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PREPARATION AND OPTICAL CHARACTERISATION OF SOL-GEL DERIVED ZIRCONIUM OXIDE FIBERS AND MICROTUBES

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For applications one of the very needed tools is structuring of materials in nano- and microscale. Sol-gel method offers big flexibility in preparation and shaping of oxide materials such as ZrO_2 and TiO_2 [1]. This method also allows doping of the host materials with optically active inclusions (e.g. rare earth ions) and other impurities (e.g. Y_2O_3) [2].

The aim of this work was to prepare ZrO_2 based waveguiding structures. Keeping in mind applications as lighting materials, the samples were doped with rare earth ions.

We prepared Sm-doped SiO_2(70%)-ZrO_2(30%) microfibers by direct drawing method from precursor material with suitable viscoelastic properties. Prepared fibers were annealed at temperatures up to 1000°C to achieve development of Sm-doped ZrO_2 nanocrystals inside the amorphous silica matrix (i.e. transparent nanoceramics) [3]. As a result we obtained light guiding fibers with bright luminescence of Sm^{3+} ions (Fig.1:a,b). XRD measurements confirm formation of ZrO_2 nanocrystals inside the silica matrix while luminescence study suggests that emitting Sm^{3+} ions remain distributed both in amorphous silica and ZrO_2.

We also worked out a novel sol-gel preparation method for ZrO_2 microtubes. For luminescence applications we doped the material with 1 mol% of Sm^{3+} or Eu^{3+} ions. To avoid cracking of the microtubes during annealing (which is present in the case of sol-gel-prepared microrolls, for example [4]) we added 8 mol% of Y_2O_3 to the material. The obtained microtubes were ~10 mm long, had an average diameter of ~40 μm and wall thickness of ~10 μm. Prepared microtubes remained crack-free even after annealing up to 1100°C and microtubes annealed at 800-900°C exposed also excellent luminescent and light guiding properties (Fig.1:c,d).

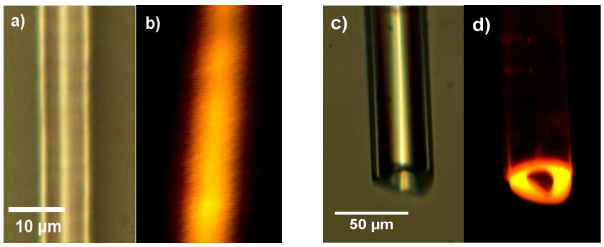

Fig. 1: On the left: Optical micrographs of Sm^{3+} doped SiO_2(70%)-ZrO_2(30%) fiber annealed at 1000°C; a) illumination with white light; b) propagation of luminescence observed through a 550 nm cutoff filter (excitation wavelength 473 nm).
On the right: Optical micrographs of Sm^{3+} doped YSZ microtube annealed at 900°C. c) illumination with white light; d) luminescence observed through a 550 nm cutoff filter (excitation wavelength 405 nm).

References

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