Rare earth doped optical fiber fabrication by standard and sol-gel derived granulated oxides

UNIVERSITÄT BERN

D. Etissa, M. Neff, S. Pilz, M. Ryser, V. Romano
Institute of Applied Physics, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland

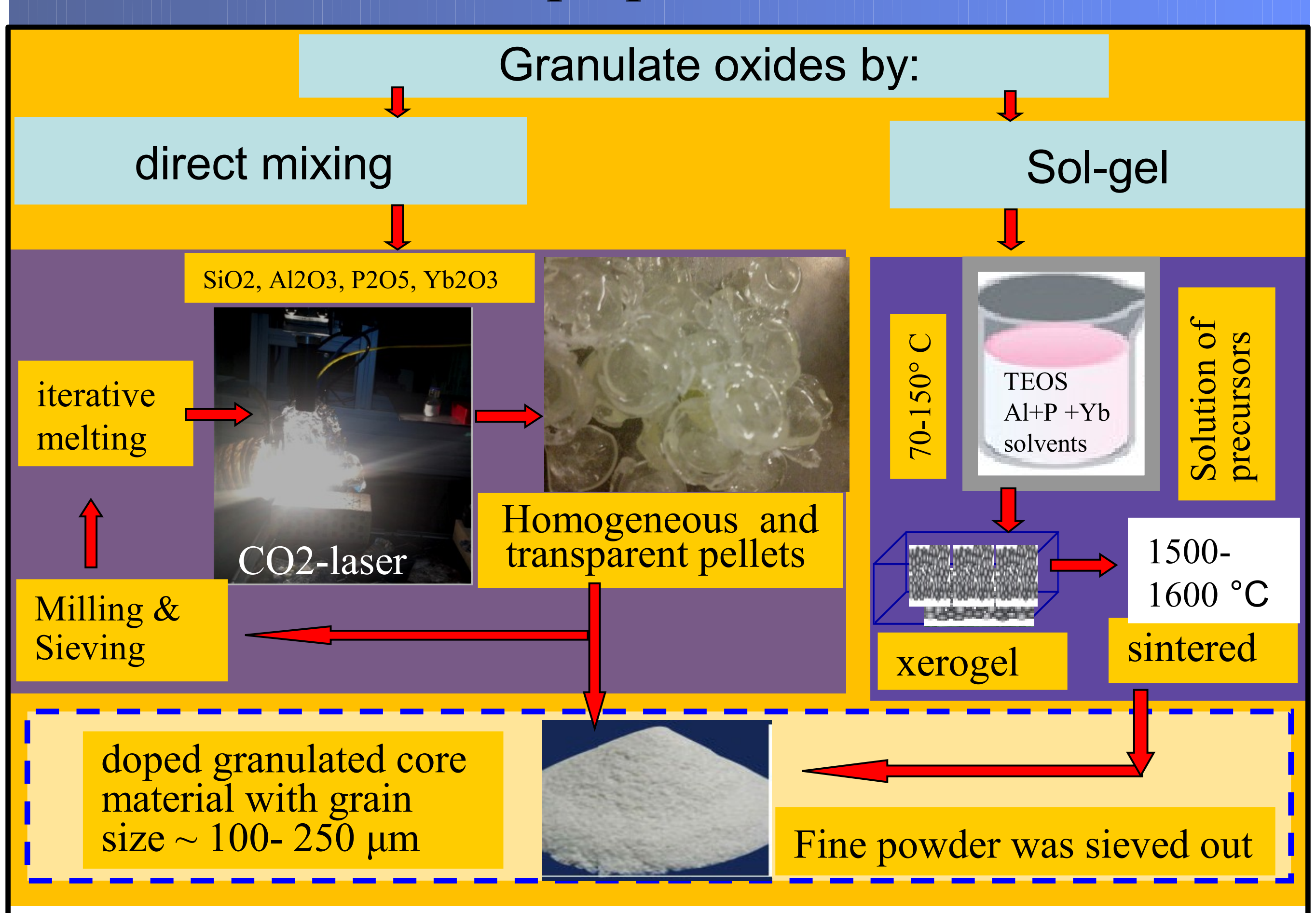
Abstract:

