**Project 4.6 Rocksalt (MgZn)O alloys and (MgZn)O/MgO quantum structure and their application in deep-ultraviolet light-emitters (experimental)**

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**Institute**: IF PAN
**Unit:** e.g. ON4.4

**Background:**

In the near future, optoelectronic devices working in deep UV spectral region are expected to further increase in importance. Such material system aims to address societal challenges and technological needs that have become even more urgent in the current time, due to the Covid-19 global pandemic. Portable deep UV emitters are technologically important already in the present day, but their commercial exploitation is expected to strongly increase in the near future, as health security is becoming one of society's priorities. However, there are also number of potential applications deepening on the emission range such as: sterilization, water purification, destruction or sequencing of DNA, optical storage, digital printing, medicine, biochemistry or plant growing. In the visible optical range, the market for semiconductor lasers and diodes is dominated by systems based on gallium nitride. However, these devices have too poor quantum efficiency in the UV spectral range, hence UV systems based on Group III nitrides are not yet commercially available.

In this project we propose to consider a new class of materials: ZnxMg1-xO based quantum structures crystallizing in cubic RS structure. They have important advantages over materials in WZ structure:

- It was proved recently that in many cases oxide quantum structures in RS crystal structure are more stable than those in WZ structure
- MgO in RS structure has a significantly larger (~7.8 eV) band gap than MgO in WZ phase (~6.1 eV).
- ZnO in WZ structure strongly opposes p-type doping. On the other hand, recent theoretical predictions indicate that change of the crystal structure can overcome doping problems, and p-type ZnO could be achieved in the RS phase with Li as extrinsic dopant.
- Like nitrides, WZ oxides suffer from built-in electric fields, decreasing internal quantum efficiency in optoelectronic devices. This effect is absent in RS structures.

To our knowledge the idea of fabricating UV emitters based on RS-ZnxMg1-xO alloys and QWs on MgO substrates is completely new, as it required some preliminary experimental proof of the emission energies of RS-ZnxMg1-xO alloys, which we have recently obtained (just published in PRB). But most important and original is the fact that, if RS-ZnxMg1-xO -based devices were efficient enough, we could provide optoelectronic actors with a technological and commercial alternative based on "cheap" substrates, which would be a major innovation compared to the more standard approach based on expensive AlN substrates. The main goal of the project is to perform a systematic study of the RS-ZnxMg1-xO alloys and quantum structures in RS phase: this study will include their epitaxial growth, the experimental determination of their fundamental physical properties (bandgap nature, energy bandgaps, bandgap offsets, etc.), which will be supported by theoretical simulations of their electronic and optical properties. In a second stage, we will exploit the grown quantum structures for demonstrating oxide-based emitters at wavelengths smaller than 300nm.

**Aim:**

The main outcome of this project will be a set of new oxide materials, enabling the fabrication of deep-UV emitting devices, and a proof-of-principle working device Aims of the project.
Collaborations, CNRS Valbonne

**Requirements:**

- Scope of work,
- growth of samples by Molecular-beam epitaxy,
- basic characterization of samples. Database management,
- presentation results at conferences,
- required professional qualifications,
- Master of science in physics

**Funding**:

Scholarship: grant funding of 5000 PLN per month, before subtracting obligatory employer and employee social security contributions (~15%), for 36 months. Afterwards, standard Polish PhD scholarship (about 3240 PLN/month net).

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