

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

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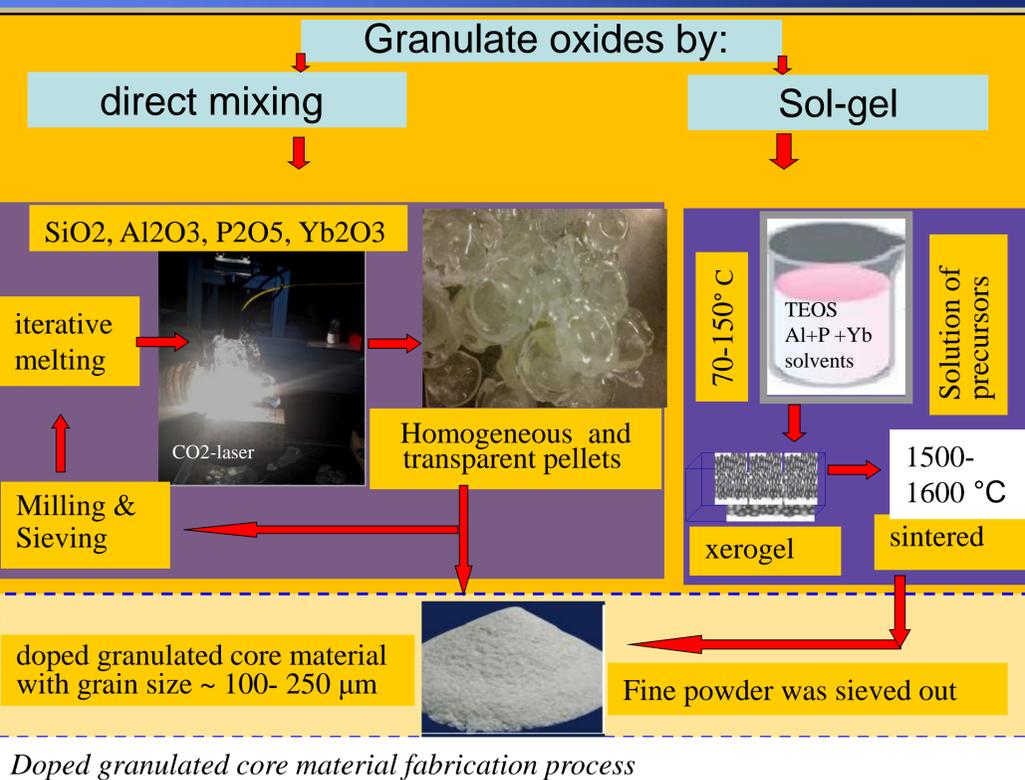
Abstract:

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 alternative 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

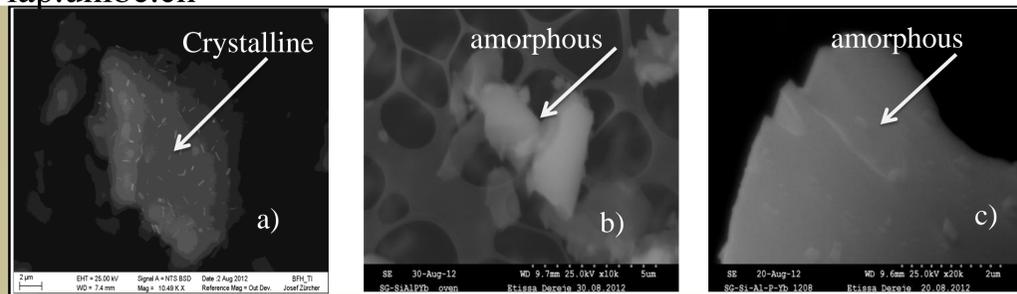
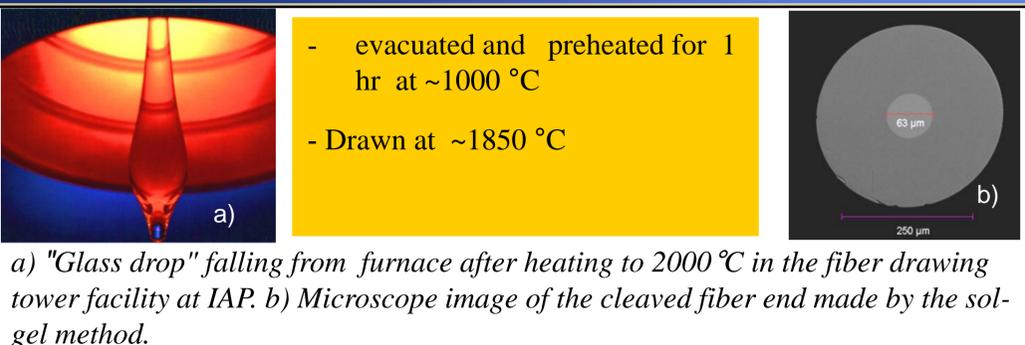
Introduction:

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.

