Carnegie Mellon
Materials Science and Engineering Seminar Series

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"HETEROEPITAXIAL QUANTUM DOTS: Evolution vs. Intelligent Design"

Friday, April 27, 2007
11:00 A.M. Seminar in Baker Hall 136A

Heteroepitaxial quantum dots form as a specific means to relax strain during lattice-mismatched epitaxial film growth. This process, whose energetics are formally similar to those associated with fracture, preferentially occurs prior to misfit dislocation formation when vapor phase growth conditions favor large surface mobility. This talk will feature two distinct aspects of our research on self-assembly mechanisms of SiGe quantum dots coherently grown on the Si (001) surface. In the first part — Evolution — I carefully follow the development of dense arrays of individual quantum dots under growth conditions "near-to-equilibrium". The focus in this part of the talk will be on how elastic repulsion between dots governs the evolution of the array, including: (1) spatial ordering of dots onto a surface lattice; (2) a novel accelerating Ostwald ripening process; and (3) a large reduction of the critical size for the first order phase transition from one dot shape to another. In the second section of the talk — Intelligent Design — we assume the guise of Epitaxy Deities, meddling with the growth kinetics in order to significantly modify the strain-induced roughening process. By enlightened choice of deposition temperature and rate, we suppress formation of dots, instead forming antidots (pits!) in the film that act as anisotropic elastic attractors for subsequent quantum dot formation. In this fashion we self-assemble *quantum dot molecules* (QDMs): bound, symmetric groupings of four quantum dots along the edges of the faceted central pit. I will discuss several novel aspects of QDMs, including kinetic size selectivity, 1D instabilities associated with pits, and, as an example of Supreme Control, the use of a focused ion beam to place QDMs exactly where we want them, thereby overcoming the randomness of pure Evolution.

Professor Floro earned a B.S. in Physics from Colorado State University, and a Ph.D in Materials Science from MIT, in 1992. In between, he spent several years as an engineer at the IBM T. J. Watson Research Lab. Floro was a staff member at Sandia National Labs in Albuquerque, NM from '92 to 2006. In 2006, he joined the faculty of the Materials Science and Engineering Dept. at UVa, and has been there ever since. Floro's research interests include semiconductor heteroepitaxy and quantum dot self-assembly for nanoelectronics, plasticity in III-nitride heterostuctures, and growth mechanisms of ZnO nanorods and carbon nanotubes. He is an avid soccer coach and Man United supporter.