

*TNT04 Abstract & Graduate Grant Application***ELECTRICAL PROPERTIES OF ULTRA-THIN MOLECULAR FILMS:
NOVEL NANOSCALE DEVICE FABRICATION & CHARACTERIZATION****Jason J Blackstock**

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The fabrication of solid-state electronic devices incorporating ultra-thin molecular films has received considerable attention in recent years due to the desire to utilize engineered molecules as active components in electronic systems. Many examples of two-terminal metal-molecule-metal¹⁻⁴ and semiconductor-molecule-metal^{5,6} junctions have been produced and electrically characterized in a variety of geometries. However, while interesting electrical behavior has been observed in numerous cases, the majority of devices suffer from one or both of the following challenges:

- 1) Arduous and/or difficult to reproduce device fabrication processes (particularly true for nanoscale devices);
- 2) Limited characterization of the physical and chemical properties of the fabricated devices has been conducted, because device geometries make the electrode surfaces and ultra-thin molecular films inaccessible to common surface characterization tools.

This poster will present a novel device fabrication process for generating very large numbers of nanoscale two-terminal devices that is both simplistic and easily-reproducible. In addition, the geometry of the devices allows a host of surface characterization tools to be used before, during and after device fabrication – on the electrode surfaces and ultra-thin molecular films – to build up precise models of the physical and chemical structures inside the devices.

The fabrication process begins with uniform and macroscopic ultra-flat metal^{7,8} or semiconductor surfaces that can be characterized using conventional surface science techniques. Next, an ultra-thin (normally monolayer) molecular film is placed on the surface by self-assembly. At this point the molecular film can also be characterized in detail using well-established techniques.

The final step in the fabrication process is the addition of the nanoscale top electrodes. The technique developed for this step involves electrochemically growing Porous Anodic Aluminum Oxide (PAAO) membranes with nanoscale pores, and using the membranes (between 200 and 800 nm thick) as shadow masks for vapor depositing arrays of nanoscale metallic circular disks. Finally, a conductive-probe Atomic Force Microscope (cpAFM) setup is used to image the nano-disk arrays and to make electrical contact to individual nano-disk junctions (of which there are millions per square millimeter on the surface). Even after the nano-disk arrays have been added to the surface, surface science techniques can still be employed to reveal further details of the physical and chemical interface of the metal nano-disks with the top of the molecular layer. The process of fabricating nano-disk arrays, SEM and AFM images of nano-disk arrays on surfaces and electrical data from a cpAFM measured nano-disk junction are all illustrated on page 2 of this abstract.

The poster will first cover the fabrication process in explicit detail, and then present electrical data and the accompanying detailed physical and chemical characterization on both metal-molecule-metal and semiconductor-molecule-metal examples of nano-disk junctions.

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Graphic Illustration of the Nano-Disk Array Fabrication and Electrical Characterization Process

