Tm-doped nanoparticles in optical fibers

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300-words

The success of silica-based optical fibers are many: transmission fibers and fiber amplifiers for telecommunications, high-power fiber lasers or sensors. These key applications rely on the qualities of silica glass: mechanical and chemical stability, high optical damage threshold, low cost, etc. New lasers and amplifiers based on rare-earth (RE)-doped silica optical fibers need improved spectroscopic performances : gain curve engineering, photodarkening, spectral coverage, etc. In this context, a route of interest consists of embedding the RE ions within nanoparticles of composition and structure different from those of silica.

In this work, we study the properties of silica-based, MCVD-prepared fibers using LaF3:Tm3+ nanoparticles. The nanoparticles with 10-20 nm of diameter were produced by precipitation methods and were incorporated by solution doping.

Through SEM analyses on preform and fiber, nanoparticles were observed across the core. As Fions evaporate, the new phase is a La-rich silicate and its composition will be discussed based on the comparison with similar samples prepared by sol-gel. The first e-folding time of the 810-nm emission band (3H4 level) increases with the concentration of La. The best compromise between lifetime enhancement and optical attenuation corresponds to 58 µs and 0.05 dB/m, respectively.

Yet, to further improve the optical properties, there is a need to limit Rayleigh scattering induced by the presence of nanoparticles. In the frame of these optical losses reductions, we propose to take advantage of the fiber drawing to tailor the size of nanoparticles. Indeed, we will report evidences that this step permits the deformation and break-up of elongated particles. The possibility of considering break-up as a way to implement size tailoring of nanoparticles will be discussed.

These results clearly offer new possibilities for the control of the luminescent properties and the development of optical fibers with *augmented* properties.

500-words

The success of optical fibers based on silica glass are many: transmission fibers and fiber amplifiers for telecommunications, high-power fiber lasers or sensors. These key applications rely on the qualities of silica glass: mechanical and chemical stability, high optical damage threshold, low cost, etc. However, new lasers and amplifiers based on rare-earth (RE)-doped silica optical fibers need improved spectroscopic performances : gain curve engineering, photodarkening, spectral coverage, etc. In this context, a route of interest consists of embedding the RE ions within nanoparticles of composition and structure different from those of silica. Thanks to this approach, the luminescent properties can be engineered through the composition of the nanoparticles. During this talk, we will discuss the formation of nanoparticles and the engineering of the rare-earth ions luminescent properties.

In this work, we study the properties of silica-based, MCVD-prepared fibers using LaF3:Tm3+ nanoparticles as the RE carrier during the fabrication process. The nanoparticles with 10-20 nm of diameter were produced by precipitation methods, suspended in ethanol and were incorporated by solution doping into the core of a preform.

Through SEM analyses on preform and fiber, nanodomains were observed across the core. However, these nanoparticles are not the initial ones (LaF3) as X-ray Photoelectron Spectroscopy reveals the absence of F- ions. The new phase is a La-rich silicate and its composition will be discussed based on the comparison with similar samples prepared by sol-gel. The first e-folding time of the 810-nm emission band (3H4 level) increases with the concentration of La. The best compromise between lifetime enhancement and optical attenuation corresponds to 58 μ s and 0.05 dB/m, respectively. It is 4 to 5 times larger than that reported in pure silica, close to that reported in alumino-silicate fibers with 9 mol% of Al2O3. Here, addition of only ~1 % of LaF3 to the fiber core suffice to obtain the same spectroscopic alteration.

Yet, to further improve the optical properties, there is a need to limit Rayleigh scattering induced by the presence of nanoparticles. In the frame of these optical losses reductions, we propose to take advantage of the fiber drawing to tailor the size of nanoparticles. Indeed, we will report evidences that this step permits the deformation and break-up of elongated particles. Analyses of size of particles inside the optical fiber show that standard fabrication process can induce the break-up of big nanoparticles (>100 nm) into smaller particles. The possibility of considering break-up as a way to implement size tailoring of nanoparticles will be discussed.

These results clearly offer new possibilities for the control of the luminescent properties and the development of optical fibers with *augmented* properties.