We fabricated ytterbium doped optical fibers by the granulated oxides method. The granulated oxides mixture was prepared by two different procedures: direct mixing of granulated pure oxides and granulate produced by starting from sol-gel. As an alterative to MCVD technique, the granulated oxides method offers great simplification of manufacturing fibers with flexible fiber geometries and composition. The material homogeneity was improved by introducing iterative melting and milling procedures. We fabricated fibers from granulated oxides prepared by the two methods and determined the refractive index profile, dopant distribution, crystalline phase and attenuation losses.

Introduction:

Fabrication of Er^{+3} and Yb^{+3} doped optical fibers is of great interest for various applications. For example in high power fiber lasers and amplifiers, very large core fibers with high doping concentrations are needed. The granulated oxides method offers a high degree of freedom for fiber fabrication (e.g. special fibers geometries, such as leakage channel fibers). Furthermore it is possible to achieve high dopant concentrations. Crucial for the optical quality of the fabricated fibers is the granulate composition from which the fibers are produced. Two different procedures for preparing the granulate were used: i) direct mixing of granulated oxides [1]; ii) sol-gel derived granulates. Here, we describe the preform preparation techniques and procedures to improve material homogeneity in order to improve the optical quality of the fabricated fibers.

Active core material preparation methods :



Doped granulated core material fabrication process

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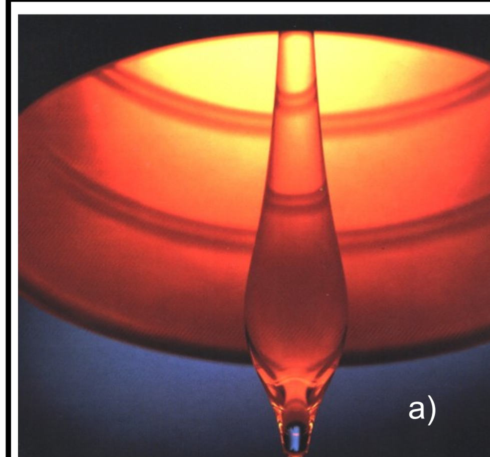
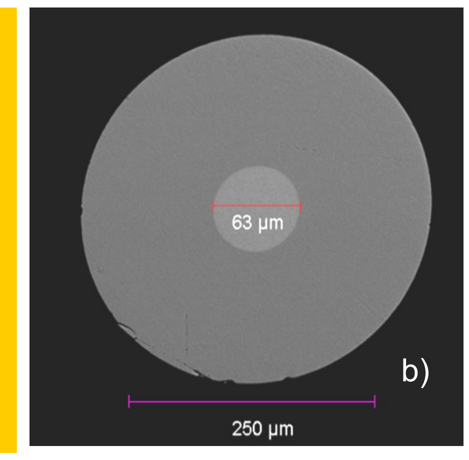
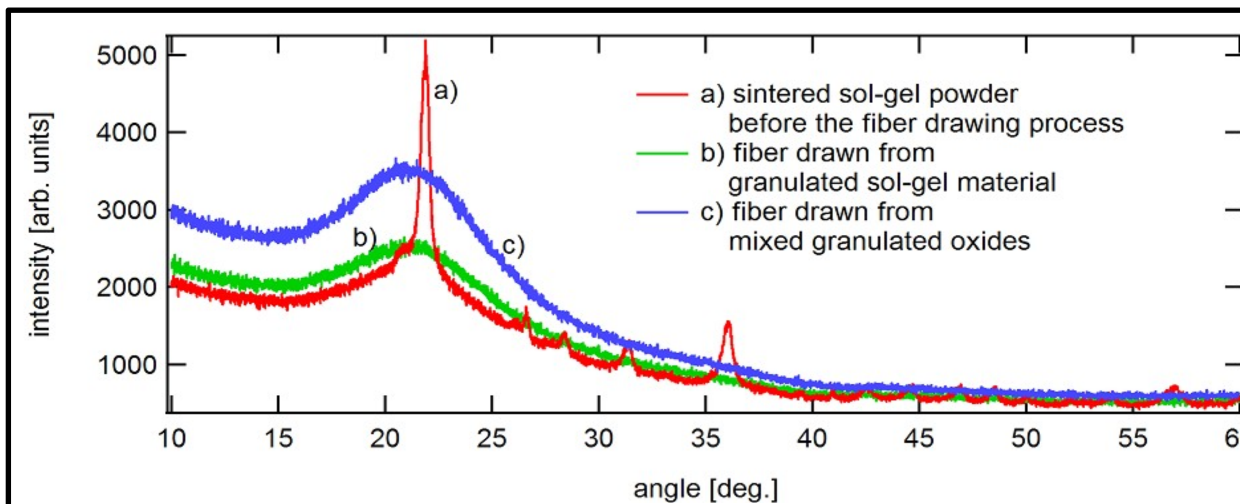
Results:



