Prospects for Nanowire Sculptured Thin Film Devices

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STFs are assemblies of parallel curvilinear nanowires that can be fabricated by design using physical vapor deposition techniques, such as thermal and arc evaporation, sputtering, and pulsed laser ablation. Because their nanostructure comprises multimolecular clusters 3-5 nm in diameter, rapid changes in the average direction of the incident vapor flux relative to the substrate lead to the growth of parallel nanowires of the same shape. Atomic self-shadowing due to oblique-angle deposition enables the nanowires to grow continuously, to change direction abruptly, and to maintain constant cross-sectional diameter. Until quite recently, STFs did not possess transverse architecture, had low growth rates and had transverse areas that rarely exceeded 1 sq cm without significant loss of transverse uniformity. We have demonstrated the combination of large thickness (> 10 μm), large-area uniformity (75 mm diameter), and high growth rate (up to 0.4 μm /min) in assemblies of complex-shaped nanowires on lithographically defined patterns [1].

We review our recent accomplishments [2-4] and prospects for the future of engineered nanowire STFs. The ability to sculpture the nanowires out of virtually limitless variety of solid materials, coupled with micro- and macroscale 1D and 2D topographic substrates points towards new vistas of photonic, fluidic and sensor devices. Applications include: nanowire assemblies for bionanotechnology, because nanopatterning of surfaces is known to influence protein adsorption and cell behavior; photonic bandgap engineering, because complex periodic features can be lithographically etched on large-area substrates, with lattice sizes >50 nm; sensors for bioremediation, where bioreduction of FeOx or MnOx STFs [3] can indicate the proper environment for reduction of hexavalent uranium or chromium; and gas and liquid phase sensors using spectral holes in the circular Bragg phenomena that can be tailored during and after deposition [2,4] . Recent results from our group of different assemblies of helicoidal and columnar nanowires for various device applications will be presented, including examples of STF magnesium films as a bioadsorbable material and new optical data showing modification of TiOx STFs after post-annealing (Figure 1) and examples of a TiOx STF with an engineered spectral hole as a liquid and/or vapor sensor (Figure 2).

