Formation and Characterization of Germanium Nanocrystals

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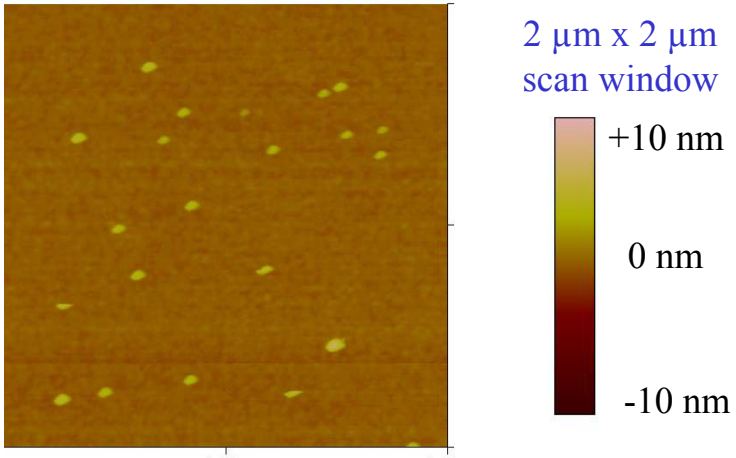
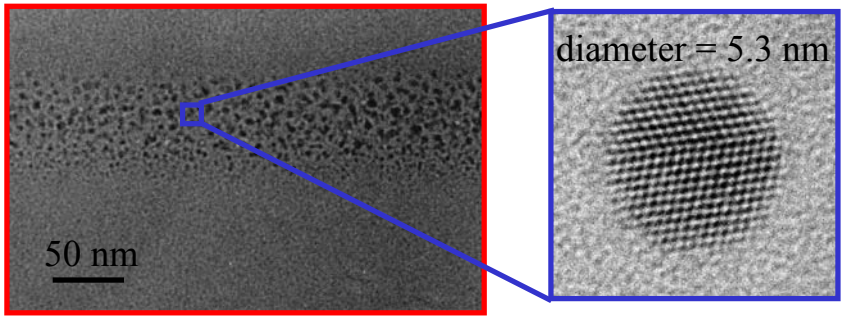
Research Goal: To develop methods of synthesizing and manipulating germanium nanocrystals and to gain an understanding of their unique optical and electronic properties. Ultimately, the properties of doped semiconductor nanocrystals will be explored.



Atomic force microscope image showing individual nanocrystals which have been liberated from the silica matrix and transferred to a smooth substrate. Lateral dimensions are increased due to the probe tip size but height data indicate an average crystal diameter of 4 nm.



Transmission electron microscope images of nanocrystals embedded in silicon dioxide synthesized by Ge ion implantation and high temperature annealing. On the left, a band of nanocrystals with diameters between 2 nm and 8 nm are observed. The image on the right shows an individual nanocrystal 5.3 nm in diameter.

Processes have been developed to expose and transfer nanocrystals, thereby significantly increasing the number of applicable characterization techniques. Experiments are underway to determine the precise electronic structure of the crystals and to directly manipulate the crystals to form ordered arrays.

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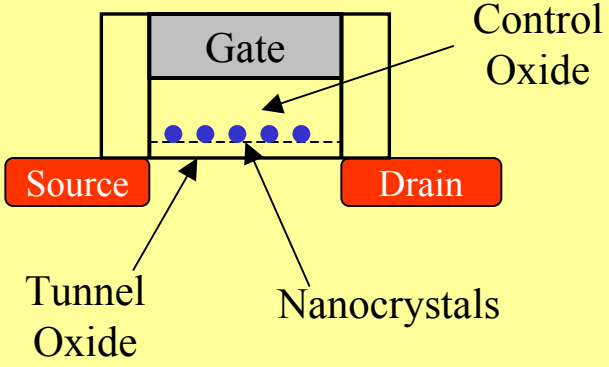
Education: Four graduate students, (Chris Liao, Ian Sharp, and Qing Xu, and Diana Yi) have contributed to this project at the University of California at Berkeley. Working at the National Center for Electron Microscopy (NCEM), Q. Xu has learned to perform a variety of advanced Transmission Electron Microscopy (TEM) techniques. C. Liao and I. Sharp have gained extensive experience with the synthesis, processing, and characterization (both electronic and optical) of nanostructures. D. Yi has developed comprehensive theoretical models of the nucleation and growth of the nanocrystals and the effects of post-processing on nanocrystal properties.

Broader Impact: The advancement of nanoscale science and technology is expected to have a great impact on a diverse range of fields. As dimensions shrink, new challenges in manipulation and measurement arise that must be overcome. A primary goal of this project is to develop characterization and processing techniques that will allow for continued miniaturization.



One possible application for Ge nanocrystals is the formation of superior non-volatile memory, a memory type which retains information after the power has been turned off. These devices may be created by placing nanocrystals in a standard transistor and storing charge on the nanocrystals themselves.