# Three Routes to Nanostructured Titania Films for Alternative Energy Applications

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Crystalline, nanostructured titania films are of interest for numerous applications including next-generation energy conversion and sensing devices. In this talk we will discuss three approaches to films with defined structures that rely on the unique properties of supercritical fluids for their fabrication and their applications.

The first approach is direct and involves reactive deposition from supercritical $CO_2$ to yield device quality films with exceptional step coverage in high aspect ratio, nano-scale features. We deposit the films via hydrolysis of appropriate precursors using a cold-wall deposition reactor on both inorganic templates and organic substrates patterned by nanoimprint or optical lithography. Removal of the latter by calcination yields hierarchical films with defined pore structures. The second approach involves the infusion and selective condensation polymerization of titania alkoxides within one phase domain of highly ordered, preformed block copolymer templates using supercritical $CO_2$ as the reaction medium followed by removal of the template by calcination. In one example we demonstrate the fabrication of titania films containing perpendicular nanochannels of prescribed diameter. While this approach potentially affords the greatest control of the device nanostructure, it is also the most complex and costly to implement. The final approach, which has recently been developed in our labs, provides a direct spray-on technique in which crystalline nano-scale dendritic metal oxides can be deposited directly onto inorganic as well as thermally sensitive substrates. This approach is low-cost and affords new opportunities for large area applications including photovoltaics.