IBAD Wire Making Techniques

HTS Coated Conductors -Fact Sheet

Performance Characteristics

- IBAD coated conductors have yielded high critical current levels of 220 amps/cm width in meter lengths cooled with liquid nitrogen.
- The ability to efficiently carry high electric currents with no resistive losses makes IBAD coated conductors suitable for many commercial power applications.

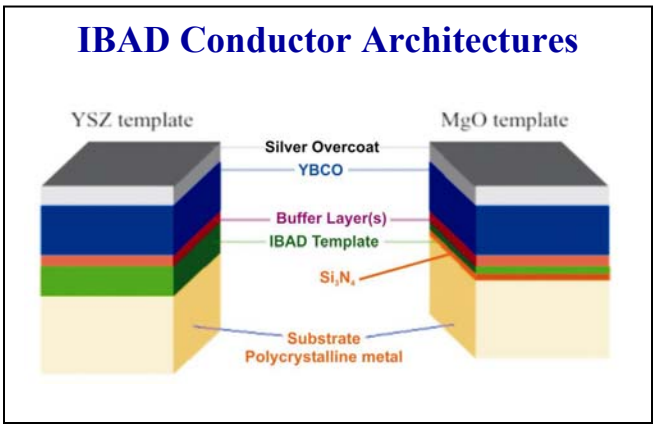
Commercial Potential

IBAD coated conductors have tremendous potential for electric power applications. Scaling up IBAD coated conductors could benefit several prototype electric power applications that are now being developed and field-tested at liquid nitrogen operating temperatures (77K). These applications include:

- power cables,
- motors,
- generators,
- current limiters, and
- transformers.

Ion Beam Assisted Deposition (IBAD) coated conductors have high current carrying capabilities, strong mechanical properties and extraordinary magnetic field tolerances.

Introduction



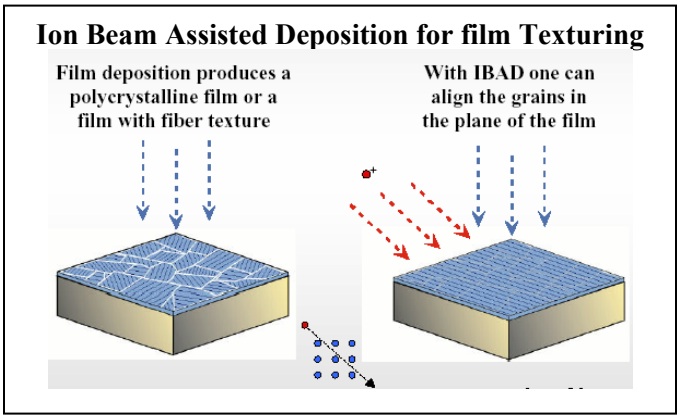
The materials architectures of IBAD/YSZ and IBAD MgO coated conductors

Soon after the discovery of high-temperature superconductors (HTS), one compound began to stand out as the most promising for high current carrying wire, namely $YBa_2Cu_3O_7$ (YBCO). It has excellent performance characteristics at temperatures up to 77K, where many device manufacturers eventually want to operate their equipment. However, the compound presented one serious problem: to get the best performance in a wire form, very slow and commercially impractical techniques were required to overcome the phenomenon of weak links.

Researchers at Los Alamos National Laboratory (LANL) have addressed the weak link problem by dramatically improving a technique first used by Fujikura of Japan, called Ion Beam Assisted Deposition (IBAD). In 1995 LANL announced achieving record performance by pulsed laser deposition (PLD) of YBCO on a template layer of yttrium stabilized zirconia (YSZ). Later, in cooperation with Stanford University, LANL demonstrated a template formation process that is 100 times faster by replacing the YSZ template material with magnesium oxide (MgO). Both materials provide excellent characteristics for subsequent deposition of a buffer layer, and finally YBCO. Because of the high degree of crystalline texture, the YBCO layer is strongly linked and has outstanding current carrying ability. Additionally, wires made under this process eliminate the need for high-cost silver required in the manufacture of first generation wire, yielding a significant cost reduction for second generation wires.

