On the evolution of nanoparticles in nanoparticle-doped optical fibers

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Active optical fibers doped with rare earth (RE) ions are used to make fiber lasers, which are crucial to many advanced manufacturing and defense applications. While silica-based fibers are required for commercially-viable fiber designs, silica has spectroscopic properties that can be detrimental to laser efficiency. The doping of dielectric RE-doped nanoparticles (NPs) into the cores of silica fibers has proven to be an effective approach for controlling the spectroscopic performance of the RE. However, little is understood about the chemical and structural evolution of the NPs during fiber preform fabrication, or how any process-induced changes in the NPs affect the optical properties of the resultant fiber. The work discussed here studies the thermal evolution of Yb-doped alkaline-earth (AE) fluoride [Yb:(AE)F_2, AE=Ca, Sr, Ba] nanoparticles developed for suspension-doping into a silica preform fabricated using a modified chemical vapor deposition (MCVD) method. A thermal profile of the preform during fabrication was developed based on optical-pyrometer temperature measurements and used for time / temperature / structural correlations. X-ray diffraction was employed to study the NP phase and structure evolution. The fluoride NPs are shown to react with the core-glass soot, eventually oxidizing and amorphizing under the thermal treatment associated with the preform fabrication. This work sets the foundation for understanding the composition and structure of Yb:(AE)F_2 NPs in silica optical fiber cores, and aids in the understanding and tailoring of the optical properties of the resultant fiber.