LOW-DIMENSIONAL HFO_2 STRUCTURES ELABORATED BY SOL-GEL TECHNIQUE

Martin Järvekülg, *Valter Reedo*[1], *Sven Lange*, *Uno Mäeorg*[2]
[1]Institute of Physics, University of Tartu, Riia 142, EE-51014 Tartu, Estonia,
[2]Institute of Organic and Bioorganic Chemistry, University of Tartu, Jakobi 2, 51014 Tartu, Estonia

martin13@ut.ee

In recent years, hafnium dioxide (HfO_2) has received great interests due to its remarkable properties in the field of electronic and photonic applications. Because of high dielectric constant (~25) and wide band gap (5.64eV) of hafnia it is promising *high-k* material for replacement of SiO_2 insulator layer in microelectronics. HfO_2 also stands out with high density, high effective atomic number, high refractive index and wide range of spectral transparency which makes it valuable for optical applications: waveguides [1,2], optical coatings [3], possible applications in detectors for high-energy particles [4].

In the last decade, sol-gel techniques in relation with materials chemistry have been extensively investigated and employed to explore new approaches in obtaining low-dimensional oxide materials with improved properties. Due to its simplicity and high flexibility, sol-gel method has great potential for preparation of low-dimensional HfO_2 structures in different forms, along with opportunity to compare the influence of structure to properties of material.

However, sol-gel method has not been widely used and employed for preparation of hafnia material until recently. Our aim is to develop viable routines for preparation of hafnium oxide fibers, films and micro structured surfaces using sol-gel method.

Our work includes:

1. synthesis of hafnium(IV)butoxide
2. preparation of sol-gel precursors
3. using precursors in order to obtain different hafnium oxide objects

Including the step of synthesis gives us the possibility to create modified alkoxides. Hafnium(IV)butoxide was obtained by the ammonia method starting with $HfCl_4$ [5]. The products of synthesis were characterized by IR spectroscopy.

Subsequently rare earth doped and undoped precursors for sol-gel process were designed through partial hydrolysis (Alkoxide/H_2O molar ratio R was varied from 0,8 to 1,6). Suitable measurements of viscosity were carried out for precursor solutions.

As a result, different doped and undoped objects were prepared. Fibers with ~50µm in daameter (Fig. 1) were produced by glass rod spinning technique, nanometrically thick (~50nm) films by dip coating and micro structured surfaces (Fig. 2) by sol-gel molding [6].

Photoluminescence radiation spectra were registered from Sm^{3+}, Eu^{3+}, Tb^{3+} doped films. Geometrical roportions of the prepared samples were evaluated by optical microscopy and interference methods. Fibers were also characterized by tensile strength analysis.

References:

[1] R. M. Almeida, A. C. Marques, S. Portal, Optical Materials, **In Press.** (www.sciencedirect.com)
[2] L. Zampedri, G. C. Righini, H. Portales, S. Pelli, G. Nunzi Conti, M. Montagna, M. Mattarelli, R.R Gonçalves, M. Ferrari, A. Chiasera, et al, Journal of Non-Crystalline Solids, **15** (2004) 345-346.
[3] D. Grosso, P. A. Sermon, Thin Solid Films,**1** (2000) 368.
[4] M. Kirm, J.Aarik,M. Jürgens, I. Sildos, Nuclear Instruments and Methods in Physics Research, **A 537**, (2005).
[5] D.C. Bradwly, W. Wardlaw, Nature, **75** (1950) 165.
[6] D. C. Bradley, R.C. Mehrotra, I. P. Rothwell, A. Singh, Alkoxo and Aryloxo Derivates of Metals*,* Academic Press, (2001).

Figures:

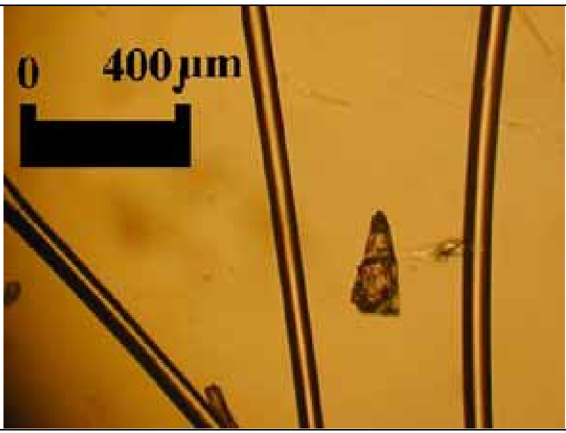

Figure 1. Hafnium alkoxide sol-gel fibers (Ø 40-50 µm).

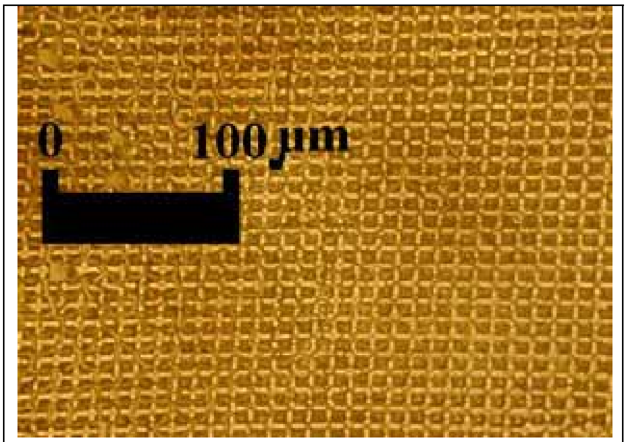

Figure 2. Hafnium alkoxide sol-gel micro structured gel surface (samples 10x10µm^2).