563c A Comparison between Sno2 Nanowires and Nanofibers for Advanced Environmental Sensing

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Nanoscale structures offer an extremely high surface/volume ratio which will improve the sensitivity, dynamic range and decrease the response time by more than 10-fold. Presented here is a comparison of the sensing capabilities of nanowires and nanofibers. With a diameter approaching twice the nominal charge depletion layer thickness (~ 10's of nanometers), the conducting channel of a nanowire is nearly entirely depleted upon adsorption of oxidizing gases, therein leading to electrical conductivity mimicking that of a field effect transistor. Although somewhat thicker, the polycrystallinity and cylindrical structure of a nanofiber permits deeper penetration of the depletion layer into the structure. Essentially the same narrowing of the conduction channel occurs. With the entire bulk of the material responsive to surface adsorbed species, sensitivity gains of 10- to 100- fold relative to film materials. Moreover, carrier depletion (or replenishment) throughout the “bulk” nanostructure will expand the dynamic range by the virtue of adsorbates leading to full charge depletion (or replenishment) and infinite (or very low) resistance.

These two forms of linear 1-d sensing elements require very different fabrication and integration processes for commercial sensing devices. Electrospinning offers direct deposition, composition control and potentially a very reactive surface reflecting the polycrystallinity of the material. Yet calcination will involve the entire substrate (sensor platform). CVD synthesized nanowires offer uniform crystal surfaces, resistance to sintering and their synthesis may be done apart from the substrate. Yet the higher the crystalline perfection, the fewer the chemisorption sites and hence the lower sensitivity and dynamic range. Electrospun nanofibers offer a dry fabrication process on the sensor chip apart from the sol-gel + polymer precursor solution. CVD nanowires will require liquid phase deposition as a washcoat and perhaps an additional binder such as a sol-gel solution. Each method is capable of synthesizing a full suite of materials including SnO2, ZnO, In2O3, etc. The work presented here will compare advantages and limitations of these two competing technologies for chemiresistors. Comparative measurements will be presented using each fabrication method supported by an interdigitated array and integral heater platform.