Ultra-long, continuous and super-flexible glass nanofibers produced by a novel technique: Continuous Fiberizing by Laser melting and Supersonic dragging.

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The necessity of materials with improved mechanical properties has driven the production of high performance fibers. The development of nanofibers and nanotubes predicted the production of new nano-composites with exceptional mechanical properties. However, the breakthrough predictions haven't been achieved jet, in part due to the reduced length of the nanofibers or nanotubes, which restrained the mechanical reinforcement and manufacturing. Consequently, there is an enormous interest in the development of advanced continuous nanofibers, but conventional methods for fiber spinning cannot produce fibers thinner than some micrometers robustly.

Here we present a novel and unique method to produce extremely flexible glass nanofibers, with diameters that range from 300 nm up to 30 µm and virtually unlimited length. The process essentially consists on heating the precursor material uniformly and extremely fast using a high power laser beam while, at the same time, the melt is rapidly stretched and cooled by the supersonic air jet. The temperature distribution must be precisely controlled by selecting the laser beam parameters in order to obtain the proper viscosity to guarantee filament stability. With this aim, an specifically conceived laser beam shaping system was designed and set-up. Concurrently, a supersonic gas flow is ejected using a de Laval nozzle expressly designed to provide an uniform supersonic air jet flowing coaxially with the filament, so that it exerts a high tension localized along the molten segment of the filament, which is essential for the rapid stretching and cooling of the nanofiber. A suitable combination of these tools permits rapid heating, stretching and cooling of the precursor material, which is a key factor to produce fibers with small diameters, preventing filament rupture or devitrification in continuous and stable process.

This new method allows producing extremely long continuous nanofibers, virtually infinite, giving total control of diameter, and, since it is a bushing-free technique, it can be employed to process compositions with high fiber forming temperatures. In the present work we demonstrate the production of pure silica continuous nanofibers, analyze their structure and, remarkably we present a preliminar assessment of their mechanical properties using a set of innovative techniques. The results reveal a tensile strength of our glass nanofibers in the same order as high performance fibers, but having a notable flexibility attaining radius of curvature of 10 µm.