- evacuated and preheated for 1 hr at ~1000 °C
- Drawn at ~1850 °C

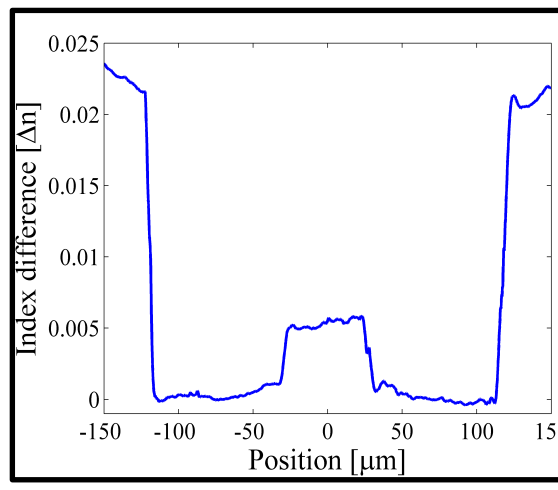


a) Fiber drawing : "Glass drop" falling slowly from the fiber drawing furnace after heating to 2000°C in the fiber drawing tower facility at IAP. b) Microscope image of the cleaved fiber end made by the sol-gel method.



XRD patterns of Yb doped and P-Al co-doped silica glass prepared by sol-gel and granulated silica methods.

Crystalline material was amorophized after the drawing process.

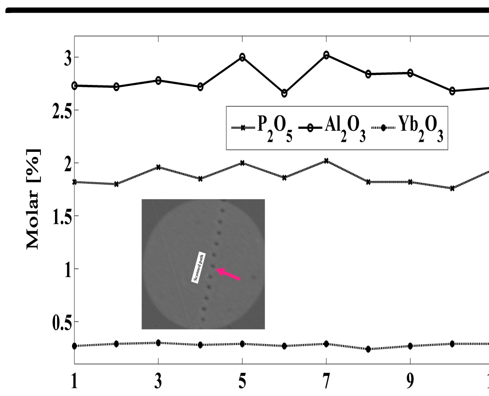


$\Delta n = 5.3 * 10^{-3}$

$\sigma = 4 * 10^{-4}$

$N_A = 0.12$

Refractive index profile of the Yb^{+3}, Al^{+3}, P^{+5} doped optical fiber



Yb^{+3} ions was distributed with σ of 0.01 %

Average elements distribution along the active fiber core measured by electron probe microanalysis (EPMA).

Attenuation measurement using cutback method:

We produced an optical fiber which was only homogeneous for short fiber pieces. The average scattering losses measured for these short pieces was < 0.35dB/m.

Conclusion:

- crystallized doped core material (sintering process) was decrystallized after the perform was drawn to an optical fiber
- sintering the sol-gel material at high temperature minimizes the formation of bubbles during the fiber drawing process
- the average attenuation loss for short homogeneous fiber pieces was < 0.35 dB/m.

References:
[1] L. Di Labio, Willy Luthy, Romano V., Frederic Sandoz, and Thomas Feurer1, Superbroadband fluorescence fiber fabricated with granulated oxides", Opt. Lett. / Vol. 33, No. 10 / May 15(2008).