enriched SFA. The SFA vertically segregates to the top of the PS-PEO layer at the air–water interface.

The mixed films were characterized by atomic force microscopy (AFM), revealing nanoscale periodic structures. The AFM images showed that their surface structures are honeycomb-like, having a hump at the center with a periodicity of about 40 nm. The same pattern was shown in all films regardless of the polymer grafting density, but the ordering increased with increasing polymer grafting density.

Although the researchers prepared Langmuir–Blodgett films of a SFA and a PS-PEO diblock copolymer, more detailed structural analysis, such as the composition of the humps and honeycomb walls, and a systematic route to prepare this structured material need to be further investigated.

YUE HU

Ancient Rust-Proof Iron Pillar Possibly Protected by Layer of "Misawite" (δ-FeOOH)

A 1600-year-old wrought-iron pillar that stands near New Delhi, India, as a well-known landmark and tourist site has intrigued metallurgists and historians for centuries. Subjected to heat, humidity, and even a direct cannonball hit, the pillar has remained essentially rust-proof. Several theories have been suggested for its virtually rust-free condition. The mystery now appears to have been solved due to the work of metallurgist R. Balasubramaniam from the Indian Institute of Technology, Kanpur.

The Delhi iron pillar was built in the 4th century AD, and stands 23 ft tall with a diameter of 16.5 in. at the bottom and 12.5 in. at the top. It is estimated to weigh ~6.5 tons. It is considered to be the biggest hand-forged block of iron from antiquity. In an article published in the November issue of *Current Science*, Balasubramaniam demonstrates that the lack of rust is due to the formation of a protective layer of misawite (δ-FeOOH), as well as a layer of crystalline phosphates, catalyzed by the presence of comparatively high levels of phosphorus in the iron.

Rust samples from the pillar have been analyzed using x-ray diffraction, Fourier transform infrared spectroscopy, and Mossbauer spectroscopy. The samples were found to contain amorphous oxyhydroxides, including lepidocrocite (γ-FeOOH), goethite (α-FeOOH) and misawite (δ-FeOOH), magnetite ($Fe_{3-x}O_4$), and crystalline phosphates, mainly iron hydrogen phosphate hydrate ($FePO_4 \bullet H_3PO_4(4H_2O)$).

The initial corrosion of the iron, aided by slag inclusions, forms lepidocrocite and goethite, which enhances the concentration of P (>0.1% in the base metal) at the metal–scale interface. This catalyzes the formation of amorphous misawite (δ-FeOOH), which offers significant initial corrosion resistance. In addition, the P reacts with moisture and forms phosphoric acid, which leads to the precipitation of amorphous phosphates at the metal-oxide interface. The phosphates, which form a thin continuous layer next to the metal, minimize corrosion because of their inhibitive nature. Over time, the amorphous phosphates transform to a crystalline phase due to alternate wetting and drying cycles. This further enhances the corrosion resistance due to the low porosity and compactness of the crystalline phase.

Kinetics studies show that an initial fast corrosion rate occurs for about three years until the misawite layer is formed. Subsequently, the corrosion rate is negligible, with corrosion resistance lasting for centuries.

GOPAL RAO

Decrystallization, Magnetic-Property Changes Caused at Sub-Melting-Point Temperatures Using Microwave Processing

Crystalline to noncrystalline transformations in a bulk material typically require an intermediate liquid or gaseous state. Now, Rustum Roy and co-workers at The Pennsylvania State University have demonstrated that crystalline phases can be rendered noncrystalline in a bulk solid and hard magnets can be converted to soft magnets in the solid state, both in a matter of seconds using microwave processing at temperatures far below the melting temperatures of the materials. Their latest findings will appear as a rapid communication in the December issue of the *Journal of Materials Research*, and is currently available on-line (www.mrs.org).

Microwave processing has been explored for the thermal processing, synthesis, and sintering of materials, primarily ceramics, over the last two decades. Most researchers held that the reaction and heating is due to the electric-field vector (**E**) component of the microwaves. The magnetic-field component (**H**) was considered to be negligible in the energy loss of the microwave radiation. Earlier, the researchers at Penn State were able to separate the **E** and **H** peak intensities of 2.45 GHz (~12-cm wavelength) microwaves in a cavity with a separation distance of 4 cm. This enabled them to subject identical samples at the **E** and **H** component peaks and study the effects of each, with the caveat that the materials' reaction to the fields could distort the pure **E** and **H** fields. Using this apparatus, the researchers have previously demonstrated that the magnetic-field losses are probably a significant portion, and in some cases the dominant one, of the overall loss mechanism in several materials.

In their present study, the researchers placed pellets of a stoichiometric mixture of the constituent oxides of $BaFe_{12}O_{19}$ ($BaCO_3$ and Fe_3O_4) in their apparatus in the **E**-field and **H**-field peaks of the 2.45-GHz microwaves. When placed in the **H** field, the material completely decrystallized in as little as 5 s, as shown by x-ray diffraction. In the **E** field, the material formed euhedral crystals of $BaFe_{12}O_{19}$. The temperatures of the specimens were closely monitored and did not go above 1200°C in the **H** field and 1400°C in the **E** field, well below the melting temperature. Similarly, pellets of the ferrite Fe_3O_4 placed in the **H** field rapidly decrystallized in less than 60 s. When subjected to the **E** field, Fe_2O_3 crystal peaks were observed in x-ray diffraction measurements of the samples. The microstructures of the decrystallized specimens consisted of smooth wavelike topologies separated by ~2 μm and made up of small contiguous points. The researchers were unable to explain this microstructural evolution.

In addition, the magnetic properties (B–**H** curves and saturation magnetization) of the samples from the **E** field and **H** field were measured and compared to a sample subjected to the usual multimode microwaves. The magnetic saturation moments and B–**H** curves were very different for all three. In particular, the decrystallized $BaFe_{12}O_{19}$ ferrite sample (subjected to the **H** field) was found to have become a soft magnet. This was attributed to the fact that different sublattices are excited for the different processing modes, since a crystalline material is comprised of a crystal lattice and a magnetic sublattice. According to the researchers, this suggests the possibility of "tuning" ferromagnetic materials using **H** field microwave processing.

This work possibly opens two synthesis routes. First, it might now be possible, using the microwave magnetic field, to decrystallize *bulk* solid materials without going through a liquid or other state. Second, magnetic properties of a material now appear to be amenable to control using appropriate electric- and magnetic-field components of microwaves.

GOPAL RAO

Solar Radiation Provides Inexpensive Substitute for Laser Surgical Technology

Because of their high power density, some of the most typical effects of surgical lasers on biological tissue are fast and