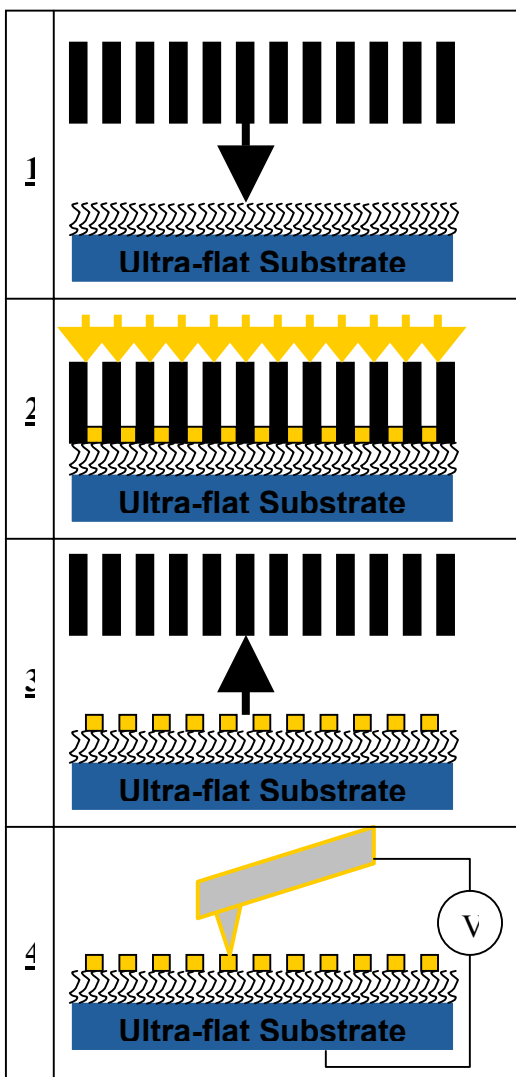


Figure 1

Schematic of the *Nano-Disk Array* Fabrication and Electronic Characterization

- 1 Pre-fabricated PAAO shadow-mask membrane is mounted onto a molecular monolayer film on an ultra-flat substrate.
- 2 Metal is evaporated through the PAAO membrane at slow rates (substrate is normally cooled to 77K).
- 3 PAAO membrane physically lifted off.
- 4 Metal coated AFM cantilever is used to create an electrical circuit with individual Nano-Disk devices.

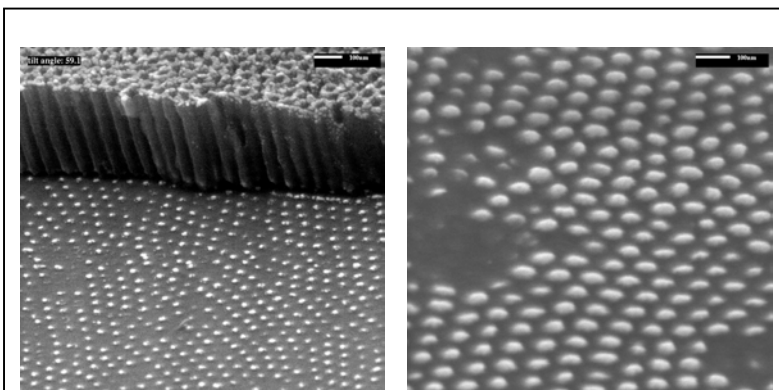


Figure 2

SEM images of nano-disk arrays fabricated directly on Silicon (no molecules) using the procedure outlined in Figure 1.

- Left: ~20nm diameter dots with part of the PAAO membrane still present in the top of the image
Right: ~60nm diameter disks

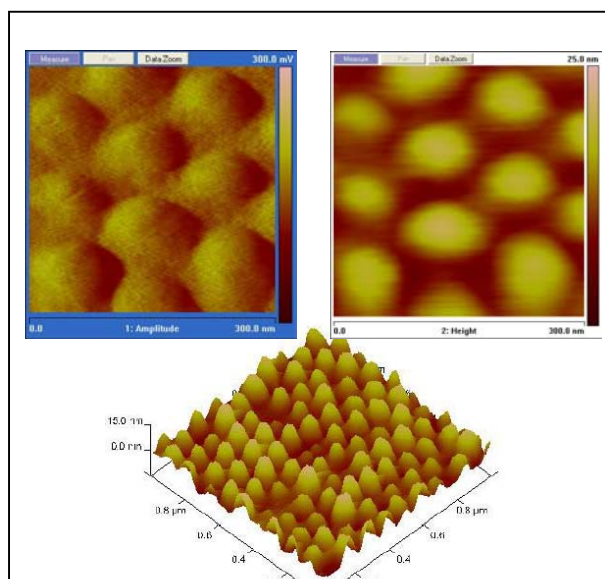


Figure 3

Tapping mode AFM images of metallic Nano-Disks on molecular monolayers on Silicon.

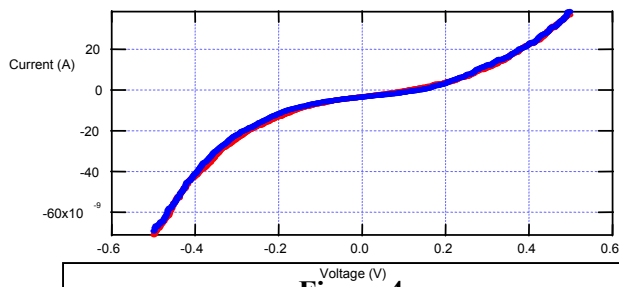


Figure 4

Example I-V data taken on a single Nano-Disk device similar to those shown in Figure 3. (Left Vertical Scale runs from -60 to +20 nA)