

## METALS AND MOLECULES ON AN INSULATING SURFACE: FIRST STEPS TOWARDS AN ATOMICALLY DEFINED MOLECULAR DEVICE

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A crucial piece of information for understanding the relationship between structure and function in a molecular device is the detailed structure of the contact wires near the molecule-wire interface [1]. One approach to addressing this is to use a planar geometry, where it is possible to determine the electrode structure by using scanning probe microscopy.

In order to avoid leakage currents, we are using an atomically flat insulating substrate. This poses additional challenges, as (1) there are few tools which enable measurements on insulating surfaces, and consequently, (2) there is little known about the growth of metals and molecules on insulators. We are using ultrahigh vacuum noncontact atomic force microscopy (NC-AFM) to examine some of the basic surface science which will lay the foundation for assembling an atomically defined molecular device on an insulator. NC-AFM, largely developed in the last few years, is unique in its ability to measure surface structure with atomic resolution on insulators [2]. It is expected that this technique will broadly expand our understanding of insulating surfaces, and provide a means for nanoscale manipulation, as STM does for metals and semiconductors.

In this study, we consider Au and Pd on KBr, as well as C<sub>60</sub> on KBr, as prototypical metal/insulator and molecule/insulator systems. The aim of these measurements is to better understand and control nanostructure formation on insulators. We are also interested in the nature of the bond between molecules and metal electrodes. To study metal-molecule interactions on an insulating surface, we are performing combined growth experiments of Au (and Pd) with C<sub>60</sub>.

The Au and Pd were deposited by e-beam evaporation, with an ion retarding grid to prevent ions from reaching the KBr surface. As observed in TEM studies [3], the metals preferentially nucleate at step edges, forming strings of aligned clusters. Stable clusters also form on terraces. Unlike TEM, NC-AFM provides a direct measure of the topography. Furthermore, it is possible to resolve small clusters at the initial stages of growth. We are exploring the possibility of manipulating the clusters, and of guiding the growth by intentionally introducing surface defects.

Submonolayer coverages of C<sub>60</sub> were deposited on KBr at room temperature by thermal evaporation, and imaged with molecular resolution. The C<sub>60</sub> islands are predominantly observed at step edges, nucleating at kink sites. The islands have an overall hexagonal symmetry. They are compact at low coverage and have a branching structure at higher coverage. First layer C<sub>60</sub> shows two effective heights, similar to that observed on metals with STM.

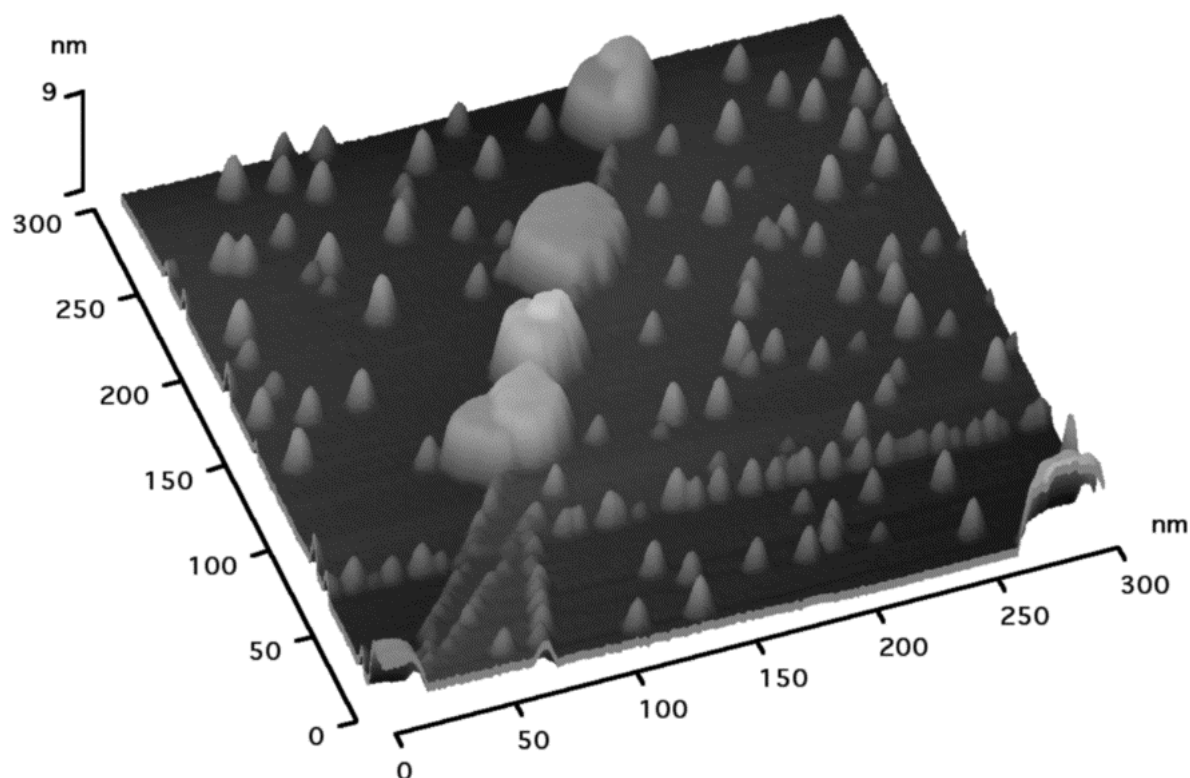
For the combined metal and molecule growth experiments, the Au (and Pd) was deposited on KBr either before or after depositing C<sub>60</sub>. It was observed that the interaction between Pd and C<sub>60</sub> is sufficiently strong for the Pd clusters to nucleate the growth of C<sub>60</sub> islands. Such an anchoring is desirable for constructing a molecular device, since it is expected that individual

molecules, which are mobile on the KBr surface, will “self-assemble” into the electrode gap and form a robust bond with the electrodes.

### References:

- [1] J. J. Palacios, A. J. Perez-Jimenez, E. Louis, J. A. Verges, Phys. Rev. B **64** (2001) 115411.
- [2] S. Morita, R. Wiesendanger, E. Meyer (Eds.), Noncontact Atomic Force Microscopy, Berlin: Springer (2002).
- [3] C. R. Henry, Surface Science Reports **31** (1998) 235.

### Figures:



NC-AFM image of C<sub>60</sub> (large islands) and Au (small islands) on KBr (001). Image size: 300 nm x 300 nm.