Multiple Thin-Films Fiber Devices

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The development of semiconductors technology has been for the most part the result of the reduction of device feature dimension, enabled by continuous improvements in thin film processing. Achieving smaller dimensions allows for an increase in the device packing density, and plays a crucial role in increasing performance of complex devices. Multimaterial integrated fiber devices processed by simple and inexpensive fiber drawing techniques have recently proven to exhibit many of the semiconductor devices functionalities. We have begun exploring the role of feature dimension reduction in these novel fiber devices (Advanced Materials, in Press). This study had significant practical implications in the optimal design of photodetecting fibers to be used in applications such as remote sensing, large-area optical-detection array systems, and functional fabrics. In this project, we study how this new thin-film design can be used to increase the device density integrated in a single fiber, and demonstrate the significant impact this has on developing complex functionalities inside fiber devices.

On Figures 1A and 1B we show Scanning Electron Microscope (SEM) micrographs of core and thin-film photodetecting fibers reported in previous publications, which focused on the implications of the extended lengths of such devices. The objectives of this project is to exasmine the role of the cross section dimensions: (1) Demonstrate the controlled fabrication of multimaterial fiber devices with new structures where two thin films of controlled thickness are integrated at prescribed radial positions and contacted by electrodes placed at prescribed angular positions, as depicted on Figure 1C and 1D; (2) show that these new fibers enable not only the detection of a light beam, but also its direction and frequency; (3) finally, we build a fiber grid made out of these new fibers which enables significant improvements to the lens less imaging system previously reported (Nature Materials, 5, 532 (2006)).

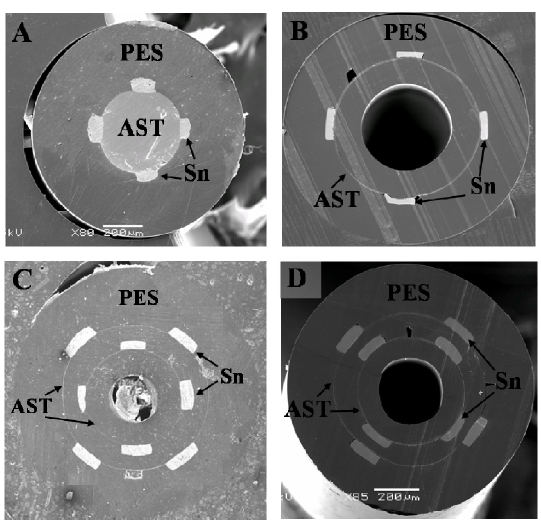

Figure 1: SEM pictures of the cross section of various multimaterial fiber devices. All fibers have PES polymer matrix, $As_{40}Se_{54}Te_6$ (AST) as a semiconducting member and tin electrodes. A: core fiber. B: Thin-film fiber. C: Dual fiber with the four electrodes of the external layer rotated by 90^0 with respect to the electrodes of the inner layer. D: Dual fiber with aligned electrodes.

