Cryogenic Cooling Decreases Fabrication Time and Increases Stability of High-Temperature Superconductive Ceramic in Polymer Matrixes

Degradation of superconductive properties in high-temperature superconductive ceramics (HTSCs) is primarily due to continuous adsorption of water vapor during exposure to environmental conditions. Addition of a polymer is a common form to prevent this problem, but the procedures used for synthesizing such a composite usually go beyond a 12-h-long process. A group of researchers from National Taiwan University led by W.-F. Su, in collaboration with S. Nedilko from Kiev National Taras Shevchenko University in Ukraine, have applied cryogenic cooling in the composite fabrication process, reducing the time frame to under 1/2 h.

Their investigation involved a superconductive ceramic widely studied in the literature, Bi-2212 ($Bi_2Sr_2CaCu_2O_x$), as described in the August issue of the *Journal of the American Ceramic Society* (p. 2673; DOI: 10.1111/j.1551-2916.2007.01813.x). First, they prepared the ceramic using a two-stage precursor method. Separately, they mixed ethylene glycol dimethacrylate, an organic monomer, with benzoyl peroxide as an initiator in a flask and then immersed the flask in liquid nitrogen. After the mixture had frozen, they placed a sample of the ceramic on top of the frozen monomer inside the flask, and then sealed and evacuated the flask before retrieving the package from the liquid nitrogen. The monomer then filled the ceramic voids while thawing at room temperature. Finally, the researchers removed the thus-formed composite from the vacuum and polymerized it.

Characterization of the resulting composite using x-ray diffractometry (XRD) revealed that no damage or breakdown occurred in the original ceramic phase, which was still clearly present in the diffraction pattern. The scientists also measured resistivity and magnetic susceptibility for the superconducting volume fraction on both the ceramic and the composite, before and after exposure to water vapor. The results revealed that the changes in resistivity with increased temperature for both ceramic and composite were very similar and that both exhibited a superconducting transition temperature of 83 K. However, after exposure to 87% relative humidity (RH) for 30 days, the resistivity of the ceramic increased dramatically, whereas the composite retained its initial behavior.

The change in superconducting volume fraction, as measured by magnetic susceptibility, decreased in the composite by only 5% with respect to that of the ceramic. After exposure to 99% RH for 7 days, the superconducting volume fraction measured 18% less in the ceramic than in the composite. The superconducting transition temperature after such exposure remained the same for the composite, whereas it decreased to 79 K for the ceramic. Thus, the resultant composite required significantly less processing time while retaining the superconductive properties of Bi-2212 and also achieving additional improved environmental stability.

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Discovery of "Hidden" Quantum Order Improves Prospects for Quantum Supercomputers

An international team of scientists, led by G. Xu of The Johns Hopkins University, has detected a hidden magnetic "quantum order" that extends over

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