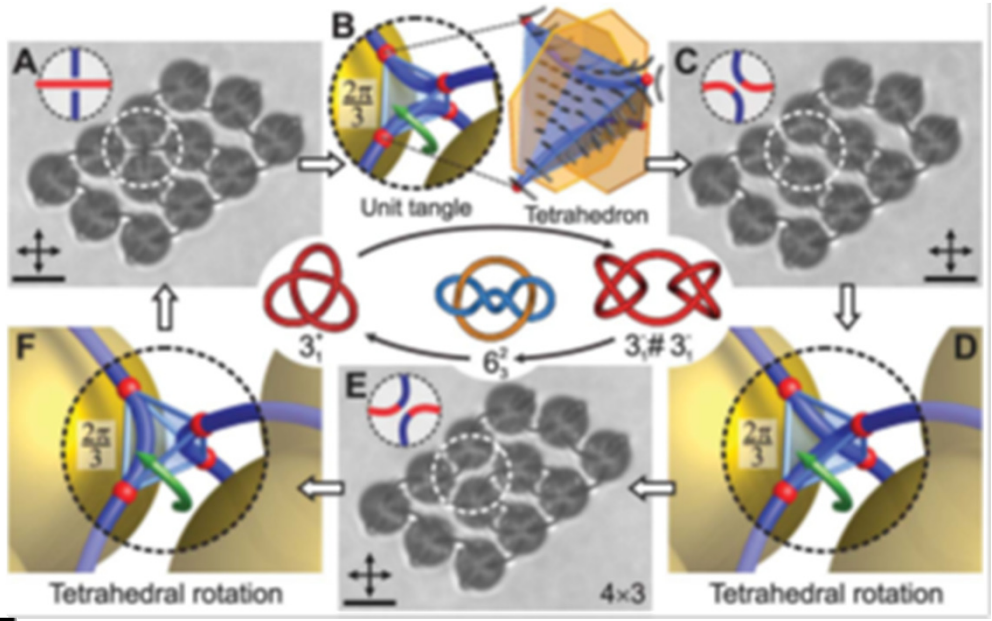
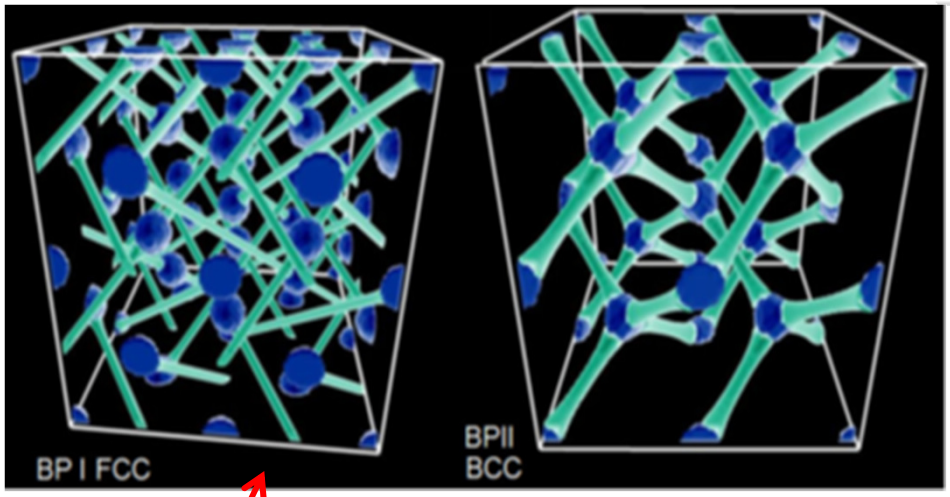
Liquid-Crystal defect and colloidal structures



