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Synthesizing Metal Nanowires that Detect Molecules

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Noble metal nanowires have attributes including strength, ductility, and chemical stability, that make them attractive candidates for chemical sensing applications. However, in contrast to semiconductor nanowires, the conductivity of metal nanowires is not expected to be responsive to "charge gating" induced by the presence at the surface of the nanowire of bound ions. Consequently the properties of metal nanowires for chemical sensing have not been explored. We have developed a new method for preparing arrays of noble metal nanowires that involves the electrodeposition of metals (palladium, silver, platinum and gold) onto stepped graphite surfaces. Under the conditions employed for nanowire growth, metal is deposited selectively at step edges on the graphite surface leading to the formation of polycrystalline nanowires that are up to 1 mm in length and 30-500 nm in diameter. These nanowires adhere weakly to the graphite surface, and arrays of hundreds of wires may be transferred onto glass surfaces using a simple embedding process. These transferred nanowires can form the basis for chemical sensors in which the resistance of the nanowire array is modulated by molecules that chemisorb at the surfaces of these metals. Two examples involve palladium nanowires in the presence of hydrogen, and silver nanowires in the presence of amines. For both of these systems, the changes in resistance ($\Delta R/R_o$) can be 1000% or more, but the mechanism response for the resistance changes are completely different. What is the origin of these enormous and unexpected resistance changes? In this talk, we focus attention on this issue and we discuss the prospects for developing practical chemical sensors based on these novel mechanisms.