# Synthesis and Characterization of Novel Nanocrystalline Oxide Film Structures: Interface Controlled, Self-Assembled Oxide Quantum Dots

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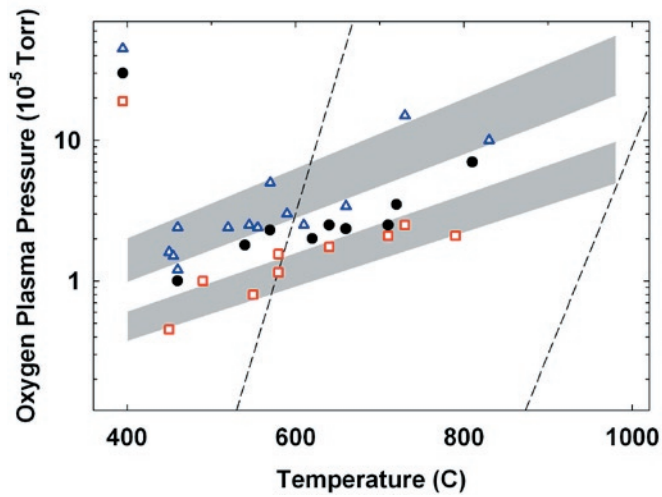
*FY 2003 Cost: $253.0K*

◆ Oxide nanostructures have the potential to significantly improve the performance and durability of the materials in several areas of national importance, including environmental cleanup, energy production, and homeland security. In particular, nanostructured oxide materials may play a key role in solar-assisted hydrogen production and organic waste destruction, as well as in the design of high-efficiency detectors for low-level radioactive waste. ◆

Nanostructured materials have many interesting and potentially useful characteristics that should, in principle, allow the tuning of both physical and chemical properties to achieve optimal conditions for a wide variety of applications. Most commonly the physical properties of such systems have received great attention. Many investigations of nanostructured materials have focused on the electronic, optical, and sometimes chemical properties of semiconductors that will not function in air or water environments. The ability to control the formation and interface structure of oxides, which often are stable in many environments, opens a wide range of possible materials systems for which the optical, electronic, and chemical properties can be used to great advantage.

In this project, we seek to understand the conditions that facilitate formation of well-defined oxide nanostructures – oxide nano dots and rings – for which the study of size, shape, and composition-dependent photocatalytic, catalytic, magnetic, and electronic properties can be systematically varied and examined.

A major focus of the work has been the growth of cuprous oxide ($Cu_2O$) nanostructures on a strontium titanium oxide (STO) substrate. The electronic structure of this system should enhance the creation of electron hole pairs when exposed to sunlight, potentially making the system useful for the destruction of waste and possibly the splitting of water. During FY 2001 and FY 2002, the copper oxide structures were grown, on a STO substrate with random surface termination. Oxide nanostructures with a variety of shapes were grown and interesting, but not always reproducible, photochemical properties were measured.




*Phase diagram comparing the large regions for the formation of bulk CuO, $Cu_2O$, and Cu (dashed lines) and the restricted region where pure $Cu_2O$ nanostructures can form.*

In FY 2003, the focus was on enhancing the reproducibility of the copper oxide structures and understanding the different shapes observed by atomic force microscopy. An analytical model based on stress-driven morphological instabilities predicts the size and shapes of the formation of $Cu_2O$ nano rings on the STO surface. To enhance the stability of the $Cu_2O$, the STO substrates were prepared with a single structure termination. This work enabled the development of a nanocluster oxide phase diagram that demonstrates the small region of stability for the desired oxide structure. Although difficult to form in its pure state, this oxide appears to have the photo-adsorption and other properties of potential use in many applications.