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Growth, Assembly, and Characterization of ZnO Nanostructures on Ag Films[1]

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In the past decade, significant advances have been made in the synthesis of ZnO nanostructures. The next step in making these nanomaterials useful is to assemble them on surfaces in a controlled and desired fashion. In this talk, I will discuss the growth of complex ZnO nanostructures via a solution method in which organic templates are used to control assembly of these nanostructures on substrate surfaces. The low temperature aqueous growth method used in this work is an environmentally benign process, which is compatible with organic templates and modifiers, can be used to grow large areas uniformly, and has potential for inexpensive manufacturing. To control the assembly of these solution grown nanostructures, we modify the substrate surfaces with patterned self-assembled monolayers, which in turn determines the final spatial organization of the ZnO nanorods. This is a bottom-up approach in which materials are deposited only where they are needed. Using this approach, we have achieved excellent control in spatial placement, selectivity, crystal orientation, and nucleation density. In addition, complex, hierarchical structures have been synthesized by controlling solution chemistry and growth conditions. Due to lack of inversion symmetry in hexagonal crystal, ZnO is a piezoelectric material with Zn (0001) polar and O $(000\bar{1})$ polar surfaces exhibiting drastically different physical and chemical properties. Hence, it is important to determine the orientation of the ZnO nanorods on surfaces. Using piezoelectric force microscopy (PFM) and a well-characterized ZnO single crystal reference, we have measured the amplitude and phase of piezoelectric responses of over 100 individual ZnO rods. The phase of the PFM signal is 180° from the applied electric field, indicating that the nanorods are [0001] oriented. This result contradicts what would have been expected based on an examination of rod morphology. Also, the PFM amplitude of the nanorods was found to be significantly larger than that of the ZnO single crystal. The origin behind this observation and the variation among different nanorods will be discussed.

[1]In collaboration with D. Scrymgeour, Z. R. Tian, N. C. Simmons, C. M. Matzke, J. A. Voigt, and J. Liu