TOWARD SUPERCONDUCTING WIRES

In the energy industry, as much as 10% of all the power converted and transmitted is lost because of electrical resistance in wires and components. The development of high-critical-temperature superconducting wire could revolutionize the industry by cutting these losses to near zero, allowing electricity to be carried without resistance. Now, researchers from the Illinois Institute of Technology and the Argonne, Los Alamos, and Oak Ridge national laboratories are using the MR-CAT 10-ID beamline at the APS to gather new clues about the chemistry of candidate superconductor materials, such as ceramic oxide compounds composed of yttrium (a rare earth element), barium, and copper. This particular class of superconducting oxides exhibits promising properties, including a critical temperature above the boiling temperature of liquid nitrogen, excellent current transport characteristics, and good performance in strong magnetic fields—such as those that occur in motors and transformers.

Numerous research groups around the world have focused on growing epitaxial films of $MBa_2Cu_3O_{7-x}$ (known as the M-123 phase), in which M is either the metal yttrium or another rare earth element, such as erbium or neodymium. Such films become superconducting at around -183° C. But more information is needed about how to control the growth of these ceramic films if they are to be made into viable zero-resistance wires for use in electrical conversion and transmission equipment.

One approach to making superconducting wire involves coating a textured metal substrate with M-123 to produce an epitaxial film. Such coated conductors are seen as the way forward for high-current and high-voltage applications because they should cost about the same as copper wires and be commercially viable even when the required cooling is taken into account.

Current synthetic schemes for making these coated conductors require the deposition of a film of M-123 onto a textured substrate in such a way that the texture of the substrate is adopted by the film. In order to make this happen, several buffer layers are applied to the substrate first to prevent substrate atoms from diffusing into the film. Each step of the substrate fabrication and film synthesis process requires meticulous attention to detail.

The researchers are exploiting the combined techniques of Raman spectroscopy and synchrotron-based x-ray diffraction to help them understand how the multilayered superstructure needed to form such coated conductors evolves during processing.

Raman spectroscopy data are providing information about phase purity, crystal morphology, and overall texture development, leading to identification of the best specimens for detailed x-ray diffraction analysis at MR-CAT. The spatially resolved diffraction measurements (Fig. 1) have allowed the researchers to discern how well the M-123 film texture mimics the underlying substrate, as well as to observe the influence of the buffer layer on the quality of the M-123 films.

An important aspect of this research is that the diffraction space mapping measurements were performed at high resolution with a robust signal-to-noise ratio, which allowed the researchers to examine in detail the features that reveal structural effects in the films. Such studies would not have been possible without the brilliance and concomitant energy resolution afforded by the APS.

The lower image in Fig. 1 shows the diffraction space map in the vicinity of the Eu-123 (006) reflection which occurs in close proxim-

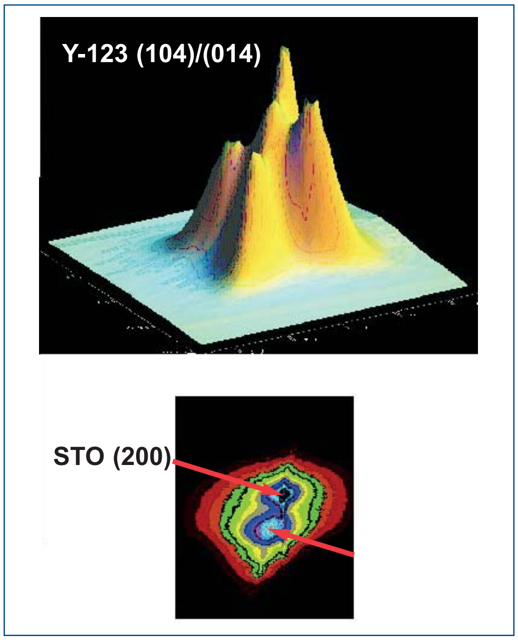

Fig. 1. The features revealed by this high-resolution diffraction space mapping have shed new light on the consequences of structural changes in the M-123 films, which will help researchers choose appropriate procedures for depositing the buffer layer and the M-123 film itself. This, in turn, will allow them to fabricate high-performance coated conductors more effectively and bodes well for rapid progress in electric power technology programs worldwide.

ity to the (200) reflection of the strontium titanate (STO) substrate. From the precisely measured two-theta and omega values we can determine the degree of strain in the Eu-123 layer near the interface with the STO surface. The upper image in Fig. 1 is the diffraction space map in the vicinity of the (104)/(014) reflections of twinned Y-123 on STO. The map evidences the proper development of the twin structure required for optimum superconducting properties. A detailed explanation of the results in Fig. 1 is presented in the appended reference

The features revealed by this high-resolution diffraction space mapping have shed new light on the consequences of structural changes in the M-123 films. Such information will help researchers make high-performance coated conductors, which bodes well for rapid progress in electric power technology programs worldwide. The implementation of M-123-based superconducting generators, transformers, and transmission lines might be possible in the coming decade. — *David Bradley*

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See: K. Venkataraman[1], A.J. Kropf[1], C.U. Segre[2], Q.X. Jia[3], A. Goyal[4], B.W. Kang[4], S. Chattopadhyay[1], H. You[1], and V.A. Maroni[1], “Detection of Interfacial Strain and Phase Separation in $MBa_2Cu_3O_{7-x}$ Thin Films Using Raman Spectroscopy and X-ray Diffraction Space Mapping,” Physica C **402**, 1 (2004).

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