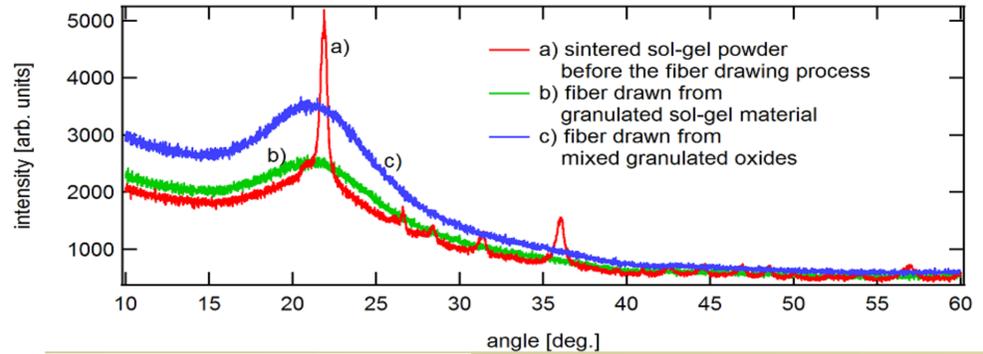
Active core material preparation methods :



Results:

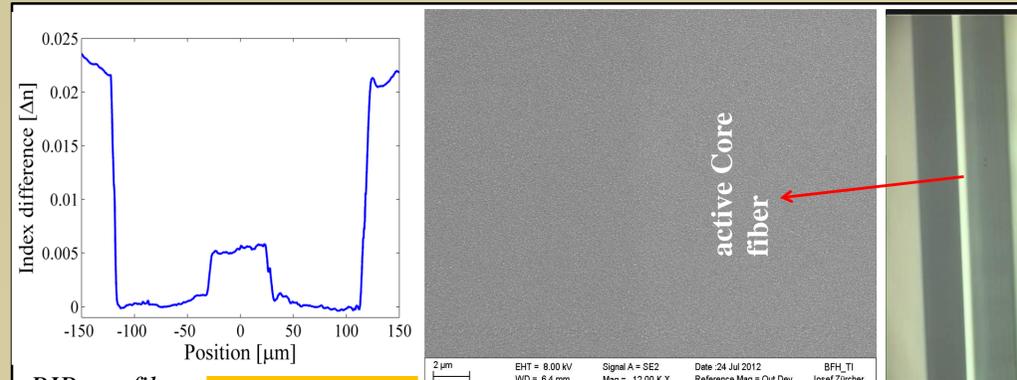


Scanning Electron Microscopy images: a) Crystalline material was formed by Slowly heating the Sol-Gel material to 1600 °C and slowly cooling before fiber is drawn b) quenching the Sol-Gel material after heating at 1600 for 4 hrs confirms its amorphous nature and c) sample (a) was drawing to optical fiber, the resulting material was found amorphous



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

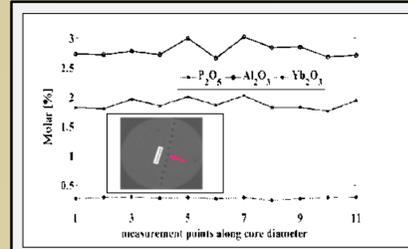
Crystalline material was amorphized after the drawing process.



RIP profile of the Yb³⁺, Al³⁺, P⁵⁺ doped fiber

$\Delta n = 5.3 \cdot 10^{-3}$
 $\sigma = 4 \cdot 10^{-4}$
 $N_A = 0.12$

SEM image of optical fiber material prepared by sol-Gel method. After several times CO₂-melting and milling process



Yb³⁺ 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 used a He-Ne laser source (633 nm) for attenuation measurements. Piecewise, our fiber is homogenous with consecutive scattering centers 10- 40 cm apart. The average scattering losses measured for these short pieces was 1.0 -3.2 dB/m. Assuming Rayleigh scattering as main loss mechanism, this translates to losses in the range of 100-320 dB/km at 1100nm.

Conclusions:

- crystallized doped core material (sintering process) was decrystallized after the preform 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 can be determined to be 100-320 dB/km at 1100nm.

Acknowledgements

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References:

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