Growth and modelling of distributed Bragg reflectors for quantum microcavities

January – December 2012
- scientific abstract -

List of activities, in accordance with the work plan:

- Simulation of Bragg reflectors using the transfer matrix theory
- PLD growth of Bragg reflectors and ZnO and InN active media
- Optical (spectroellipsometry), morphological (AFM, SEM), structural (XRD), and compositional (SIMS) characterizations of the obtained structures.

Stage results:

- Participation with 2 posters at EMRS 2012 - Spring Meeting conference
- A scientific paper accepted for publication in Romanian Reports in Physics

Study of InN and ZnO active layers

Prior to the simulation and growth of Bragg structures we considered two types of active media based on which the structure of Bragg reflectors will be decided. Materials considered as active media were InN and ZnO.

InN has been considered for applications in solar cells, LEDs and laser diodes, and is used in ternary alloys with GaN in heterostructure based electronic devices [M.R. Krames et al., J. Disp. Technol. 3 (2007) 160]. Samples were grown by laser ablation of an In target (purity >99.999%) in controlled nitrogen atmosphere. Pulses emitted by an ArF laser (λ = 193 nm, pulse duration of 20 ns, repetition rate of 10 Hz, fluence of 2 J/cm^2) were focused on the target under a 45 degree angle.

Our analysis illustrates the very different ways in which substrate temperature and nitrogen flow affect the mechanisms of InN formation during the plasma assisted PLD process. **Results have been synthesized in a scientific paper accepted for publication in *Romanian Reports in Physics*. They are also part of a poster (P3 4) - *Structure, morphology, and optical properties of InN and AlN nanostructures obtained by laser techniques* - presented at *EMRS 2012 - Spring Meeting*, Symposium *V - Laser materials processing for micro and nano applications*.**

Although successful growth of highly *c*-axis oriented InN was achieved, the morphology of obtained structures is columnar, and thus inadequate for use in quantum microcavities. Therefore, we considered the growth of ZnO, material with good electronic properties, in view of subsequent realization of semiconductor microcavities.

AFM measurements have evidenced roughness values of approximately 1 nm for ZnO films, making them a viable alternative for the subsequent realization of semiconductor quantum microcavities. **These results have been included in a poster (P1 9) - *Optical properties of ZnO and MgZnO thin films as a function of thickness and Mg content* - presented at *EMRS 2012 - Spring Meeting*, Symposium *V - Laser materials processing for micro and nano applications*.**

Sudy of SiO_2/TiO_2 Bragg reflectors

SiO_2 and TiO_2 thin films were deposited following the ablation of Si and Ti targets in oxygen atmosphere. The use of quartz microbalances allowed us to control the layers thickness by adjusting the number of laser pulses. In order to produce a Bragg structure with 3 pairs of $\lambda/4$ layers, centered at λ = 360 nm, the SiO_2/TiO_2 pair of materials must have thicknesses of 61 nm and 26 nm, respectively. 8400 pulses were used for the SiO_2 layer and 4200 for TiO_2.

Morphology and real thicknesses of the Bragg structure layers were determined by TEM analysis (Figure 1). The layers are smooth and uniform, and the value of their thickness is quite close to the projected one.

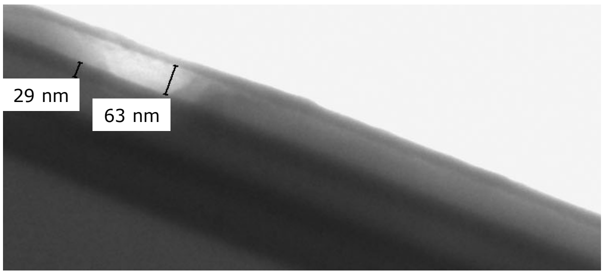

Figure 1. TEM cross-section of the multi-layer structure.

Experimental reflectance spectra determined by spectro-ellipsometry are in good agreement with the calculated ones (Figure 2).

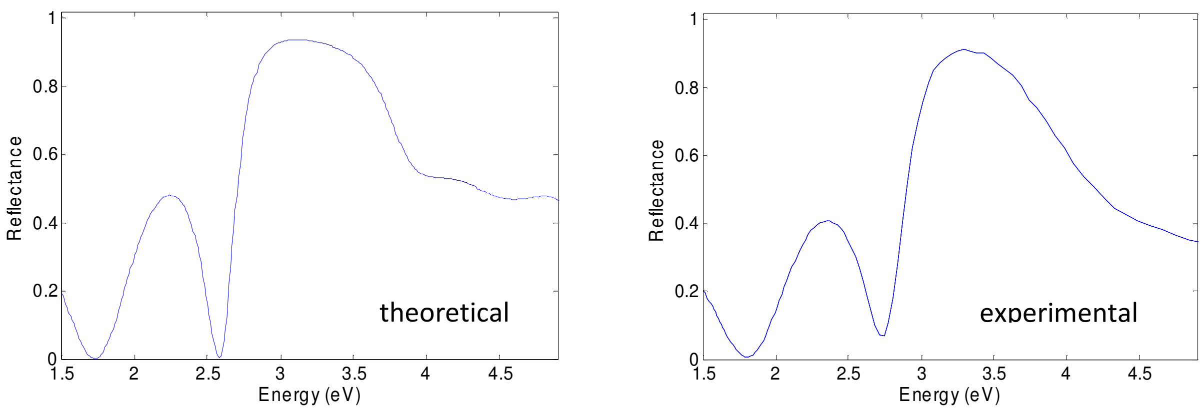

Figure 2. Theoretical and measured reflectance spectra of an actual Bragg mirror made of 3 pairs of SiO_2/TiO_2.

Our preliminary findings on Bragg structures of alternating layers of oxides and nitrides reveal a strong contamination with oxygen of the later ones, and therefore our subsequent studies will focus on those realized with oxides.