Biotechnology Provides a New Route to Semiconductors

Sumerel, Kisailus, Weaver and Morse, 2003

Harnessing the genes and proteins that control the nanofabrication of the intricate fiberglass constructions made by sponges made it possible in our earlier MRL-supported research to control the structures and optoelectronic properties of silicon-based polymers and materials. Now, based on those results, a biotechnological approach to metal oxide semiconductor nanofabrication is being developed.

Gene cloning and genetic engineering, in conjunction with materials synthesis and characterization enabled us to identify the proteins, genes and molecular mechanisms governing the synthesis of silica at neutral pH and low temperature. Recently we discovered that "silicatein", the enzyme we found responsible for this synthesis, could be harnessed to produce nanostructure-controlled titanium dioxide and other metal oxide semiconductors from solution precursors at low temperature. This represent the first discovery of enzyme-catalyzed, nanostructure-directed synthesis of semiconductors. Most remarkably, we found, the enzyme directs the nanoscale assembly of these materials with some control over their atomic alignment. The surface of the proteins filaments actually guides the assembly of the atoms of titanium and oxygen! The result is a partial alignment of the nanocrystallites of the semiconductor on the protein surface. We now are working to characterize, harness and further enhance this nanostructure-directing activity.

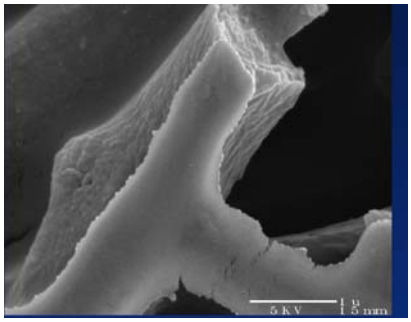

Figure caption: Silicatein catalyzes and structurally directs the growth of titanium dioxide from an alkoxide-like precursor at low temperature and neutral pH. Notice that the metal oxide follows the path of the underlying filaments of silicatein. Selected area electron diffraction reveals that the titanium dioxide is partially nanocrystalline, with the atomic lattices of the nanocrystals preferentially aligned with the silicatein fiber axis. (From Sumerel, Morse et al., 2003.)