gas bubbles which had to be bridged by 2212 grains that reformed during the solidification process."

So how to eliminate the formation of gas bubbles during the heating stage? Hellstrom and Larbalestier had met a variant of this problem earlier with Bi-2223 when they had noticed some residual porosity in samples of that material. Working with American Superconductor Corporation, they had jointly patented an overpressure process that closed up the small residual pores left after rolling the wire to tape, raising the current density by about 30%. Using this process, researchers Jianyi Jiang and Maxime Matras at FSU started reacting round, 0.8-mm-diameter Ag wires embedded with 666 Bi-2212 powder filaments, each 15 µm in diameter. Inserting this wire into an overpressure furnace at pressures of 1–100 bars during the heat-treating process prevented wire diameter expansion by Ag creep, allowing for the first full densification of the Bi-2212 phase. Measurement of the whole-conductor (or engineering) current density, $J_E$, revealed that $J_E$ increased by a factor of eight going from 1 bar to 100 bars pressure. The overpressure collapsed bubbles as they formed, leading to higher critical current density.

The research team made a test coil that reached 33.8 T. Larbalestier said, "This is not just a breakthrough result for short wire samples—it's a breakthrough using long samples that have been tested in a very high field magnet. The wires are now being scaled up to kilometer lengths with the wire producer, Oxford Superconducting Technology."

The research team wants to repeat this process in YBCO next which, they said, would be genuinely revolutionary for superconducting magnet technology because it would allow construction of multi-Tesla magnets in the 30–70 K regime where no other superconductor can operate.

**Tim Palucka**

Bio Focus

## Skin cancer probe applied to in-depth artwork investigation

A few years ago, W.S. Warren of Duke University (Durham, N.C.) saw an exhibit at the National Gallery in London on scientific methods for detecting art forgeries. "I walked through that exhibit, and at the end of that time realized that the technologies that were being used were the technologies of 30 to 40 years ago. And asked what would happen if we started using modern bioimaging technologies in this particular application," Warren said.

Warren's group at Duke University works on biomedical imaging techniques, where they have applied the pump-probe microscopy technique to provide high-resolution images of biological pigments in skin cancer research. Pump-probe microscopy is a nonlinear technique in which the signal intensity is proportional to the product of the intensities of two lasers, and less affected by light scattering. Using near-infrared wavelengths, skin can be probed to ~1 cm depth.

As reported in the February 4 issue of *PNAS* (DOI: 10.1073/pnas.1317230111; p. 1708), Tana Villafana demonstrated the feasibility of the pump-probe microscopy technique to detect forged paintings using mock paintings; this technique was used to investigate specific pigments in a 14th-century painting. Villafana is a graduate student in Warren's team and worked in collaboration with the North Carolina Museum of Art and the Washington National Gallery of Art.

There is actually a great deal of similarity between imaging skin and imaging a painting. Warren said, "There are many layers of painting and the layers are designed to replicate the refraction and scattering that you have at normal skin; that's what makes it look realistic. For example, Da Vinci, when he painted the Mona Lisa, put 40 layers of paint on the face." Therefore, he said, the issues associated with attempts to image through skin to detect cancer are the same when trying to figure out the various layers in paint.

What makes analysis of paint more complicated than skin is that skin has only a few different kinds of pigments—while the different kinds of pigments in a painting are limited only by the artist's imagination. To cope with the larger range of molecular pigments, an increased spectral range of pump and probe wavelengths was used. Furthermore, based on what is known about the palette used, for example, by renaissance painters, a library of different pigments was created that produce very different signals as a function of the pump-probe delay.

The great advantage of the technique is its nondestructive character. "The conventional method is to take a scalpel to the painting, take out a tiny chip, and do microscopy on that chip. So obviously that's destructive and obviously the sampling that you do is very incomplete," said Warren.

Jennifer Mass, senior scientist and adjunct professor at the Winterthur/University of Delaware Program in Art Conservation, welcomes the advent of this new technique. "Nondestructive analysis is commonly applied to the characterization of works of art, but nondestructive depth profiling is a particular challenge for the field. Femtosecond pump-probe microscopy is a welcome addition to our arsenal for investigating the structure, authenticity, technology of manufacture, and state of preservation of works of art."

The investigation of paintings is just a start. With a three-year grant from the US National Science Foundation, Warren's team will carry out further research on artwork exploration. One of the next subjects is the investigation of old pottery, where the signal from the iron oxide used for coloring can be used to image temperatures for glaze firing. While biomedical applications remain the main focus of his laboratory, Warren sees the work relating to art as a nice spin-off of biomedical research investment to benefit society in another way.

**Dirk Wouters**


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