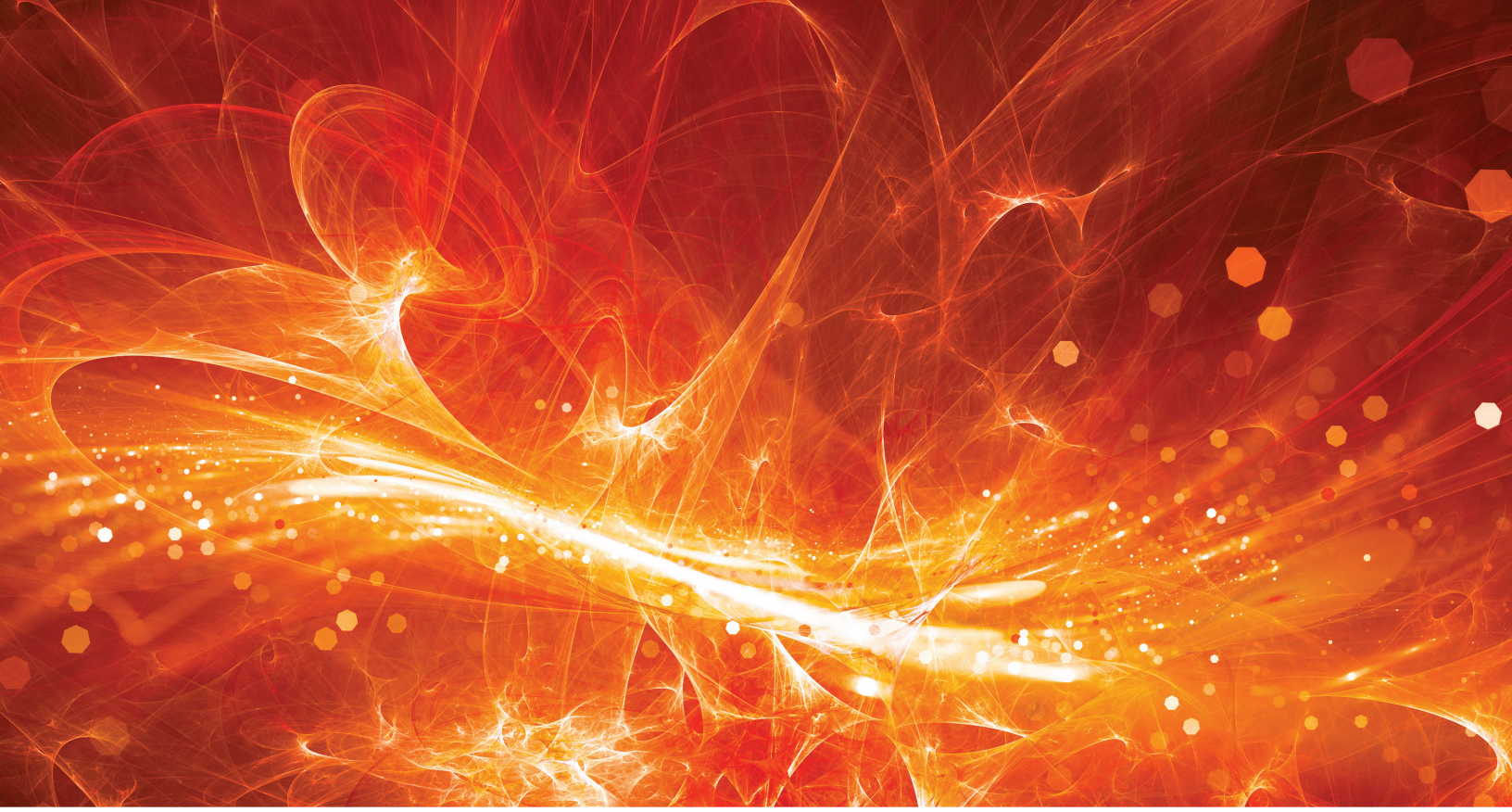


Physical Vapor Deposition (PVD) Production Systems for the Coated Conductor Industry

Engineered for High Quality, Long Life, and High Availability

The goal of PVD Products is to ensure our customers meet superconducting wire demand for new resilient, reliable, and sustainable power applications—including fusion, next-generation electricals, transmission cables, high-field magnets, fault current limiters, and energy storage—by providing them with the necessary production systems.

PVD PRODUCTS

Maximize Production Line Output

PVD Products Inc. has 27 years of experience making production and custom reel-to-reel deposition systems for the coated conductor industry. We supply quality vacuum equipment for the production of each layer of the coated conductor stack. Our tools are engineered with high-quality components and a history of long life with high uptime.

