ness of the TeSW-prepared p-Si is very thin and the rms roughness is only 1.6 nm.

The researchers also performed a controlled experiment of p-Si formation using NaOH etchant at various pH levels, but they observed no efficient PL emission from any of the NaOH-prepared samples. The researchers pointed out that the reproducibility appeared to be a problem for the photoetched p-Si synthesis technique. They point out that others have suggested that the preexisting state of the Si surface plays a decisive role in determining p-Si formation.

TAO XU

High Frictional Anisotropy Found on Quasicrystal Surface

A collaboration of scientists from Lawrence Berkeley National Laboratory (Berkeley Lab) and the Ames Laboratory at Iowa State University have determined that friction along the surface of a quasicrystal in the direction of a periodic geometric configuration is about eight times greater than in the direction where the geometric configuration is aperiodic (i.e., without regularity). In an article published in the August 26 issue of *Science* (p. 1354), the research collaboration led by Miquel Salmeron, a physicist with Berkeley Lab's Materials Sciences Division, and Patricia Thiel, a chemist in Ames Lab, reports that geometric periodicity was confirmed by rows of atoms that formed a Fibonacci sequence, a numerical pattern often observed in quasicrystals. The research combined the use of scanning tunneling microscopy (STM) and atomic force microscopy (AFM) to observe the surface structures and measure the frictional forces.

"That we can get such a large difference in frictional force just by scratching the surface of a material in a different direction was a major surprise," said Salmeron. "Our results reveal a strong connection between interface atomic structure and the mechanisms by which frictional energy is dissipated."

At the atomic level, when two surfaces come in contact, the chemical bonds and clouds of electrons in their respective atoms create frictional force and cause energy to be dissipated. It has long been known that friction is greater between surfaces of identical crystallographic orientation than between surfaces of differing orientation. Some recent studies have reported frictional differences, or anisotropy, less than a factor of 3 for incommensurate crystal surfaces when there were periodicity differences.

To measure the frictional effects due to periodicity alone and not to other factors such as chemical differences, the researchers worked with decagonal quasicrystals of an aluminum-nickel-cobalt (Al-Ni-Co) alloy. Stacked planes of Al-Ni-Co crystals exhibit both tenfold and twofold rotational symmetry. By cutting a single Al-Ni-Co quasicrystal parallel to its tenfold axis, the researchers were able to produce a two-dimensional surface with one periodic axis and one aperiodic axis, separated by 90°. In order to avoid surface damage and also wear of the tip used in the combined AFM–STM instrument, a TiN tip passivated with a molecular layer of hexadecane thiol was used.

"Strong friction anisotropy was observed when the AFM tip slid along the two directions: high friction along the periodic direction, and low friction along the aperiodic direction," said co-researcher J.Y. Park of Berkeley Lab. "We believe the source of this friction has both an electronic and a phononic contribution." Phonons are quantized vibrations in a crystal lattice. The frictional anisotropy vanished when the samples were oxidized by exposure to air.

The researchers said that new theoretical models are needed to determine whether the electronic or phononic contributions dominate the observed frictional anisotropy.

La-Doped 0.3PZN-0.7PZT Ceramics with Pure Perovskite Phase Synthesized

It is well known that the single-crystal relaxor ferroelectrics, $Pb(Zn_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PZN-PT) and $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMN-PT), possess ultrahigh piezoelectric properties. However, in comparison with single crystals, ceramics have advantages including low production cost, homogeneous compositions, tunable properties for applications such as medical ultrasonic probes and microfine actuators. Although pure perovskite PMN-PT ceramics have been synthesized near their morphotropic phase boundary (MPB), until now success has eluded such efforts for PZN-PT. In the August issue of the *Journal of the American Ceramic Society* (p. 2310; DOI: 10.111/j.1551-2916.2005.00391.x), G. Deng and colleagues from the Shanghai Institute of Ceramics, China, have reported their success in synthesizing pure perovskite ceramics of PZN-PZT, as an alternative to PZN-PT, near their MPB. The researchers have observed much higher piezoelectric and electromechanical coupling coefficients for their newly synthesized material than those reported earlier.

Because their goal was to find good piezoelectric values, the researchers explored $0.3Pb(Zn_{1/3}Nb_{2/3})O_3$-$0.7Pb_{0.96}La_{0.04}(Zr_xTi_{1-x})_{0.99}O_3$ [La-doped 0.3PZN-0.7PZT], with x ranging from 50 to 53 stepwise by 0.5 (i.e., values around the MPB). The samples were prepared by the two-step hot-pressing process. X-ray diffractometry (XRD) revealed that the microstructures of these complex compounds experience a gradual transition process from tetragonal to rhombohedral phase with an increase in the Zr/Ti ratio. The MPB is defined as the coexistence of tetragonal and rhombohedral phases. Therefore, the research team deduced that the MPB in their samples can be delimited in the range of Zr/Ti = 51/49–52/48. In addition, XRD revealed that samples in the entire composition range had pure perovskite structure. The piezoelectric coefficient (d_{33}) was measured using a quasi-static piezoelectric d_{33} meter. The maximum of d_{33} was found to be 845 pC/N for Zr/Ti = 51/49, which the researchers indicate is much higher than the previously reported value of 670 pC/N. Electromechanical coupling was measured using an impedance analyzer, and its maximum value was observed to be 0.7 for the same composition Zr/Ti = 51/49 and larger than the previously reported value of 0.65. Dielectric coefficient and dielectric loss were measured using the impedance analyzer. This series of piezoelectric ceramics have high T_{max} (206–213°C) and large dielectric constants (3321–4088 for poled and 2048–2796 for depoled samples). The researchers concluded that these high values of piezoelectric properties make 0.3PZN-0.7PLZT an interesting material for potential applications in transducers, actuators, and probes.

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