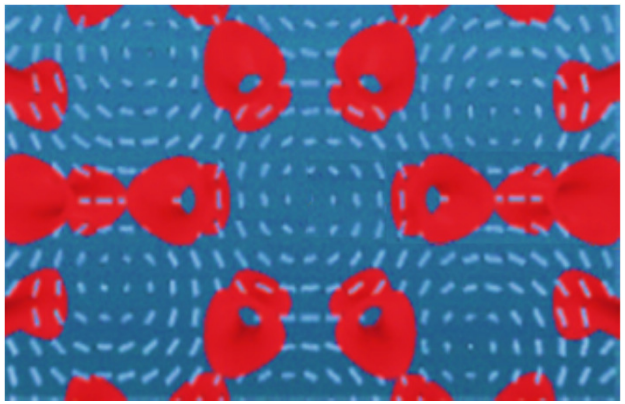
Spletanje nematskih pletenic,

Science 2011



Colloidal blue phases, *PNAS 2011*

Skyrmions in confined blue phases



Nature Communications 2011

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MICRORESONATOR & MICROLASER AND OPTICAL FIBRE

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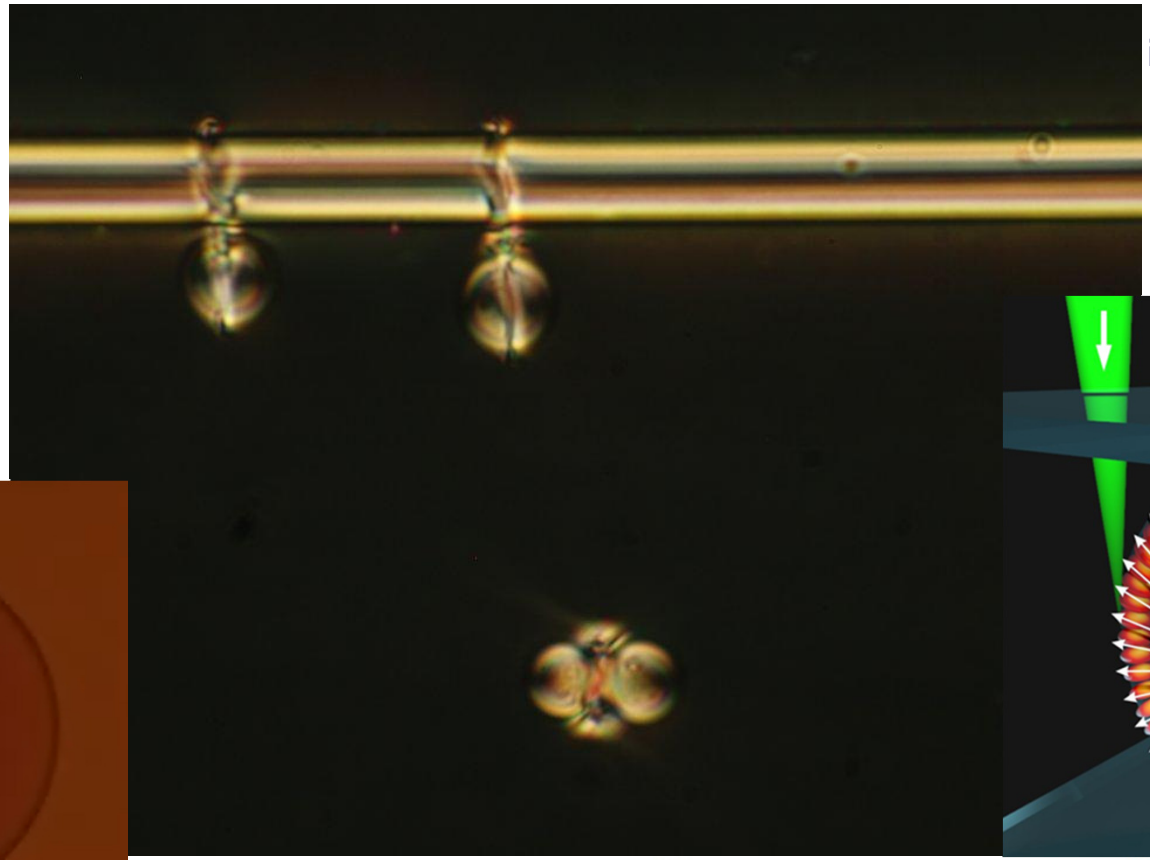
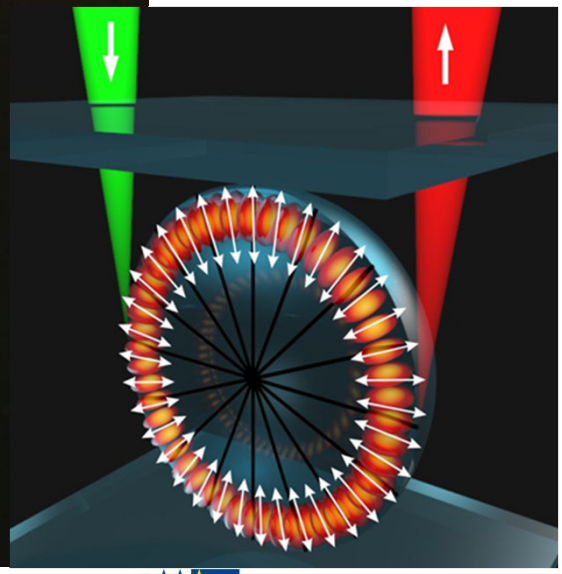
colloidal particle and
optical fiber coupling through evanescent field

