Institute of Electronic Materials Technology

invites for the cooperation within:

Programme T E A M funded by
F o u n d a t i o n f o r P o l i s h S c i e n c e operated within
the Innovative Economy Operational Programme 2007-2013

Self-organization approach towards photonics/optoelectronics

Project duration: 1 February 2009 – 31 January 2013

Project leader: Dr. Dorota Anna Pawlak

We offer stipend in the amount of 3000 PLN for:

- **PhD student**

Requirements:

- Interest in the subject
- Good level of English
- Engagement at work
- Team working ability
- Experience in some of the following fields will be welcomed: (a) crystal growth, (b) self-organization of materials, (c) eutectics, (d) differencial termogravimetric analysis, (e) characterization methods of materials (structural properties, dielectric properties, magnetic properties and others), (f) metamaterials/photonic crystals/plasmonics

Your research initiatives will be strongly appreciated.

We offer: Work in team of energetic scientists, access to modern labs and participation in novel research programme.
Payment: A stipend of 3000 PLN/month will be provided.
Application: Interested and field related candidates with relevant expertise are welcomed to send, preferably by e-mail: (a) an application letter, (b) Curriculum Vitae, (c) a scanned copy of University diploma, (d) record of achievements (papers, presentations etc), and (e) a reference letter* to the following e-mail address: Agata.Hass@itme.edu.pl Applicants who receive a recommendation in the first stage will be invited to an interview which will be held on (26-29) October in Institute of Electronic Materials Technology. Foreign applicants will be interviewed via teleconference.

Please send your CVs, and application letters to
agata.hass@itme.edu.pl until **October 22nd 2009**

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Project description

Concept and objectives. The fundamentally novel CONCEPT of our group is to utilize eutectic self-organisation for the preparation of multi-component and multi-scale structured materials with controlled physicochemical and structural properties, with geometrical motifs capable of generating novel, predictable and controllable electromagnetic functionalities, which could find application in photonics/optoelectronics (metamaterials, photonic crystals). The team will work on the research complementary to an EC project the ITME group is involved in.

State-of-the-art. In recent years, two different types of materials are being developed in the area of photonics: photonic crystals and metamaterials. **Photonic crystals** are materials that exhibit a photonic bandgap effect. **Metamaterials** are engineered composites that exhibit superior electromagnetic properties not observed in the constituent materials or in nature. They can exhibit novel and extreme properties and capabilities such as: artificial magnetism; negative refraction; giant dielectric constant; subwavelength resolution imaging; cloaking ability, and others. There are many sophisticated methods for obtaining these two types of materials. But they could be also obtained by self-organization.

Progress beyond the state-of-the-art. Until now metamaterials are mostly made as periodic structures by top-down approach with sophisticated methods. The result of such approach is resulting eg. in metamaterial behaviour in a very narrow wavelength/energy region. One of the possible solutions for this and also for lowering the costs of manufacturing would be using the self-organization mechanism and the chemical methods/technologies.

Materials to be investigated: Growth of eutectics is recognized as a paradigm for pattern-forming or 'self-organising systems'. Self-organised structures on size scales reaching down to the submicron and nanoscale regime emerge due to the interplay of chemical diffusion and capillarity. Eutectics exhibit the unusual characteristics of being both monolith and multicomponent/multiphase in nature. Eutectic composites may have multiple functionalities arising from the constituent phases of the eutectic (additive properties) as well as new functionalities which do not exist in the component phases but which uniquely derive from their combination and appropriate structuring on the nano- or micro-scale (product properties). The product properties are particularly important, as they promise metamaterial-like behaviour. The great advantage of eutectics is that they are quite versatile: different component

materials pertinent to photonics (isolators, semiconductors, metals), different geometries (rod-like, spiral, lammelar, globular, percolated and others) can be obtained. Component materials with demanded properties can be applied (eg. ferroelectric, ferromagnetic, superconducting, active, nonlinear and others). The characteristic wavelength of eutectic pattern formation can be controlled by varying growth over a wide range of velocities; this in turn will control scaling of the systems from submicron to nanosizes. The structuring can be also controlled by such growth factors as temperature gradients and hot-zone design. Examples of eutectic microstructures grown in our laboratory are shown in Fig. 1.

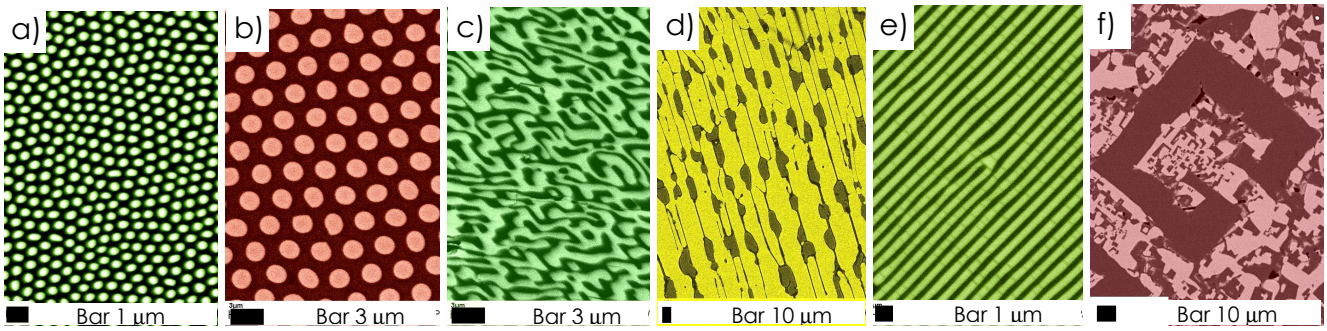

Fig. 1. Examples of eutectic microstructures obtained in ITME: a) and b) rod-like, c) percolated-like, d) fishnet-like, e) lamellar, f) split ring resonator-like.

Planned topics: The TEAM member will take part in complementary to the EC projects research. Main planned topics of the research for the young scientists joining the project are as follows:

1. Investigation on self-organized eutectic structures for potential applications in photonics.
2. Investigation of new eutectic compositions (such as metal-metal oxide) by Differential Thermo-Gravimetric Analysis
3. Investigation of eutectic systems doped with metal/semiconductor nanoparticles, looking for metamaterial like properties
4. Investigation of the dependence of the microstructure of metal/semiconductor-oxide eutectics on such conditions as: composition, growth rate, thermal setup.
5. Investigation of obtained eutectics microstructure by such methods as scanning electron microscope, atomic force microscope, quantitative analysis of the microstructure and others.

Directionally solidified eutectic will be obtained by the micro-pulling down method. In this technique we have a crucible with a die at the bottom in which there is a centrally-placed nozzle. The raw materials are melted in the crucible by the RF and/or resistive heating. The melt passes through the nozzle; is touched with the seed crystal, and the crystal is pulled down. Samples in the form of fibres down to 150 µm and up to few mm in diameter are available.

International Cooperation. Project leader guarantees a wide international cooperation for the young member of the TEAM. The strong interconnection will be maintained with world-wide recognized scientists in the field thanks to the EC projects the group is involved in.