We offer systems for buffer layer deposition, both amorphous and epitaxial oxides. Our high-speed deposition techniques are proven to support high critical currents in high-temperature superconducting (HTS) products. The high throughput of the tools helps maximize production line output.

New pulsed laser deposition (PLD) tools for HTS layer deposition are currently in development. We are also developing solutions for the silver contact layer and copper encapsulation, with extremely high silver utilization and supporting reduced silver thickness.

PVD Products Inc. has

27 years
of experience

making production and custom reel-to-reel deposition systems for the coated conductor industry.

Reel-to-Reel Stanford Process Machine

PVD can help you grow all required layers of the HTS stack:

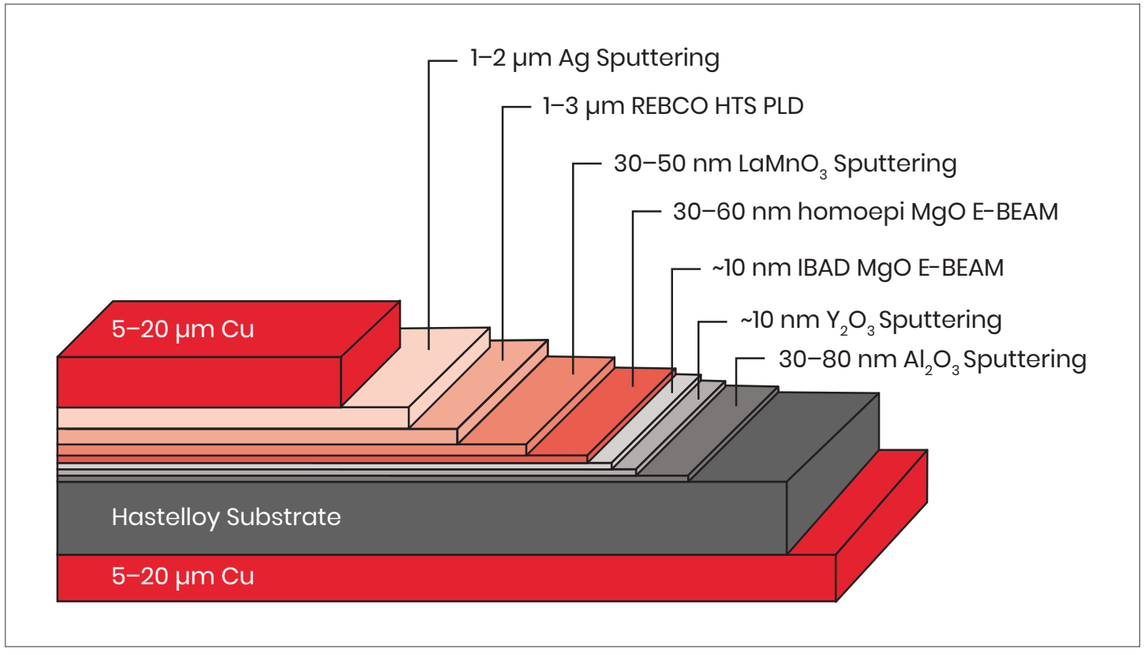
- Buffer: alumina and yttria amorphous oxides
- Buffer: magnesium oxide IBAD (Stanford Process or dual ion beam)
- Buffer: magnesium oxide homoepitaxial
- Buffer: lanthanum manganate or cerium oxide lattice matching
- REBCO layer by PLD
- Silver contact
- Copper encapsulation

Grow All Layers of the HTS Stack

Our applications expertise and connection to the coated conductor industry is strengthened as a subsidiary of High Temperature Superconductors (Santa Barbara, CA). This enables us to serve you better by offering tools with process recipe packages. As a full-spectrum equipment producer with strong roots in production and customized equipment, we can help you grow all required layers of the HTS stack.

For a given process, our tools can run up to 150 m/hr. And depending on the process, the systems can accept various tape widths and thicknesses. All tools run from an easy-to-use LabVIEW™ interface, with fully automatic, recipe-driven operation.

This brochure explains each tool further. Connect with PVD Products to discuss your coated conductor production equipment needs.



