

Abstract for an Invited Paper  
for the MAR09 Meeting of  
The American Physical Society

### **Hierarchical Assembly of Epitaxial Quantum Dot Nanostructures on Templated Substrates**

ROBERT HULL, Rensselaer Polytechnic Institute

Using the focused ion beam (FIB), we have modified the local topography and chemistry of Si(100) surfaces, and demonstrated control of the geometry, size, location and proximity of epitaxial Ge(Si) quantum dot (QD) nanostructures which are nucleated on these templated surfaces. We show how QDs can be located with a precision  $\sim 10$  nm using local  $\text{Ga}^+$  FIB doses  $\sim 10^{14}$   $\text{cm}^{-2}$ , and how QD size and morphology can be modified by local surface chemistry. We further describe how growth kinetics can control formation of more complex nanostructures with internal length scales bridging the  $\sim 10$  nm dimensions necessary for application to potential nanoelectronic device architectures and dimensions that are accessible through external lithography. In particular, we describe the self assembly of “quantum dot molecule” (QDM)  $\text{Ge}_x\text{Si}_{1-x}$  nanostructures where a four-fold QD structures form around shallow strain relieving pits. Positional control of these QDMs using external lithographic templating allows formation of hierarchically assembled systems with length scales ranging from  $\sim 10$  nm in QD size and proximity, through the  $\sim 100$  nm dimensions of the QDM, to the micro/macro-scopic dimensions accessible with external lithography. We also describe methods for electronic and magnetic functionalization of these nanostructures by separation of ion species from alloy liquid metal sources in a mass selecting FIB column. This allows generation of ion beams comprising electronically non-invasive species for nanoscale surface templating (e.g. Si, Ge), electronic doping (e.g. As, B), or spin doping (e.g. Mn). Application of such structures to potential novel nanoelectronic device structures will be discussed. This work is done in collaboration with J. Floro, J. Graham, M. Gherasimova, J. Thorp (UVa), F. Ross (IBM), A. Portavoce (CNRS), M. Kammler (U. Duisburg) and J. Gray (U. Pittsburgh).