

Final Report Grant DAAG55-98-0095
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An interdisciplinary team of researchers at Purdue University involved in several research projects supported by ARO, DARPA, and NSF submitted a 1998 DURIP Equipment proposal entitled "Instrumentation for Chemical Sensing and Computational Applications of Molecularly Linked Networks of Nanometer Scale Metallic Clusters" to the Army Research Office (ARO Proposal NO. 38247-PH-RIP). This proposal was funded as Grant DAAG55-98-0095. A summary of the instrumentation purchased under this Grant is listed below.

<u>ITEMS</u>	<u>COST</u>
1)Inert Atmosphere Glove Box, Vacuum Atmospheres Co. (and Taylor-Wharton liquid nitrogen transfer cylinder)	\$27,500
2)Laminar Flow Hood and Clean Room Work Station, Terra Universal, Inc.	\$11,275
3)Sony camera and optics, Navitar Inc.	\$5,550
4)Variable Temperature Probe Station, MMR Technologies	\$21,900
5)Misc. items for UHV Chamber, Kurt Lesker and Thermionics Northwest	\$7,100
6)Omicron UHV STM/AFM	\$52,000
7)Misc. scientific equipment, Keithley Instruments, EG&G, Tektronix, Yamaha, Digital Instruments	<u>\$21,175</u>
TOTAL	\$146,500

The first three items on the above list are critical for fabrication of prototype chemical sensors and nanoscale computational elements. Fabrication of

these complex structures, which include reactive organic molecules and in the case of our DARPA research easily oxidized GaAs substrates, requires steps in which the substrate is protected from exposure to both oxygen and water vapor. These steps are done in the inert atmosphere glove box. The fabrication of these devices also involves colloidal application of metallic nanoparticles. During these steps, it is critical that the substrate be manually manipulated but not exposed to airborne particulates, and these steps are carried out in the laminar flow hood.

The Vacuum Atmospheres glove box was itemized on the original proposal to include a refrigerator and a Nikon dark field microscope. It became evident as the research progressed that the refrigerator was not critical and the laminar flow hood and clean room work station (Item 2) was purchased in lieu of the refrigerator. The Sony camera and optics (Item 3) was purchased in lieu of the dark field microscope listed in the original proposal.

Item 4, the MMR variable temperature probe station listed in the original proposal, is being used as a controlled environment/variable temperature chamber for electrical measurements. The probe station has been modified to allow the chamber to be filled with various gases, or to be used under vacuum (Items included in Item 7). The probe station is interfaced with computer-controlled electrical test equipment (Items included in Item 7) to allow current-voltage measurements on various samples. This electrical measurement capability allows the characterization of devices realized using networks of metallic nanoclusters. Specifically, nanoelectronic devices consisting of nanoclusters linked by organic molecules are in turn linked to contact pads, so that their response can be monitored in the probe station. Devices characterized to date include prototype chemical sensor devices, nanostructured electronic conductors, and novel semiconductor device structures.

The items listed as Item 5 were used to construct a UHV chamber as described in the original proposal. The original concept was to construct a pre-treatment chamber to be used in conjunction with a Park UHV-STM that is used for making scanning probe electrical measurements on nanoelectronic structures. As our research progressed it became evident that this Park STM (although a valuable part of the nanoelectronic facilities at Purdue) was not able to fully characterize the devices we were fabricating. Thus, a request was made to ARO to use \$52,000 from the grant as part of the purchase price of an Omicron UHV STM/AFM (Item 6).

The Omicron STM/AFM is a state of the art instrument that allows both STM and AFM studies of a wide variety of nanostructures in a controlled UHV environment. The \$125,000 cost of this instrument was shared (roughly equally) between three different grants. It combines various STM and AFM measurement modes including contact mode AFM with simultaneous lateral force detection and non-contact mode AFM in a single instrument. In addition, the instrument allows multi-mode imaging i.e. the simultaneous acquisition of several AFM and STM related signals such as tunneling current, force, and force gradient in a single image. This instrument will significantly expand our scanning probe capabilities.

The items grouped under Item 7 include an EG&G Digital Signal Processor Lock-in, a Keithley low-current amplifier, Digital Instruments nanoprobes, vacuum fittings, and a vacuum pump. These are items used in the probe station and the UHV scanning microscope facilities dedicated for electrostatic measurements on molecules and nanocontacts.