TAILORED ZnO NANOPARTICLE GROWTH IN POLYMER AND CERAMIC MATRIXES

G. Mežinskis[1], A. Medvids[2], D. Lazdina[1], A. Cimmermane[1], A.Pludons[1]

[1] *Institute of Silicate Materials, Faculty of Materials Science and Applied Chemistry, Riga Technical University, 14/24 Azenes Str, Riga, LV 1048, Latvia*

[2] *Institute of Institute of Technical Physics, Faculty of Materials Science and Applied Chemistry, Riga Technical University 14/24 Azenes Str, Riga, LV 1048, Latvia*

Combination of high stability, very high melting point with valuable physical characteristics makes zinc oxide by one of most attractive material for application in varius areas of modern tehnologies such as low - voltage and short wavelenght elektro-optical devices, chemical sensors, lasers etc. Due to bright UV luminiscence, zinc oxide is a perspective material for manufacture of UV light emitting diodes, UV lasers operating at room temperature and display devices. ZnO should be considered as functional material that maximally adapted for obtaining laser radiation in UV region at room temperature. The effective generation in UV region for disordered nanosized ZnO powders and films was one order higher in comparison with bulk crystal. This fact explains growing interest to manufacture of ZnO low-dimensional powders and films.

Zinc oxide is a versatile wide band gap semiconductor with an array of uses including transparent conductor, piezoelectrics, and short-wavelength light-emitting devices. ZnO is especially attractive for UV laser applications due to its band gap of 3.3 eV and high exciton binding energy of 60 meV. The exciton binding energy of ZnO is more than double that of GaN, enabling room temperature lasing and improved photonic device reliability [1].

Detection of ultraviolet radiation is becoming important in a number of areas such as environmental monitoring, missile warning systems, space research, and high temperature flame detection. The most common detectors currently in use are the photomultiplier and the silicon photodetectors, but they are not blind and require costly filters to attenuate unwanted and infrared radiation. With the use of wide band-gap semiconductors such as GaN, diamond and ZnO, the need for these filters would be eliminated [2].

Recently, there are many techniques used to deposit high quality ZnO thin films, such as RF magnetron sputtering [1, 4], chemical vapor deposition

[6], pulsed laser deposition and sol-gel process [7, 8], etc. Among them, the sol-gel technique offers the possibility of preparing a small as well as large-area coating of ZnO thin films at low cost for technological applications.

In this work, we report preparation of possible UV detector based on sol-gel synthesized ZnO-SiO_2 coatings on glass and polimer composite ZnO films. Both ZnO nanoparticle containing materials were treated with YAG:Nd laser radiation to monitor ZnO particle size.

The thin ZnO-SiO_2 coating films were performed by dip-coating technique onto the glass slides. As a starting material for sol preparation, TEOS (tetraethoxysilane) was used. Ethanol and hydrohloric acid were used as a solvent and catalizator, respectively. Addition of ZnO nanoparticles to silica sols was done at determined sol viscosity. Sonification was used to deagregate ZnO particles. After deposition by dip-coating, the coatings were dried at 150°C for 15 min to evaporate the solvent. The thickness of the coatings was in the range of 400 to 450 nm. Coatings were inserted into the furnace and annealed at 500°C for 10 min.

Polyvinylalcohol is thermoplastic a water-soluble synthetic polymer with excellent film forming, emulsifying, and adhesive properties. Polyvinylalcohol (PVA) powder was dissolved in distilled water under magnetic stirring to form a transparent solution. Prepared ZnO nanoparticles were added to the PVA solution followed by a mixing process to produce a homogeneous mixture. Then, PVA/ZnO solution was sonificated to deagregate ZnO particles and to distribute homogeneously nanoparticles in PVA matrixes. PVA/ZnO nanocomposites were prepared by solution mixing, followed by film casting, and their physical properties were investigated. The films were obtained by slow evaporation in dry air.

The crystalline structure was analyzed by X-ray diffraction (XRD, Rigaku Ultima +). The surface morphology was investigated using scanning probe microscope VEECO SPM-II. The spectral photoresponse was measured using Xe lamp UV-light source.

Literature

1. T.M. Barnes, J. Leaf, C. Fry, C.A. Wolden. Room temperature chemical vapor deposition of c-axis ZnO. *J. Crystal Growth.* 274, 2005, 412-417.
2. S. Jeong, J. H. Kim, S. Im. Ultraviolet-enhanced photodiode employing n-ZnO/p-Si structure. *Appl. Phys. Lett.* 83, 2003, 2946.
3. H. Deng, J. J.Russell, R.N. Lamb, B. Jiang. Microstructure control of ZnO thin films prepared by single source chemical vapor deposition. *Thin Solid Films.* 458, 2004, 1-2, 43-46.

4. E.G. Fu, D.M.Zhuang, G.Zhang, M.Zhao, W.F.Yang. Properties of transparent conductive ZnO: Al thin films prepared by magnetron sputtering. *Microelectr. J.* 35, 2004, 9, 383-387.
5. Y. Zhou, P.J. Kelly, A. Postill, O. Abu-Zeid, A.A. Alnajjar. The characteristics of aluminium-doped zinc oxide films prepared by pulsed magnetron sputtering from powder targets. *Thin Solid Films,* 447, 2004,
6. J. Mass, P. Bhattacharya, R.S. Katiyar. Controlling the orientation of ZnO nanorod arrays using TiO_2 thin film templates dip-coated by sol-gel. *J. Nanoparticle Res.,* 9, 2007, 245-250.
7. V.Musat, B.Teixeira , E.Fortunato , R. C. C.Monteiro, P.Vilarinho. Al-doped ZnO thin films by sol-gel method. *Surf. Coatings Technol.,* 180-181, 2004, 659-662.
8. G.Westin, M.Wijk, A. Pohl. Preparation and studies of ZnO:Al films and powders. *J. Sol-Gel Sci. Techn.,* 31, 2004, 283-286.

Corresponding author: G. Mezinskis
Institute of Silicate Materials, Faculty of Materials Science and Applied Chemistry, Riga Technical University, 14/24 Azenes Str., Riga, LV 1048, Latvia, gundarsm@ktf.rtu.lv