MAYA BLUE PAINT

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It has been noted by many people who have had the privilege of exploring Mayan ruins that there is a stunning blue color that has been preserved amazing well for centuries. Considering the tropical jungle is quite a hostile environment, the tenacity of this "paint" is remarkable. It had been suggested that this "paint" was made by mixing indigo dye with clay, but this did not explain its special characteristics. Recent work by Miguel José-Yacamán at the National University of Mexico and colleagues[2] has revealed what is special about this material, which is called Maya blue paint. They collected specimens in Mexico at archeologic sites known as Jaina Island and Palenque. Then they examined the specimens with high-resolution transmission electron microscopy (TEM), scanning electron microscopy (SEM) coupled with x-ray microanalysis, electron energy loss spectroscopy (EELS), and electron diffraction.

Elemental analysis revealed the presence of magnesium, silicon, aluminum, and oxygen, elements that would be expected from a certain type of clay known as palygorskite. Unexpectedly, iron was also detected. TEM demonstrated two regions, one containing well-defined plate- or needle-shaped crystals, the other an amorphous solid that contained small (nanometer) particles. The needle-shaped crystallites were identified by electron diffraction and x-ray microanalysis as palygorskite, probably with a chemical composition of $Mg_5(Si,Al)_8O_{20}(OH)_2 \cdot 8H2O$. Atomic resolution images, that were obtained by Fourier transform of the digital image and application of masks, showed a periodic feature larger than the expected lattice distance on the crystallines, suggestive of a superlattice. This kind of superlattice was not seen in control specimens of palygorskite that were not mixed with indigo. Intercalation of indigo molecules might explain the corrosion resistance of Maya blue paint.

However, José-Yacamán *et al.* found that the material is more complex. The amorphous material was basically SiO_2, with particles of iron, chromium, manganese, titanium, and vanadium, iron and chromium being most common. These elements appeared in metallic form as well as oxides. Previously, these elements were considered to be impurities, but José-Yacamán *et al.* suggested that particles of these "impurities" have an important effect on the spectral qualities of the material, imparting the special blue color.

To test their theory, José-Yacamán *et al.* obtained clay from an ancient mine that could have been the source used by the ancient Mayans. The clay contained palygorskite. They mixed the clay with the type of indigo dye used by the Mayans and heated it at 100°C, according to pre-Hispanic methods. The resulting material had the same microstructure as Maya blue paint. Their conclusion was that the combination of an intercalated clay forming a superlattice and the metallic and oxide nanometer-sized particles creates a paint that, in modern terms, would be called a nanostructured material. One would speculate that ancient makers of this paint worked in an empirical fashion, but they created a sophisticated paint that not only had a spectacular blue color, but it had an internal structure that allowed it to survive the ages relatively intact, much to our delight! ■

1. The author gratefully acknowledges Professor Miguel José-Yacamán, for reviewing this article.

2. José-Yacamán, M., Luis Rendón, J. Arenas, and Mari Carmen Serra Puche, Maya Blue Paint: An Ancient Nano-Structured Material, Science 273;223-225, 1996.

Front Page Image
SEM Photograph of a Female Mosquito (Aedes aegypt)

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 4 X 5 transparency.

