ISD

Wire Making Techniques

HTS Coated Conductors -Fact Sheet

Performance Characteristics

- ISD is a simple process that can be executed at room temperature.
- ISD does not require the assistance of an ion beam.
- The ISD process allows for high deposition rates and good epitaxial texture.

Commercial Potential

There are many potential applications for coated conductors due to their ability to support high currents in magnetic fields of 2 Tesla or greater. Scaling up ISD coated conductors could benefit several prototype applications which are now being developed and field-tested at liquid nitrogen temperature (77K). Electric power applications include:

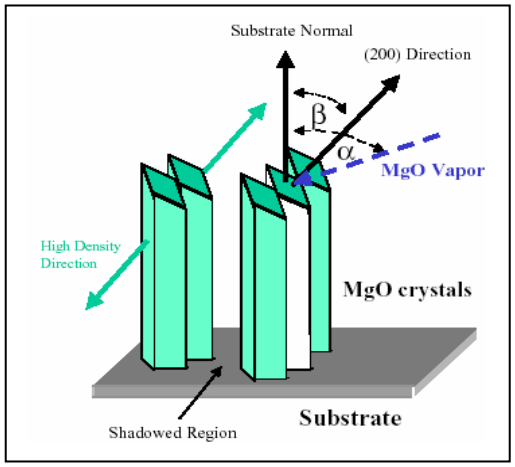
- power cables,
- motors,
- generators,
- current limiters, and
- transformers.

Inclined Substrate Deposition (ISD), characterized by its fast deposition rate, is an excellent candidate for fabrication of high quality coated conductors.

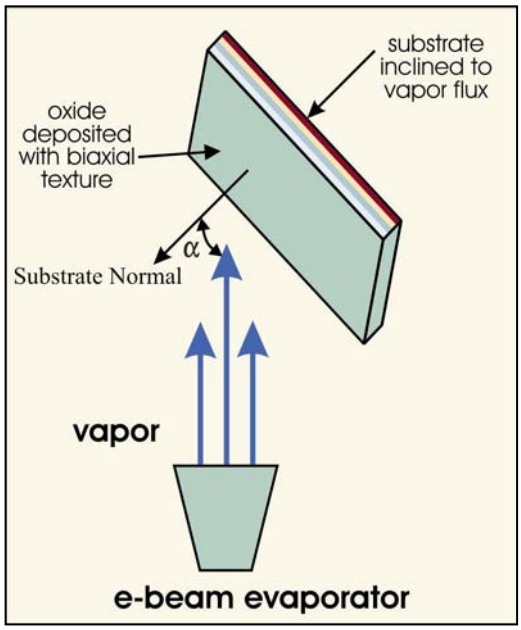
Introduction

After the discovery of high-temperature superconductors (HTS), yttrium-barium-copper-oxide (YBCO) began to stand out as the most promising material for carrying high currents. However, to achieve best performance in a wire form, processes were required that are too slow to be commercially viable. Additionally, HTS wires made by early techniques were characterized by high costs, due to the need to use large quantities of pure silver.

Researchers at Argonne National Laboratory (ANL) are investigating a method that addresses the obstacles in fabricating cost-effective HTS wires with high critical current densities. The Inclined Substrate Deposition (ISD) method is a simple approach characterized by a high deposition rate. ISD coated conductors also eliminate the need of expensive silver. In this process, substrates can achieve biaxial texture without the assistance of an ion beam. Instead, an e-beam evaporation system is used on an inclined substrate, resulting in a fast and reliable process.



The ISD process allows for rapid crystal growth on a metallic substrate.



ISD produces biaxial texture on a substrate inclined at an angle relative to the vapor source.

The ISD Process

In the ISD technique, a flexible metallic substrate, such as Hastelloy, is held at an angle to the direction of the plume of an e-beam evaporation system, and a biaxially textured oxide layer, such as magnesium oxide (MgO), is obtained (see adjacent figure). YBCO films are subsequently deposited on the ISD-MgO buffered substrates by pulsed laser deposition (PLD) or metalorganic chemical vapor deposition (MOCVD). The ISD method is especially attractive since it offers the potential to produce high–quality biaxially textured layers in a simple and efficient process.

