Organization:	**Oak Ridge National Laboratory**
Project Title:	**Buffer Layer Strategic Research and Development**
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FY 2002 Funding:	**$750K (DOE to ORNL)**

Project Purpose and FY 2002 Objectives: To develop a basic understanding of and practical synthesis paths for epitaxial buffer layers on textured metal tapes for coated conductors. The primary objectives for FY 2002 are:

1. Investigate single buffer-layers for YBCO/RABiTS
2. Optimize epitaxial buffer layers on metal alloy substrates.
3. Optimize sulfur treatment to demonstrate consistent epitaxial seed layer deposition.

FY 2002 Performance and FY 2003 Plans:

Because of the need to produce a simpler and more robust buffer-layer architecture for the RABiTS approach ORNL focused on a new task of developing single buffer layers in FY 2002. Two effective, potential single-layer candidates, $LaMnO_3$ (LMO) and $La_2Zr_2O_7$ (LZO), were identified. These buffers can be grown epitaxially on Ni or Ni-W metal tapes by scalable vapor and/or solution techniques. In addition, they are good Ni diffusion barriers, and they are structurally and chemically compatible with high-J_c YBCO coatings. High critical current density values of over 10^6 A/cm^2 have been obtained for PLD YBCO films.

We have extended our study of the S superstructure's effect on seed buffer layer nucleation to a wide group of oxides used in coated conductor architectures, and (001) textured metal surfaces other than pure Ni. Using in-situ RHEED, the nucleation of oxides with the fluorite structure (CeO_2, YSZ), the RE_2O_3 structure (Y_2O_3, Gd_2O_3), the perovskite structure ($SrTiO_3$, $LaMnO_3$), and the rock salt structure (MgO) were studied. The metal substrates used were pure Ni, Ni-3%W, and Ni-13%Cr textured tapes, and Pd (001) textured overlayers. With the exception of MgO, epitaxial (001) seed-layer growth was achieved only on a $c(2\times2)$ sulfur template for all four of the metal surfaces considered. Of particular interest are the cases of $SrTiO_3$ and CeO_2 layers on Pd, which required the presence of the S template on the metal surface although the lattice mismatch with the Pd substrate is only 1.7% for CeO_2 and 0.4% for STO. For MgO seed layers, fully epitaxial growth occurred only on the clean and pure metal surface. The different results are explained in terms of structural matching of the S $c(2\times2)$ template with oxygen (00l) seed layer sub-planes, and the different strength of the cation-oxygen bond in these classes of oxides.

The FY 2003 plans are:

1. Research and develop faster, potentially lower cost, and simpler RABiTS buffer-layer architectures that are compatible with *ex-situ* BaF_2 or TFA processes.
2. Collaborate with LANL and ANL to develop suitable buffer architectures on IBAD-MgO and ISD-MgO substrates for compatibility with *ex situ* YBCO.
3. Continue fundamental studies of epitaxial growth on textured non-magnetic substrates, including copper and copper alloys.
4. Develop a viable high rate solution process to fabricate high quality buffer layers.

FY 2002 Results:

An alternative buffer layer architecture that is suitable for Ni-13%Cr and other highly reactive Ni-alloys was developed, where rapid oxidation prohibits growth of good seed layers. The new architecture consists of a thin Pd film (100-nm thick or less), an MgO film and a $LaMnO_3$ cap layer. MgO was selected as a buffer layer because of its low oxygen diffusion coefficient and the low deposition temperature required for epitaxial growth. The Pd layer acts as a structural template for the epitaxial growth of MgO, and the $LaMnO_3$ cap layer is used due to its good lattice match with YBCO and for its ease of growth on MgO. YBCO films on such architecture have shown J_c as high as 3 MA/cm^2 at 77 K in self-field.

Solution precursor approaches have been examined as potential low-cost processes for manufacturing $YBa_2Cu_3O_{7-d}$ (YBCO) coated conductors. Although there has been significant progress in the development of low-cost manufacturing technologies for select components of the YBCO coated conductors, key deposition technologies must still be improved. To study the effect of c(2×2) sulfur superstructure on solution-based buffers, we have fabricated several Ni-W substrates with varying sulfur concentrations. Both Gd_2O_3 and $La_2Zr_2O_7$ (LZO) buffers were coated on these substrates and the effect of S superstructure on epitaxy was investigated. Initial studies indicate that sulfur superstructure is indeed *necessary* to reproducibly obtain highly cube textured solution buffers.

A single buffer layer of either $LaMnO_3$ or $La_2Zr_2O_7$ deposited on textured Ni and Ni-W tapes can be used for the deposition of YBCO, yielding J_c values that are comparable to those typically obtained using CeO_2/YSZ/Y_2O_3 tri-layers on identical substrates, i.e. in excess of 1 MA/cm^2 at 77 K and self-field. The LZO buffers were deposited using a low-cost sol-gel process, while the LMO buffers were deposited by rf magnetron sputtering. Effects of buffer-layer thickness were assessed for YBCO films deposited by PLD. These results show no observable differences in the texture or the microstructure, but both T_c and J_c increase with buffer layer thickness to the ~100-nm range. A high J_c of 1.9 MA/cm^2 was obtained on YBCO films grown on 3 coats of LZO-buffered Ni-W substrates. These results offer a new, promising route to coated-conductor fabrication using a single buffer layer processed using scalable solution deposition.

Collaborative work on non-RABiTS templates exploited the development at ORNL of $LaMnO_3$ as a cap buffer layer. YBCO coatings using both the *ex-situ* BaF_2 process and PLD on LMO-buffered MgO single crystal substrates yielded J_c values of over 4 MA/cm^2. Through collaboration with both LANL and ANL, MgO IBAD and MgO ISD substrates were also capped with LMO. In both cases, YBCO films by PLD showed J_c values comparable to the best previously obtained.

Research Integration: Five CRADA teams are working directly with ORNL staff members to develop the science base for buffer layers for coated conductors. These teams are led by AMSC, 3M, MicroCoating Technologies, Neocera, Oxford Superconducting Technology. Collaborations also are under way with universities and other national laboratories, including University of Florida, University of Kansas, University of Wisconsin-Madison, ANL, LANL, and SNL. Numerous publications (including a Web-based posting of the FY 2001 ORNL annual report) and presentations help assure transfer of information to industry.