

sufficient time period ($t = 1800$ s), two DWs approaching the defects from each side are effectively stationary.

The line defects act as "chalk lines" to straighten the DWs in the magnetic recording layers. Only a few defects stabilize large areas of films. Good results were produced in field up to $\sim 2 H_c$. The researchers said that situations at higher fields ($H \sim 32 H_c$) and speeds of current recording technology (1 Gbit s^{-1}) need further studies.

LI ZENG

Spinodal Decomposition Underlies Evolution of Nanoporosity in De-Alloying

The selective dissolution of an alloy is a well-known de-alloying process with broad applications in the chemical industry. During the de-alloying process, the less noble elements of the alloy are dissolved while the more noble elements remain. After selective dissolution, a nanoporous sponge is formed by the remaining noble elements.

Although the chemical phenomenon is well documented, the physical mechanism of selective dissolution has remained unclear. A team of researchers from Johns Hopkins, Harvard, Northeastern, and Arizona State universities have developed a scenario for the de-alloying process, reporting in the March 22 issue of *Nature* that the effect known as spinodal decomposition is responsible for the characteristic nanoporosity size. Jonah Erlebacher of Johns Hopkins and his research team used critical potential as an index to construct a simulation model.

Basing their experiments on the de-alloying of Ag-Au alloy, Erlebacher and his research team placed the alloys into an electrolyte and measured the critical potential of the alloys with different alloy compositions. After the dissolution, scanning electron micrographs showed a nanoporous sponge composed of gold on the surface of the alloy with ligament spacings of the order of 10 nm.

The researchers proposed the following scenario. Initially, a single silver atom on a de-alloying surface is dissolved. Then, the nearby atoms are more easily dissolved because of the vacancy. But as a more noble element, the gold atoms on the surface do not dissolve. They agglomerate by diffusion into "islands." At first, the tops of the "islands" are gold-rich while the bases are not de-alloyed material. As more and more silver atoms are dissolved, the bases of the islands become exposed to the electrolyte.

"These mounds get undercut, increasing the surface area that gold must cover

to bring about passivation," according to the researchers. So, by agglomerating together while keeping enough surface area, the gold atoms evolve into a nanoporous sponge.

When the nanoporosity size is large, the sponge will grow slowly because of the time required for gold to diffuse. On the other hand, the sponge will also grow slowly if the nanoporosity size is small because, the researchers reported, "short-length-scale fluctuations create much energetically unfavorable incipient interface between phases, inhibiting their growth." This effect, known as spinodal decomposition, is the reason why the nanoporosity

can have a characteristic spacing.

Based on their observations and critical potentials measurement, Erlebacher and his team developed a Monte Carlo model on the (111) alloy surface, covering the diffusion of silver and gold and the dissolution of silver, to simulate the de-alloying. They report that their model is consistent with both the predictions based on continuum theory and their experimental data. Compared with the well-known results of the vapor-phase deposition case, they said, their results do not depend on the reversibility of the aggregation, which suggests the existence of universal scaling laws for aggregation.

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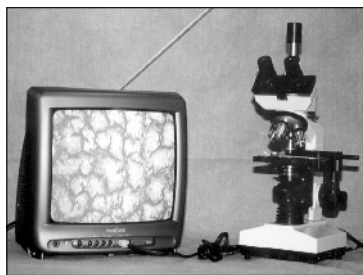
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Extending their Monte Carlo simulation to three dimensions, the researchers said it elucidates the process and the mechanism of the nanoporosity evolution in selective dissolution.

HAILONG HUANG

Molecular Random-Access Memory Cell Demonstrated

As a result of the common computer user's demands, both the software and hardware industries are struggling to push technological resources to the farthest limits possible. However, the traditional limits appear to be not that far away, so research focuses on faster and smaller microprocessors, faster and larger memory, and larger data-storage capabilities, for example. Researchers at Yale and Rice Universities have developed and demonstrated devices that exhibit electronically programmable and erasable memory bits compatible with conventional threshold levels, but at a molecular monolayer level. They reported their work in the May 28 issue of *Applied Physics Letters*.

Electronic memories that operate at the charge limit (single electron effects) have been previously demonstrated by other research teams, but without addressing yet the dimensional limit of a single molecule, which this team now believes is achievable. They have observed a charge storage in a self-assembled nanoscale molecular device that is operated as a random-access memory with practical thresholds and output under natural ambient operation, and with a bit retention time of 15 min. They said that their device can potentially be scaled to the single-molecule level.

