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Controlling the growth of Si-, Ge- and Er-nanoclusters inside fused silica glass

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The operability and durability of erbium and germanium doped fused silica components in harsh environments are limited by thermal diffusion, responsible for structural changes that induce irreversible material degradation and failure. An alternative solution for improving both the thermal and radiation resistance of these compounds consists of synthesizing Si-, Ge- and Er-based nanoclusters. This technique enables to control atom diffusion, using chemical trapping effects induced by silicon dangling bonds and the pinning of nanoaggregates by silicon nanoparticles during high temperature annealing. Our experimental approach and methodology combine the fabrication of advanced materials by the use of single or multiple ion implantations, with subsequent advanced characterizations by Raman/photoluminescence spectroscopy, transmission electron microscopy, X-ray photoelectron spectroscopy and nuclear analysis. Our work shed light on the nucleation processes of group-IV nanocrystallites as well as on the formation of nanocavities in Ge-based materials. The nanoclustering of mixed Si/Er and Si/Ge materials is also found to extend the lifetime of near infrared Er light sources exposed to cosmic radiations and prevent Ge desorption, more than several hundred degrees above heating conditions where drastic outgassing effects occur. High resolution imaging supported by Monte-Carlo simulations and Rutherford Backscattering Spectroscopy measurements shows how the size, the homogeneity, the depth-distribution as well as the composition and the crystallinity of the formed nanoclusters can be set as a function of the fabrication parameters, in order to design components with specific properties and superior resistance.

Biography

David Barba is a Senior Research Associate working in Federico Rosei's group at INRS-EMT since 2013. He has 10 years of experience in Advanced Materials for Application in Photonics and Photovoltaics. He has published more than 50 papers in peer-reviewed journals and co-supervised about 20 graduated students and postdocs. He is an expert in nanomaterial, ion implantation, optics, electron microscopy, Raman, luminescence and photoelectron spectroscopy. He had worked on several collaborative projects with a dozen of Canadian companies, related to nanotechnology, aerospace industry, optical sensing and fibers, laser design, energy production and advanced manufacturing.

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