1. M.W. Horn, M.D. Pickett, R. Messier and A. Lakhtakia, Nanotechnology 15, pp. 303-310, (2004).
2. S.M. Pursel, M.W. Horn, and A. Lakhtakia, Optics Express 14 (17) pp. 8001-8012 (2006).
3.H.Tan, OK Ezekoye, J. Van Der Schalie, M. W. Horn, A.Lakhtakia, J. Xu, W. D. Burgos, Environmental Science & Technology 40 (17) pp. 5490-5495 (2006).
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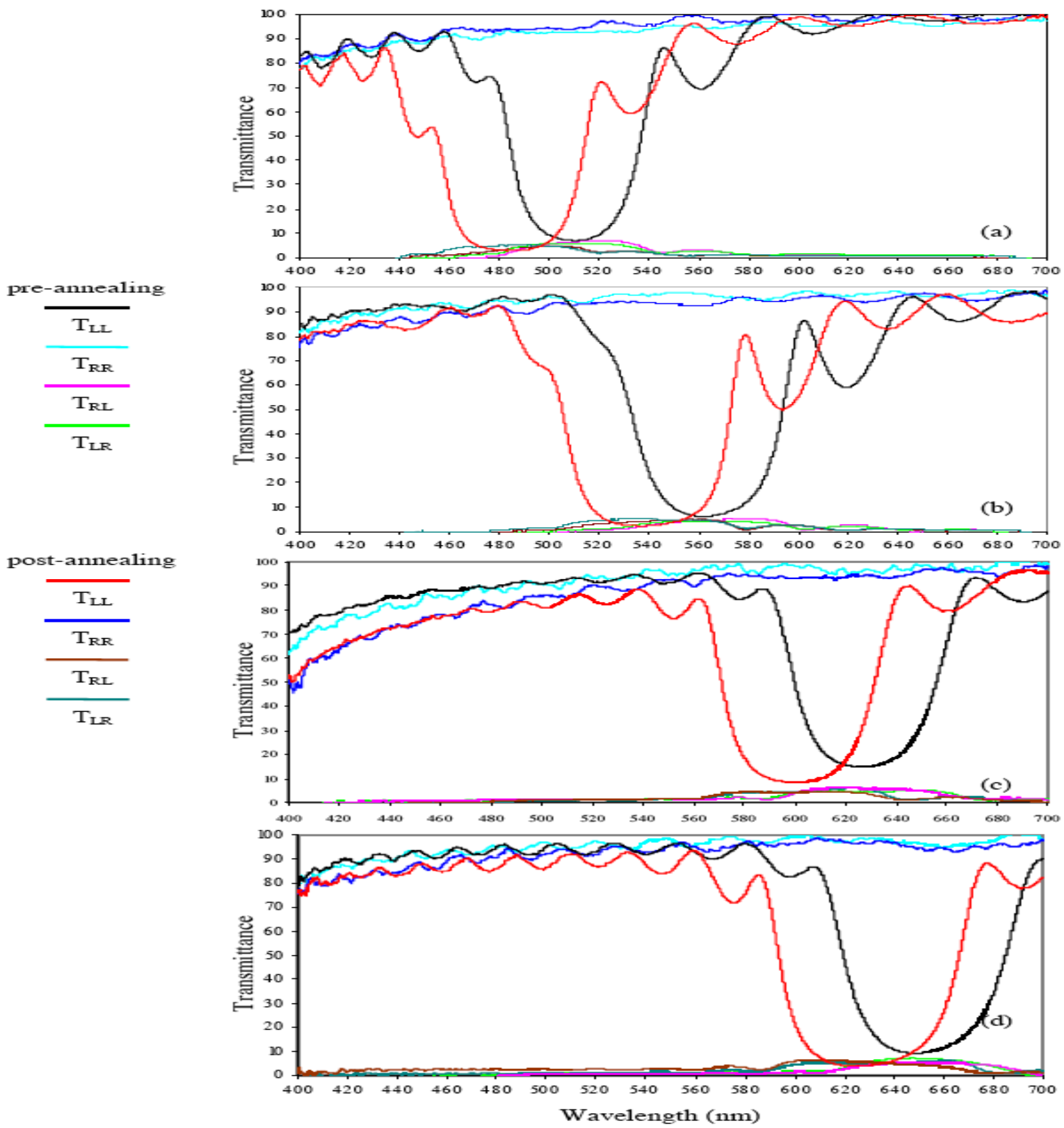

Figure 1(a-d) Transmission spectra of left-handed and right handed circularly polarized light incident on four different left handed chiral STF films before and after annealing. Note the red shift of all the left-handed in left handed out (T_{LL}) spectra before (black) and after (red) annealing.

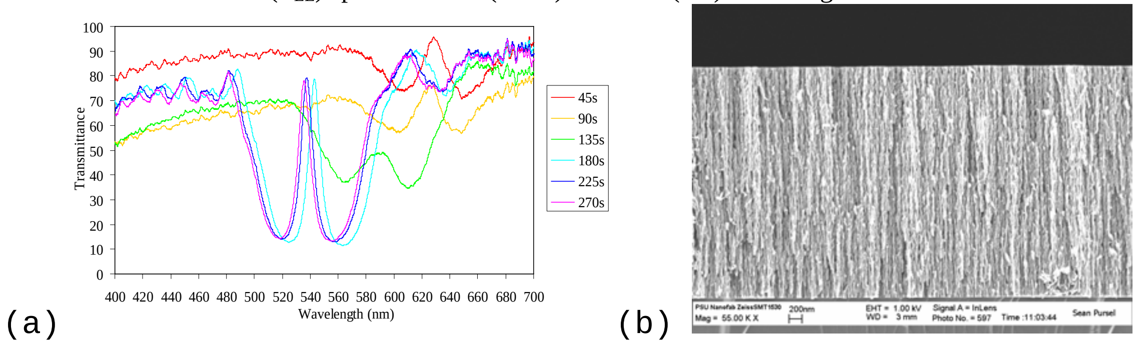

Figure 2 (a) Transmission spectra (T_{LL}) of STF with spectral hole after immersion in acetone as a function of time. (b) Cross-sectional FESEM of STF with spectral hole.