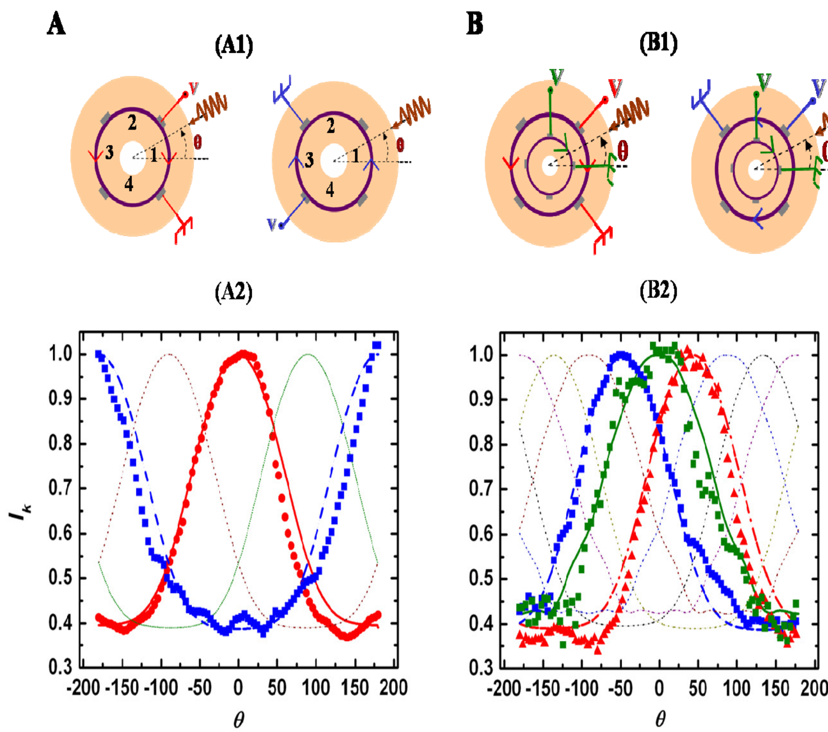

Figure 2: (A1): Schematics of single thin-film fibers where quadrant 1 (left) and quadrant 3 (right) are contacted, the number labeling the 4 quadrants. (A2): Normalized current B1: Schematics of single thin-film fibers where quadrant 1 (left) and quadrant 3 (right) are contacted, the number labeling the 4 quadrants. B2: Dependence of photocurrents on θ when contacts are made like in the schematics in A: black curve (theoretical model) and dots (experimental results) for (A1), red for (A2) and blue for (A3). C1: SEM picture of a dual ring fiber with the four electrodes of the external layer rotated by 45^0 with respect to the electrodes of the inner layer. C2:

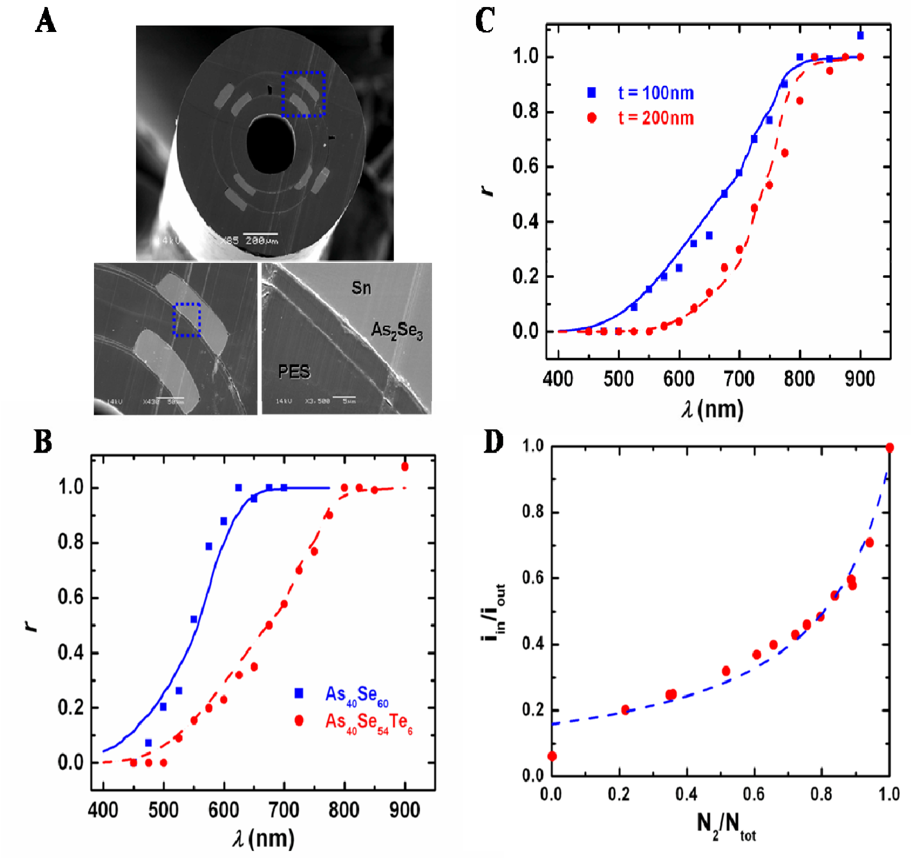

Figure 3: A. SEM pictures of the whole cross section of a fiber with two thin films. Below: magnification on two electrodes and on an electrode contacting a thin film. B: Dependence of the *r* function on wavelength for two fibers with the same glass thickness (*t* = 100nm) but different glass compositions. C: Dependence of the *r* function on wavelength for two fibers with the same glass $As_{40}Se_{54}Te_6$ and different film thicknesses (*t* = 100nm and *t* = 200nm). D: Ratio of currents for different relative powers for an illumination at two wavelengths, 488 nm and 830 nm.