A "PUSHY" MICROSCOPE

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The process of ultra-miniaturization has been termed nanofabrication. It looks like the scanning tunneling microscope (STM) and related microscopes will be players in this technology of the future. One of the most recent contributions has been the demonstration that single molecules can be "pushed" across a surface with the STM. This remarkable achievement was demonstrated by Thomas Jung, Reto Schlittler, and James Gimzewski of the IBM Zurich Research Laboratory and Hao Tang and Christian Joachim of the National Center for Scientific Research in Toulouse[2]. They were able to position intact individual molecules on a two-dimensional surface at room temperature by a controlled "pushing" action of the tip of a STM. Similar positioning feats have been done at low temperatures while thermal motion is limited. At room temperature, the molecule to be moved must be attached to the substrate with sufficient bonding to prevent random diffusion, yet the bond must be sufficiently weak to allow for the molecule to be pushed. The key to this dilemma was to select a molecule that would be positionaly stable and yet could be moved. The ideal molecule, dubbed Cu-TBP-porphyrin, has four di-tertiary butyl phenyl substituents, that acted as "legs," that rotated out of the plane of the porphyrin ring. Saturated t-butyl groups attached to the legs dominated the interactions between the molecule and the surface, which was Cu(100), to give the desired effect.

Atomically clean Cu(100) was 10 to 15% covered with a monolayer of Cu-TBP-porphyrin, followed by annealing. Jung et al. used an ultrahigh-vacuum STM, operating at room temperature, to image these molecules. Using the STM electron-scattering quantum chemistry technique, they could identify the four "legs" on each molecule in the STM micrographs. For imaging, they used the STM in a mode with high gap resistance (27.5 gigohms), relatively high voltage (about (2200 mV), and low current (80 pA). For moving the molecules, they used low gap resistance (10 to 15 megohms), lower voltage ((30 mV), and higher current (2 to 3 nA). An area of interest was imaged several times to be sure it was thermally stable, then a selected molecule was displaced using software that provided mouse-controllable two-dimensional translations of the tip. Jung et al. were able to show that repulsion between the tip and the molecule caused movement of the molecule. Hence it is appropriate to say that the STM tip "pushed" the molecule. They also found that the molecule distorted until the resistance between the "legs" of molecule and its substrate was exceeded, then the molecule moved. This and other details of the interaction between the tip and molecule, as well as motions within the molecule, are important to nanomechanics of movement of individual molecules. What Jung et al. were able to achieve is different from sliding processes used in low-temperature manipulation.

The structure of the molecule is key to this nanomanipulation technique. Functional groups ("legs") attached to a rigid planar molecule allow for tip-induced translation without breaking chemical bonds within the molecule. Jung et al. proposed that this approach goes beyond current methods in nanofabrication. And we would readily agree that their "pushy" microscope has the potential for being very useful. ■

1 The author gratefully acknowledges Thomas Jung for reviewing this article.

2 Jung, T.A., R.R. Schlittler, J.K. Gimzewski, H. Tang, and C. Joachim, Controlled room-temperature positioning of individual molecules: Molecular flexure and motion, Science 271:181-184, 1996.

A Repeat Editorial Note!

The "good news" with this pub is that advertising continues to increase!

But, as I have no interest in publishing another "advertising catalog", the "bad news" is the lack of articles and material to balance with advertising.

The solution to my dilemma is to again ask you for article/material contributions. The only criteria is that the subject should be of interest to a reasonable number of working microscopists - and they can be of any length.

I am of the opinion that the vast number of our readers could make such contributions - and could do so with a minor amount of effort..

*Your help would be **much** appreciated!*

- - - Don Grimes, Editor

Front Page Image

SEM Photograph of Pollen Mix (Common Allergens)

Ragweed (Yellow), Plantain (Brown), Bermuda Grass (Green), Balck Willow (Blue), Red Maple (Red)

Imaged on an ETEC SEM at 5 kV using the SEM Wideband Multi-Detector Color Synthesizer (designed, built and patented by David Scharf). Then acquired digitally at 2,048 X 1,536 pixels directly into a Macintosh Power PC as a TIFF file, using Digital Micrograph software and Digiscan hardware. Then output to a CELCO film recorder, using Ektachrome 100+ film, to produce a 4x5 transparency.

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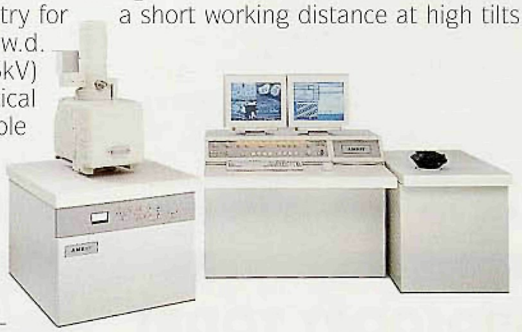

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