The IBAD Process

IBAD is carried out on thin strips of metal—usually nickel-chromium alloy—by bombarding a growing film of YSZ or MgO with ions at a few hundred eV. As the material is vapor-deposited on the metal tape an ion beam, also impinging on the tape, produces crystalline orientation in the growing film. The biaxial texture of an IBAD film structure is similar to a single-crystal oxide substrate (see adjacent figure), regardless of the crystallinity of the starting substrate. When completed, intermediate layers such as cerium oxide (CeO_2) can be deposited on the IBAD film allowing a crystal structure match between the IBAD and the YBCO layer which is subsequently deposited (see figure above for IBAD architectures).



Ion Beam Assisted Deposition produces biaxial texture on a polycrystalline base tape

Industrial Partners

Three CRADA teams are working directly with Los Alamos National Laboratory staff members to develop the industrial technology base to scale-up IBAD coated conductors:

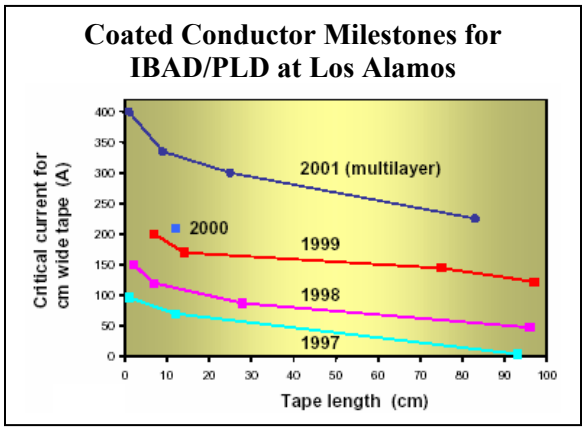
- **3M -** Jonathan Storer (651) 733-6462
- **American Superconductor -** John Scudiere (508) 836-4200
- **IGC SuperPower -** Venkat Selvamanickam (518) 346-1414

Contact Information

- Dean Peterson, Los Alamos National Laboratory dpeterson@lanl.gov
- James Daley, U.S. Department of Energy james.daley@hq.doe.gov
- Marshall Reed, U.S. Department of Energy marshall.reed@hq.doe.gov
- Roland George, U.S. Department of Energy roland.george@hq.doe.gov

Current Status

Surface roughness has been found to increase with increasing YBCO thickness, causing poor connectivity. In an attempt to solve this problem, LANL has investigated the effects of using multilayers of YBCO/samarium-barium-copper oxide that yielded highly smooth coatings. LANL has achieved critical current densities of 1.1 MA/cm^2 and critical currents of over 200 A/cm-width on a 1-meter length multilayer of YBCO/samarium-barium-copper-oxide deposited on an IBAD/YSZ template. LANL is now attempting to obtain similar high performance IBAD/MgO tapes since the latter architecture has higher commercial viability. The template formation process with MgO requires less than a minute to develop high quality texture. Other research efforts have been aimed towards investigating alternate substrates and buffer layers.



Over the years LANL has been achieving higher critical currents and longer length IBAD/PLD coated conductors.

Challenges Ahead

In its strategic research, LANL plans to enable increased performance, reduced cost, and increased continuous lengths of IBAD coated conductors. A primary challenge remains in optimizing deposition of IBAD films over longer tape lengths. Various approaches to continuous deposition of superconducting thick films on IBAD tapes will also be explored including PLD. To address these issues and accelerate the production of long length IBAD coated conductors, new facilities have been created at LANL's Research Park. This industrial user facility provides expertise and technology transfer from the national laboratories to industry partners. The Research Park laboratories have been supplied with the equipment necessary for continuous reel-to-reel processing of IBAD and/or PLD for coated conductor development. This allows industry researchers to explore tape processing parameters in a systematic way, moving a step forward towards the production of low-cost, long-length, high current carrying capacity HTS wires.

User Facilities Accelerate Technology Transfer: *Los Alamos Research Park is an industrial user facility that provides unique equipment and expertise for scaling-up and accelerating coated conductor development and market introduction.*