359d Individually and Selectively Grown Ag-Ga Nanowires and Their Applications in Nanomechanics and Nanolithography

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Gallium (Ga) will spontaneously alloy with films of silver (Ag) at room temperature (both in vacuum and under ambient room air) resulting in rapid nucleation and growth of long crystalline alloy needles of nanometer diameter. Of greatest significance is that an individual metal needle can be directed to grow in any desired direction. An example of this concept and its demonstration is presented in Fig. A-D where a silver-coated AFM tip is dipped into a liquid drop of Ga at room temperature. The Ga readily adheres to the Ag coating, forming a meniscus on partial retraction of the tip. With further retraction, the tip, with a freshly grown needle attached, breaks free from the Ga. Immersion of the tip in the Ga for as short as 2 s frequently results in a single needle forming. Needles from 25 nm to microns in diameter and up to 33 microns long (Fig. E) were grown by this method. These metal-tipped cantilevers have been successfully used in AFM and AFM voltage lithography. Direct measurements in the AFM and SEM of various interrelated mechanical properties of individual needles are in progress including measurements of Young's modulus, AFM force vs. distance measurements of buckling, tensile/yield strength measurement and mechanical resonance frequency (as stimulated by an AC electrical field. See Fig. F,G.) The sensitivity of the needles to mass loading is calculated and preliminary measurements of the effects of loading on Q and resonance frequency due to vapor adsorption in the variable pressure of the SEM are reported. **Figure Caption:** Fabrication and mechanical properties of freestanding nanoneedles. (A-D) Schematic and SEM images of the process. Ga was etched in HCl to remove the oxide which leads to a spherical drop. (E) Our longest selectively grown needle to date. It is 130 nm diameter over 23 mm of its 33 microns length. (F,G) A needle excited at two resonance frequencies. A Q of ~3000 at the fundamental frequency was measured from the displacement amplitude changes versus frequency.