Rare-earth Information Center Insight

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DOE Superconducting Wire Review 2000

Each year in July, the Office of Utility Technologies, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, holds its annual peer review of the Superconductivity Program for Electric Systems in Washington, DC, and for the past several years, I have reported on these reviews. As in previous years, significant progress on demonstration projects in a number of areas, including power cables, fault current limiters, and motors, continues to be made with these projects, actually beginning the test phase. As the only conductors available in the lengths required for these projects are based Bi-Sr-Ca-Cu-O (BISCCO), no rare earths are involved. However, the so-called "second-generation" conductors are based on $YBa_2Cu_3O_7$ (Y123) biaxially textured films on buffered metallic substrates. These high-temperature superconductors are extremely anisotropic; and for the orthorhombic Y123 material, the superconducting current flows almost exclusively in the basal plane, and even high angle grain boundaries between basal planes result in losses. As a consequence, to carry currents over long lengths, something that is essentially a long thin single crystal must be produced. As has previously been discussed in the *RIC Insight*, methods of depositing highly textured superconducting films on highly textured substrate have been developed. A group, led by Los Alamos National Laboratory (LANL), is using ion-beam-assisted deposition (IBAD) to deposit a textured buffer layer on a commercial metal tape. In this process, texture is induced by an ion beam impinging on the sample during deposition. A second team, led by Oak Ridge National Laboratory (ORNL), is developing a process called Rolling Assisted Biaxial Textured Substrates (RABiTS). Where the LANL approach starts with an untextured metal ribbon and deposits a textured substrate, the RABiTS approach uses a textured Ni substrate produced by a conventional rolling process. Unfortunately, it is not possible to deposit Y123 directly on Ni as Ni diffuses into Y123 replacing Cu, which destroys the superconductivity. Oxidation does not exactly do the Ni a lot of good either. As a result, this process also requires a ceramic buffer layer, which acts as a diffusion barrier for the Ni. A third attractive alternative, called inclined substrate deposition, is currently being evaluated for long lengths by Argonne National Laboratory (ANL). In this process, the substrate is simply inclined with respect to the vapor flux during the e-beam deposition of MgO. Texture is developed very rapidly, but unfortunately the resulting surface is stepped, which is not ideal for the deposition of the superconductor. Progress this year has been mostly incremental with significant advances in the understanding of the sources of various problems. A major problem, which has limited the total current that can be carried by the conductor, is that when the layer of superconductor exceeded 1 μm, only the first μm carried significant current. This has been shown to be because of the formation of voids in the thicker layer. Since

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the underlying metal substrates and buffer layers are of order 100 μm thick, this puts a severe limit on the engineering critical currents that can be obtained. LANL has addressed this problem by going to a multilayer approach where thin layers of $SmBa_2Cu_3O_7$ (Sm123) are placed between sub-μm thick Y123 layers. The Sm123 tends to grow with a smoother surface than the Y123, but no one has produced films of Sm123 carry high currents. It is my belief that this is because of problems with grain boundary stochiometry in the Sm123. In the layered approach, the Sm123 grows epitaxially on the Y123 and smoothes out the surface. The Sm123 grain boundaries make up an insignificant portion of the total cross section and do not significantly degrade overall performance.

For large scale applications, long lengths of conductors are required. The economics of vacuum processes are not particularly good for meeting cost goals, and thus there is considerable interest in non-vacuum processes for the deposition of both the buffer layers and the Y123 superconducting layer. ORNL, Sandia National Laboratory and Brookhaven National Laboratory are all working on different aspects of this problem. For the Y123 layer, different versions of the BaF process are being developed. In this process, a precursor layer of CuO, Y_2O_3 and BaF_2 is deposited on the buffered substrate. Preferably, this is done by a wet chemical solution process. When heated in the presence of oxygen and water vapor, the precursor converts to Y123 and HF. The rate limiting step has been identified as the rate of HF removal, and considerable effort has been made to insure uniform removal of the HF.

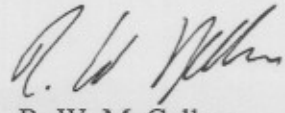
A number of companies, including 3M, American Superconductor and Intermagnetics General are heavily involved in the development of coated conductors. For information on the DOE Superconductivity Program for Electric Energy Systems, contact James Daley (James.Daley@hq.doe.gov).

Shelf-life of Sr Doped $LaMnO_3$

Rare earth researchers have always been aware that our samples may degrade with time. For us it is an inconvenience that can often be avoided by sealing the samples in quartz or storing them in a glove box. For industrial chemicals, this is not always an option. Sr doped $LaMnO_3$ (LSM) is the most common cathode material for solid oxide fuel cells, and therefore knowledge of the degradation of this material as a function of time under normal storage conditions is of considerable interest. S. P. Jiang et al. {*J. Mater. Sci.* **35**, 2735-41 (2000)} have recently reported on the the effect of humidity and RE-site stochiometry on the shelf-life of LSM materials. Wet chemical synthesis methods were used to prepare samples of $(La_{0.8}Sr_{0.2})_{1.0}MnO_3$ and $(La_{0.8}Sr_{0.2})_{0.9}MnO_3$. LSM powders, inks and as-fired coatings were then stored for ~350 days in air with 20-30% relative humidity and 84% relative humidity. In contrast to previous results for RE-site over-stochiometric compositions, no macroscopic degradation of the samples was observed. In both humidity levels, un-reacted La_2O_3 was converted to $La(OH)_3$. The presence of La_2O_3 and $La(OH)_3$ peaks in the x-ray diffraction patterns were not associated with poor adhesion and unstable electrochemical performance.

Conferences

Permanet Magnet Systems: From Concept through Commercialization, September 25-27, 2000, Atlanta, GA, USA, www.goradv.com, Email: gorham@goradv.com.



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