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### **Title**

Applications of Planar and Patterned Metal Oxide Nanocomposites and Reactive Polymer Blends as Gas Permeation Membranes

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## Abstract

The work in this dissertation is divided into two distinct projects. The majority of this dissertation was based on applications of planar and patterned metal oxide nanocomposites; in particular modifying the properties of both polymer nanocomposites and all inorganic nanocomposites. A series of nanocomposites were generated to modify the refractive index or dielectric constant of these materials. Three applications were developed for the material systems created. The first was a high dielectric constant ( $k$ ) layer that was used to generate all solution processable OFETs. Next, a novel strategy was created for patterning metal oxide nanoparticle nanocomposites, by using a form of solvent assisted nanoimprint lithography, which had previously only been adapted for metal nanoparticles. This simple and straightforward approach was used for a number of different nanoparticle systems, titanium dioxide ( $\text{TiO}_2$ ), cerium dioxide ( $\text{CeO}_2$ ), zirconium dioxide ( $\text{ZrO}_2$ ), iron oxide ( $\text{Fe}_2\text{O}_3$ ), and indium doped tin oxide (ITO), along with either organic or inorganic based binders. These nanocomposites were then developed to generate high surface area doped solid oxide fuel cell electrolytes. Finally, the first known all solution processable log-pile 3D photonic crystal was created, by using a high refractive index  $\text{TiO}_2$  nanocomposite. A transfer printing technique was invented to use a layer-by-layer strategy to generate a 6-layer 3D photonic crystal that was able reflect over 70% of the incident electromagnetic spectrum at 1000 nm.

The second project developed a reactive polymer blend that was used as for  $\text{CO}_2/\text{N}_2$  gas separations. The polymer blend was based on commodity scale block copolymers, Pluronic® (poly(ethylene oxide)-*b*-poly(propylene oxide)-*b*-poly(ethylene oxide), PEO-*b*-PPO-PEO) which are phase separated in the melt. The block copolymer becomes phase separated upon the addition of a hydrogen bond donating polymer, in this case a polyimide precursor, poly(amic acid) (PAmA), which was synthesized from pyromellitic dianhydride and 4, 4'-oxydianiline (PMDA-ODA PAmA). These blends were shown to favorably interact due to the amide and carboxylic acid groups present on the PMDA-ODA PAmA. The PMDA-ODA PAmA can be thermally imidized, while maintaining order and the ideal gas permeation properties were investigated to determine the likelihood of these blends to be used for commercial gas separation membranes.

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