The molecular systems investigated were Au-(1)-Au (1: 2'-amino-4-ethynylphenyl-4'-ethynylphenyl-5'-nitro-1-benzenethiolate); Au-(2)-Au (2: 4-ethynylphenyl-4'-ethynylphenyl-2'-nitro-1-benzenethiolate); Au-(3)-Au (3: 2'-amino-4-ethynylphenyl-4'-ethynylphenyl-1-benzenethiolate); and Au-(4)-Au (4: 4-ethynylphenyl-4'-ethynylphenyl-1-benzenethiolate). The first two combinations were observed to change conductivity state upon application of a voltage pulse, indicating the responsible molecular moiety. Although the size of the nanoscale structures built was determined by the limitations of the lithographic technique used for defining the contacts, there are no indications in the observed characteristics that limitations exist in scaling down to one the number of molecules in the active region of the device, assuming that an appropriate fabrication scheme can be identified.

CLAUDIU MUNTELE

Use of Area Array Detector for X-Ray Fluorescence Holography Allows Simultaneous Recording of the Full Hologram without Sacrificing Angular Accuracy

Holography has traditionally, as in the case of lasers, been limited by the radiation wavelength, the source size, and the detector resolving power. X-ray fluorescence holography (XFH) has recently been studied as a method for creating holograms of bulk structures with atomic-scale resolution. The primary hurdle to developing XFH into a practical investigative tool has been the difficulty associated with measuring the fluorescent radiation with an acceptable signal-to-noise ratio. While typically a solid-state detector with energy discrimination is employed, researchers at the Sincrotrone Trieste in Italy have developed a simpler method whereby an absorption filter is used in front of an area detector without energy resolution. They have increased their photon count rate by more than an order of magnitude without sacrificing angular accuracy.

As reported in the May 7 issue of *Applied Physics Letters*, the researchers performed an internal source XFH experiment using a position sensitive detector (i.e., an image plate with pixel size $150\ \mu\text{m}^2 \times 150\ \mu\text{m}^2$) along with an absorption filter to record the full hologram of a CoO single crystal. They employed an 8.0-keV monochromatic x-ray beam collimated to a $0.3\ \text{mm}^2 \times 0.3\ \text{mm}^2$ spot. A 50- μm -thick Fe absorber was placed between the sample and the detector in order to create an energy window. The fluorescence emitted by the Co atoms was incident on this Fe foil, causing the elastically scattered primary x-ray beam along with Co $k\alpha$ radiation to be absorbed, so that only Co $k\beta$ photons along with some inelastically scattered photons reached the detector. An intensity pattern was recorded by measuring the fluorescent radiation, leaving the sample in different directions, and an image of the (001) plane of Co atoms was reconstructed.

"An important point," said researcher Andrea Lausi, "is that this setup does not require complex or dedicated instrumentation. Since both area detectors and foil filters are readily available at synchrotron facilities, this simplified setup should open up XFH experiments to a much wider community."

The scientists found that the photon flux incident on the image plate, or detector, was $\approx 5 \times 10^8$ photons/s which represents a gain of approximately three orders of magnitude over XFH experiments that employ solid-state detectors. The entire image was

recorded on the position sensitive detector with an angular resolution better than $0.1^\circ \times 0.1^\circ$. They found that the recorded image was undistorted even though the measurement was performed at only a single photon energy, and images of the third, fourth, and fifth Co neighbors were visible up to a distance of greater than 7 Å from the emitter. Furthermore, the real-space image obtained from the experimental hologram was in good agreement with simulated data.

The researchers are excited by the ability to record x-ray holograms on an area detector, and Milos Kopecky said, "The combination of fast data collection times and high angular accuracy, which has not been demonstrated before, creates the possibility of time-resolved holographic imaging. This is a promising tool for imaging the structures of small clusters or molecules."

STEFFEN K. KALDOR

Dicyclopentadiene Serves as Automated Healing Agent of Cracks in Thermosetting Materials

When thermosetting polymeric materials are damaged by mechanical loading or thermal fatigue, cracks develop which may continue to grow and compromise their structural integrity. Recently, a team of researchers from the University of Illinois at Urbana-Champaign have developed a material system with the ability to automatically heal cracks. As reported in the February 15 issue of *Nature*, the system incorporates dicyclopentadiene (DCPD) as a healing agent into an epoxy matrix. The healing agent is microencapsulated within a urea-formaldehyde shell. When the cracks in the thermosetting material reach the 50–200 μm microcapsules, they rupture and release the healing agent into the crack plane. Once in the crack plane, the healing agent contacts an embedded catalyst, triggering polymerization of the healing agent and bonding the crack faces.

A transition-metal catalyst (Grubbs' catalyst) is used to initiate the living ring-opening metathesis polymerization (ROMP) with the DCPD. The ROMP reaction satisfies the diverse requirements of the self-healing system such as long shelf life, low monomer viscosity and volatility, rapid polymerization at ambient conditions, and low shrinkage upon polymerization.

The researchers confirmed their work with a series of materials characterizations and analysis. The results of solution-state and solid-state nuclear magnetic resonance offered information on the stability and activity of the Grubbs' catalyst in the epoxy