Elongation, break-up, dissolution and growth of nanoparticles during the fiber drawing of silica-based optical preforms

Manuel Vermillac*†[1], Martiane Cabié[2], Daniel Borschneck[3], Jean-François Lupi[4], François Peters[5], Philippe Vénnéguès[6], Thomas Neisius[2], Courtney Kucera[7], John Ballato[7], and Wilfried Blanc‡[8]

[1]Institut de Physique de Nice (LPMC) – Université Nice Sophia Antipolis (UNS), Centre national de la recherche scientifique - CNRS (France), Université Côte d'Azur (UCA) – Parc Valrose, 06108 Nice Cedex 2, France, France

[2]CP2M – CP2M – France

[3]CEREGE – Centre de Recherche et d'Enseignement de Géosciences de l'Environnement [CEREGE] – France

[4]Laboratoire de physique de la matière condensée (LPMC) – CNRS : UMR7336, Université Nice Sophia Antipolis [UNS], Université Nice Sophia Antipolis (UNS) – Parc Valrose 06108 NICE CEDEX 2, France

[5]Institut de Physique de Nice (InPhyNi) – CNRS : UMRUMR7010, Université Nice Sophia Antipolis (UNS), Université Côte d'Azur (UCA) – avenue Joseph Vallot 06100 Nice, France

[6]Centre de recherche sur l'hétéroepitaxie et ses applications (CRHEA) – CNRS : UPR10, Université Nice Sophia Antipolis [UNS], Université Nice Sophia Antipolis (UNS) – Bat. 5 Rue Bernard Grégory 06560 VALBONNE, France

[7]Université de Clemson (COMSET) – Advanced Materials Research Laboratory 91 Technology Drive Anderson, SC 29625, United States

[8]Institut de Physique de Nice (INPHYNI) – Université Nice Sophia Antipolis, Université Côte d'Azur, Centre National de la Recherche Scientifique : UMR7010 – Avenue Joseph VALLOT Parc Valrose 06100 NICE, France

Abstract

Rare-earth-doped (RE) silica-based optical fiber lasers and amplifiers are developed for numerous applications. However, silica glass has certain characteristics (high phonon energy, low RE solubility, ...) which may be detrimental for the luminescence properties of RE. To overcome this issue, the incorporation of RE in nanoparticles is investigated to tailor the spectroscopic properties through the control of their composition [1]. Such optical fibers are elaborated by a high temperature fiber drawing (2000∘C) of nanoparticles-doped optical preforms.

This communication focuses on the thermodynamical and morphological changes undergone by nanoparticles throughout the fiber drawing. Dissolution and growth of particles induced

*Speaker

†Corresponding author: manuel.vermillac@unice.fr

‡Corresponding author: wilfried.blanc@unice.fr

by high temperatures will be discussed. Also, tomography-based (FIB/SEM) and X-ray nanotomography Multiscale imagery show that nanoparticles elongate and can even break-up during the fiber drawing [2]. Such modifications are explained by Rayleigh-Plateau instabilities and the competition between viscous forces and surface tension. These observations allow us to envision a new top-down strategy, the use of these phenomena to tailor optical properties through the control of the size and shape of nanoparticles during the drawing step.

W. Blanc et al., Journal of Optics 45, 247-254 (2016)
M. Vermillac et al., Journal of the American Ceramic Society 100, 1814-1819 (2017)

Keywords: optical fibers, silica, nanoparticles, fiber drawing, break up