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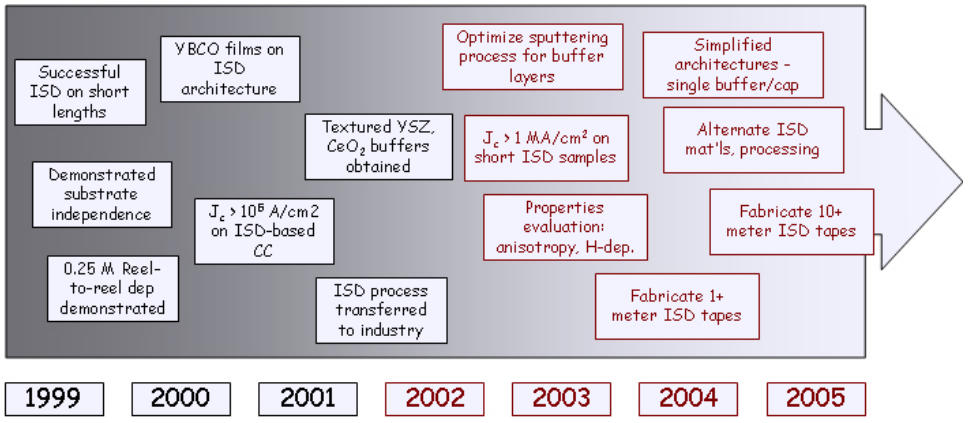
Industrial Partners

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

- **American Superconductor -** John Scudiere (508) 836-4200
- **IGC SuperPower -** Venkat Selvamanickam (518) 346-1414
- **Universal Energy Systems** Rabi Bhattacharya (937) 426-6900

Contact Information

- Balu Balachandran, Argonne National Laboratory balu@anl.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



ISD coated conductor milestones at Argonne National Laboratory

Current Status

Argonne National Laboratory (ANL) successfully achieved biaxially textured ISD-MgO template layers at deposition rates of 50 Å/sec without ion beam assistance in 2002. The ISD process has also been extended by studying the deposition of YBCO directly on silver surfaces. ANL plans to further improve ISD to obtain biaxial texture of MgO and yttrium-stabilized-zirconia (YSZ) on moving substrates at target deposition rates of 50-200 Å/sec. Additional plans remain to use ISD in obtaining short-length coated conductors with critical current densities of 1 MA/cm^2. Efforts will continue in the scale-up of buffer layers for ISD templates and the deposition of YBCO on silver. Other strategic research efforts include performing coated conductor characterization studies, investigating the current-limiting mechanisms of coated conductors, and measuring mechanical properties such as strength of metallic substrates and residual stresses in various layers of the coated conductor architecture. Close collaborations are held with Los Alamos and Oak Ridge National Laboratories in search for alternate buffer layers and improved deposition techniques. These collaborative efforts are essential to the scale-up of the ISD process that will enable industrial manufacture of long length coated conductors with uniform properties.

Challenges Ahead

The ISD technique is a relatively new process that needs further exploration; at the present stage, ISD has only been investigated in the production of short length samples (≈15-mm). However, Argonne National Laboratory is aiming to scale–up the ISD technique and fabricate long length tapes in the near future (see milestone chart above). As with other wiremaking techniques, the critical current density of ISD coated conductors decreases with increasing YBCO thickness. A challenge remains in obtaining thicker high-quality YBCO films that are capable of transporting large amounts of current suitable for electric power applications. Other generic challenges include achieving single texture in buffer layers and improving texture in continuous processing. ANL will use newly acquired processing and characterization equipment and will maintain its close collaborations with industrial partners and other national laboratories to accelerate the coated conductor development process, and transfer technology and expertise from the laboratories to industry.