case" conditions, where the surface exhibits uniform chemistry. In this respect, a few published works investigate the ability to create continuous surface energy gradients to study the effect of surface energy on phenomena such as wetting and self-assembly in one single sample surface. Now, a team led by Michael J. Fasolka at the National Institute of Standards and Technology (NIST) in Gaithersburg has reported a unique fabrication of a new class of substrates that combine a micrometer-scale chemical pattern with a surface energy gradient.

As reported in the August 10 issue of *NanoLetters* (p. 1535; DOI: 10.1021/nl050612n), Fasolka and co-workers fabricated a micropatterned sample with a gradual and systematic change of chemical contrast, that is, surface energy differences between surface domains. To achieve fabrication of this specimen, they developed a method for patterning monochlorosilane (MCS) self-assembled monolayers (SAMs) which combines microcontact printing and vapor deposition. This approach provides reproducible microscale SAM patterns on a Si substrate with the ability for multisample batch processing. The process starts with a composite elastomer stamp containing both flat and corrugated regions, allowing the deposition of a SAM strip adjacent to a calibration strip.

The gradient of the surface chemistry in the sample was acquired by exposing the surface to ultraviolet ozonolysis in a graded manner. This model specimen, which presents a multitude of patterned chemical conditions in a single substrate, can be used as a reference substrate for the development and calibration of surface-chemistry-sensitive measurements such as the SPM techniques listed earlier. The researchers demonstrated this by using the graded specimen to correlate friction SPM image contrast with surface energy differences over a number of SPM probe functionalities. These experiments illuminated the full spectrum of contrast/surface energy relationships, including the ultimate sensitivity of the probes, by using a single specimen. In addition, the researchers demonstrated the potential of this new specimen for the high-throughput analysis of thin-film stability by studying the wetting behavior of polystyrene over the gradient micropatterns with a custom-made automated optical microscope.

FENGTING XU

MWNTs Follow in Geckos' Footsteps

The physical properties of the gecko lizard's foot anatomy allow the animal to climb any vertical surface and to hang upside down by a single toe. Covering each five-toed foot are microscopic elastic hairs called setae, whose ends split into "spatulas" that adhere to surfaces by van der Waals forces. The aspect ratio and stiffness of gecko foot hairs allow them to deform at different length scales so that they can come into close contact with surfaces of any type and shape at sufficient density to bring about high adhesive forces. Recently, researchers from the Department of Polymer Science at the University of Akron, Ohio, and the Department of Materials Science and Engineering at Rensselaer Polytechnic Institute in Troy, New York, used multiwalled carbon nanotubes (MWNTs) to fabricate a gecko foot-hair mimic that displays strong nanometer-level adhesion forces 200 times greater than those observed for gecko foot hairs.

As reported in *Chemical Communications* (issue 30; p. 3799; DOI: 10.1039/b506047h), University of Akron researcher A. Dhinojwala and co-researchers grew 10–20-nm-diameter, 50–100-µm-long, vertically aligned MWNTs on silicon substrates through chemical vapor deposition. After embedding the free ends of the MWNTs in a poly(methyl methacrylate) (PMMA) matrix, the PMMA–MWNT sheets were peeled off the silicon substrate, thereby forming a very smooth surface. This surface was then etched with either acetone or toluene. Not only can the researchers control the length of exposed MWNTs by varying the etching time, but also the solvent-

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drying process results in a MWNT morphology (entangled bundles 50 nm in diameter) that creates surface roughness. The researchers used scanning force microscopy to characterize the adhesive behavior of the foot-hair mimics and said that the disordered and entangled MWNT bundles provide penetration space for the probe. Higher penetration depths and adhesion forces were observed for this morphology than for MWNTs aligned vertically and densely packed or lying flat on the surface.

The researchers said that any pattern of MWNTs on silicon, which can be controlled by photolithography, can be precisely transferred onto a polymer surface. Furthermore, elastomeric polymers can take the place of the glassy PMMA and provide flexibility on different length scales. In addition, the researchers said that "this approach can provide excellent candidates for dry adhesives for microelectronics and space applications."

STEVEN TROHALAKI

Optical Control of THz Reflectivity of High-Resistivity Semiconductors Achieved

L. Fekete, J.Y. Hlinka, F. Kadlec, and P. Kuzel from the Institute of Physics, Prague, Czech Republic, and P. Mounaix from the Centre de Physique Moléculaire, Optique et Hertzienne, Talence, France, have achieved good modulation of the reflected terahertz wave (reflectivity R = 3–85%) in GaAs by means of optical pumping of the semiconductor. In a report published in the August 1 issue of *Optics Letters* (p. 1992), the researchers said that their finding can be useful in applications such as all-optical devices that allow transfer of information from the optical spectral band to the THz band, opto-THz switches, and modulators. In their ground state, high-resistivity semiconductors are transparent and virtually dispersion-free for THz radiation. However, photoexcited semiconductors exhibit a strong interaction with THz light mediated by free carriers. Fine tuning of the strength of the interaction by the intensity and/or wavelength of optical excitation then leads to interesting phenomena that are directly utilizable for THz light modulation and switching.

The scientists used high-resistivity semiconductor (GaAs and Si) wafers as samples. In their experiments, a Ti:sapphire multipass optical amplifier delivered 1 mJ light pulses with a duration of 55 fs and a mean wavelength of 810 nm at a repetition rate of 1 kHz. One part of the beam (pump) was used for the excitation of the sample surface. Another part of the beam was used for the generation and detection of broadband THz (probe) pulses. The THz pulse, generated at a separate sample, was incident on and transmitted through the GaAs or Si sample under test. The pump pulse was allowed to be incident upon the entrance face of the sample after the THz pulse had entered the sample, but while it was still completely inside the sample. A fraction of the THz pulse was reflected at the exit face of the sample and then propagated back to the entrance face, where a fraction was again reflected back toward the exit face. The transmitted THz signal then consisted of the initial transmitted pulse as well as the echo arising from the reflection at the entrance face. The internal THz reflectance on the photoexcited surface (entrance face) depended dramatically on the excited layer thickness (controlled by the wavelength of the optical pump pulse) and on its conductivity (controlled by the pump pulse intensity). An analytical model was used to explain the experimental result.

VIVEK RANJAN

Extended Low-Temperature Plasma-Assisted Bonding Enhances Wafer Bonding Strength Uniformity

In a plasma-assisted low-temperature Si/Si wafer bonding process, a major concern is how to avoid voids at the bonding interface and improve bonding strength. However, when using

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