Liquid crystal
microresonator,
induced by green laser
Nature Photonics
2009



3D microlaser,
Optics Express
2011



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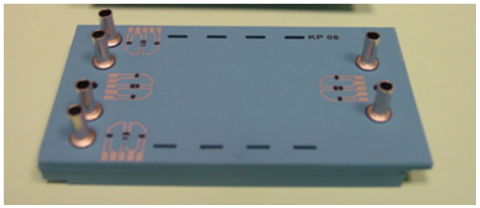
Four pressure sensors integrated into the complex ceramic microsystem (reactor) by LTCC technology



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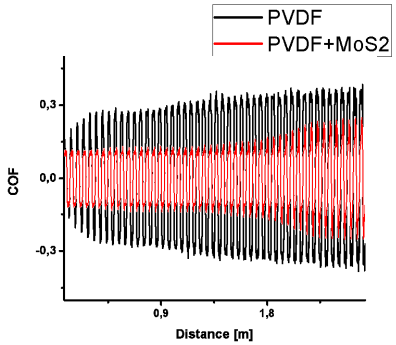
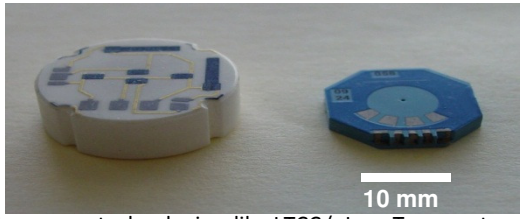


New patented construction of miniaturized and self-extinguishing gas-discharge tubes (GDT).

Materials and devices for overvoltage protection

ZnO-based varistors with high stability under DC field for overvoltage protection of solar panels and wind turbine generators.

Ceramic pressure sensors based on alumina (left) and LTCC (right)



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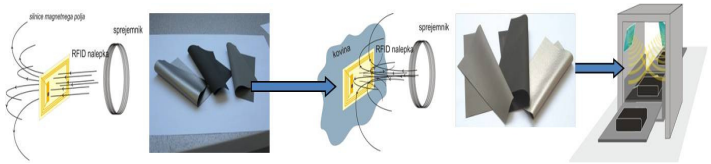
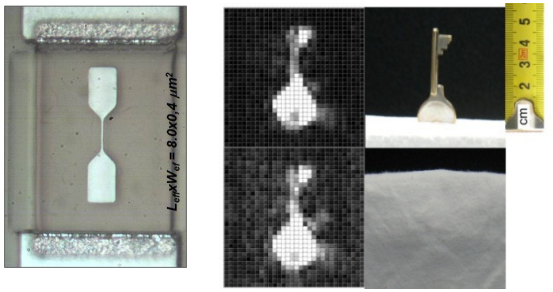
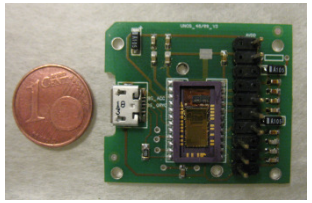
Development of *magnetic nano- and micro-powders for foil and composite absorbers of electromagnetic (EM) waves.*



THz Sensor System (300GHz – λ=1mm)



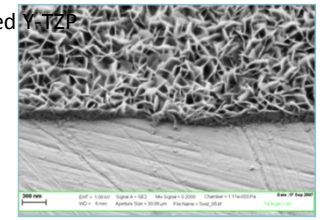
Electronic Detection of Hazardous Substances in the Air



Measured result: 3.5ppt (3.5 molecules in 10^{12} molecules of N_2)

Detection level: <=0,5 aF/√Hz (1aF = 10^{-18}F)

The procedure for preparation of adhesive Al2O3 layers for **enhancing adhesion of dental cements** to sintered Y-TZP ceramics has been developed and patented.