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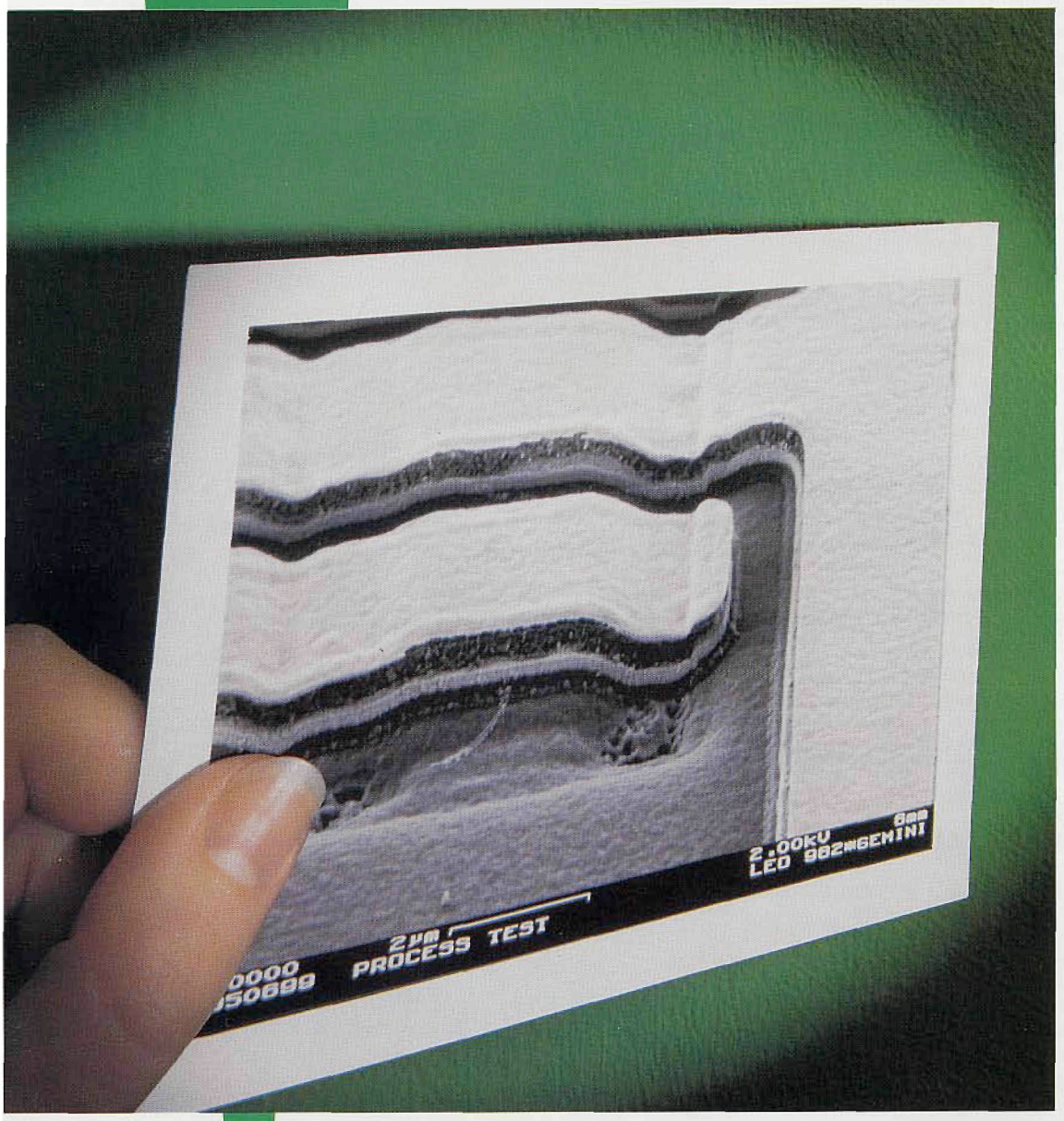
Don Grimes, Editor

Electron microscopy – the future is clear



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Wishing you the Merriest of Christmases And the Happiest of New Years

A New Year Editorial

With this issue we complete five full years of publishing this newsletter. Should you recall all four pages of our first issue, I trust you see some improvement.

Our objective remains, perhaps unlike any other, to publish material and information of interest to the working microscopist. As the publication grows in size, thanks in major part to increased advertising, the major challenge is to obtain articles/materials of real interest. Bottom line is that we do not wish to publish an "advertising catalog", and as advertising increases we are faced with the challenge **each** month of obtaining more and more articles and materials.

My first New Year's thanks go to the individuals that have contributed articles and materials in the past. It is interesting to note that while few individuals volunteer articles, etc., when asked to provide an article with a specific subject, most do respond. Sure, some are late, but most that are asked do respond.

My next thanks goes to those manufacturers and suppliers who have elected to support the publication with their advertising. It is most satisfying that the majority of companies that advertise with us continue to do so. Many, but certainly not all, are represented in this issue. Should you, Dr./Mr./Ms. Reader, occasionally find the publication of value, you might do me a major favor and express your appreciation to their local representatives.

My last thanks goes to the management, both elected and professional, of the Microscopy Society of America and the Microbeam Analysis Society. Just as these individuals continue to assist us in the development of the publication, we attempt to provide what support we can in their various activities.

So, to the future! Our first hope is that we can find the help in the industry to improve the content of the publication. If we are unable to find this assistance, our options seem to be twofold:

1) To decrease publication from 10 times a year to, say, 6 times a year.

2) To hire one or more technical editors. To do so, unfortunately, would require that we charge a modest fee for subscriptions.

Neither of the above options are very exciting to us. The bottom line is our hope that **more** of you will help in making the publication worthwhile - both for you to read and us to publish.

Best regards for a nifty holiday season.

Don Grimes