June 2012

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Foreign reviewer statements 1/2

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1. From the presentations during the midterm evaluation, as well as from the numerous joint publications it becomes clear that the cooperation of industrial partners and academic partners within this CoE is strong and successful even if often only in a bilateral way. It appears that many of the technologies and products developed at the research partners within this CoE can be transferred successfully to the commercial (industrial) partners.

The technological excellence of this CoE NAMASTE is clearly demonstrated by the number of innovations and patents achieved so far as well as by the number of prototypes and demonstration projects. The number of publications is remarkable and so is the rank of the journals which have been chosen for publication, including *Proc. Nat. Acad. Sci. USA, Nature Comm., Phys. Rev. Lett.,* or *Chem. Comm.*

Foreign reviewer statements 2/2

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2. CoE NAMASTE has demonstrated during the first period of operation a truly excellent performance. The organisational structure was established and implemented, and allowed for the frictionless and efficient operation of this Centre of Excellence.

3. It is a particular strength of this CoE that it has an excellent balance between fundamental and applied research. While the applied research delivers solutions that can be transformed into technical products or services on a relatively short timescale, fundamental research will provide the basis for future technologies which not necessarily can already be anticipated at the current time.

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Knowledge Dissemination

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The dissemination of knowledge – in particular teaching and lecturing – is an important activity:

- more than 40 invited researchers and lecturers have visited the center,
- there are 24 lecturers and 20 mentors of higher-education programs among the participating researchers in the CoE,
- the CoE's researchers have been invited to lecture at and chair international conferences and scientific meetings.

CoE NAMASTE has organized or co-organized:

- strategic conferences,
- seminars,
- workshops,
- international and domestic conferences,
- presentation conferences for partners exploring new ideas for development,
- invited lecture in the Slovenian Parliament by the CoE Director.

Knowledge Dissemination

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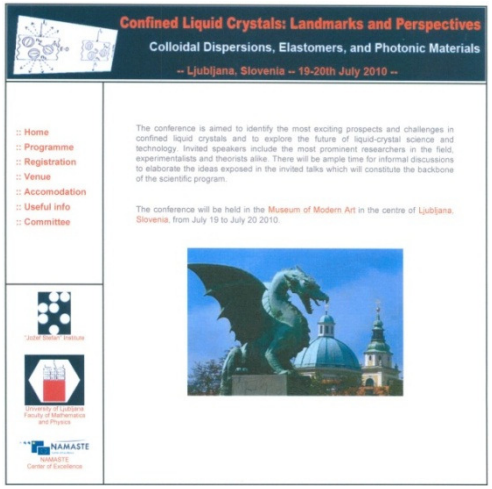
National conference

Napredni materiali s tehnologijami prihodnosti
Ljubljana, 7-8.9.2011

International conference

Confined Liquid Crystals: Landmarks and Perspectives
Ljubljana, 19-20.6.2010



Workshop

Exploring cell-material interactions
Brje, 15.11.2010

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Knowledge Dissemination

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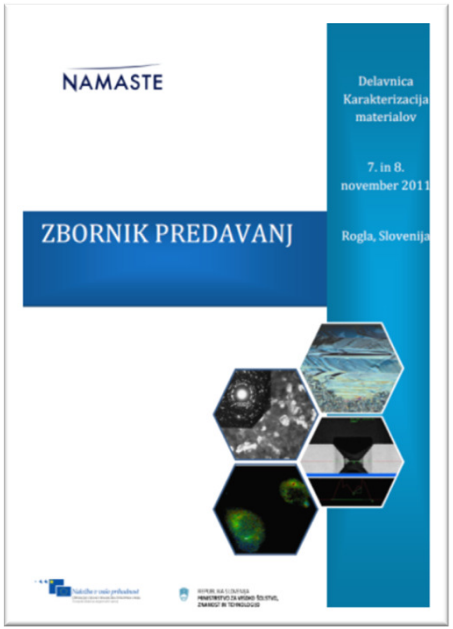
Workshop
Characterization of Materials
Rogla, 7-8. 11. 2011



- ✓ 10 tutorial lectures: optical and electraon microscopy, XRD, IR, Raman microspectroscopies, EPR, AFM, Laser tweezers, nanoparticles detection…
- ✓ 106 participants (18 from industry, 26 students)
- ✓ more than 50% young generation
- ✓ the participants liked the review of the methods and their applications in practice

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Advanced Materials for the Future

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