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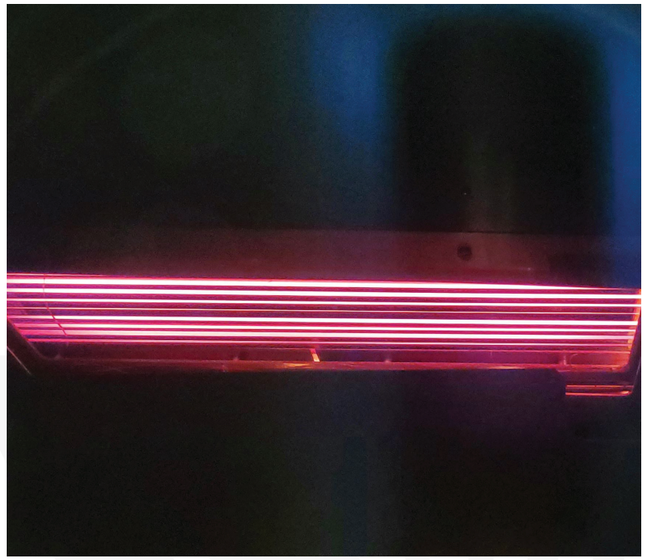
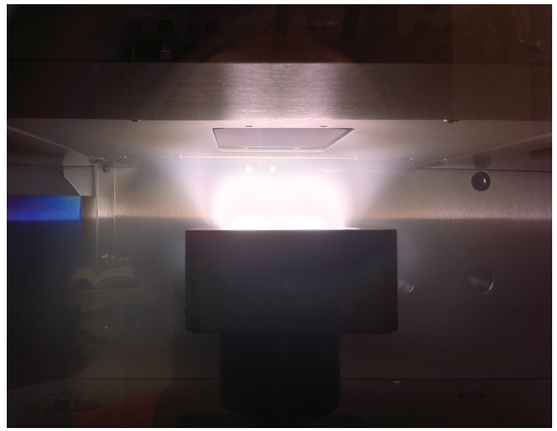
Deposit Alumina and Yttria Layers in a Single Run

The alumina (Al_2O_3) and yttria (Y_2O_3) amorphous layers are the first two layers of the buffer stack for most coated conductor products. The Al2O3 layer is deposited directly on the tape and serves as a diffusion barrier against metal ion migration from the tape. The Y_2O_3 layer serves as a seed layer for subsequent deposition of epitaxial magnesium oxide (MgO).

PVD Products has developed high-speed sputtering deposition for these two layers. This results in a tenfold increase in processing speed and provides a compact tool with tape speeds up to 150 m/hr.

You can choose between single and dual-process chamber solutions. The single chamber tool can be equipped with one or two deposition zones for single layer coating, or bilayer coating done sequentially. The dual-process chamber tool provides maximum throughput, allowing both materials to be deposited in a single run.





Extended Deposition Zones for Faster Epitaxial MgO Growth

Ion beam assisted deposition (IBAD) of MgO begins the required crystalline template for growing the REBCO layer. Angled ion beam bombardment happening at the same time as deposition (by evaporation or ion beam sputtering) creates a textured film on the amorphous oxide layers. This is followed by high-temperature homoepitaxy, which further improves crystallinity to support a sufficiently ordered REBCO film.

PVD Products has extensive IBAD/Epi experience. You can get MgO IBAD using either the “Stanford Process” (electron beam evaporation) or dual ion beam processing. Including large ion guns and large heaters can scale MgO deposition to higher speeds. Our highly advanced deposition tools have excellent subsequent REBCO performance at tape speeds up to 350 m/hr.

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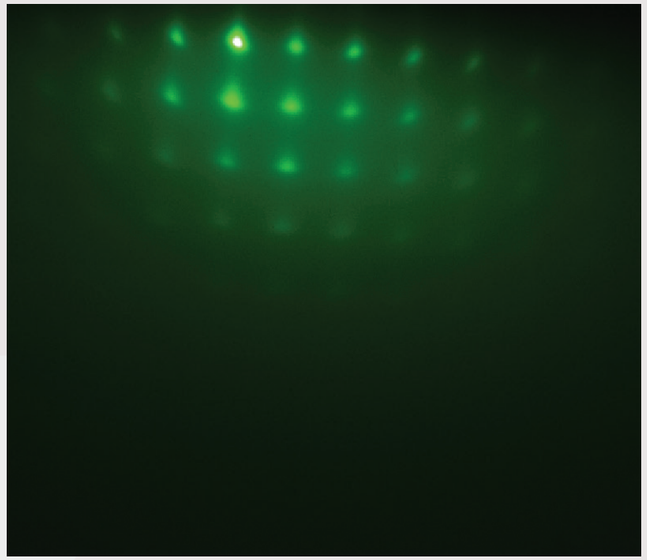
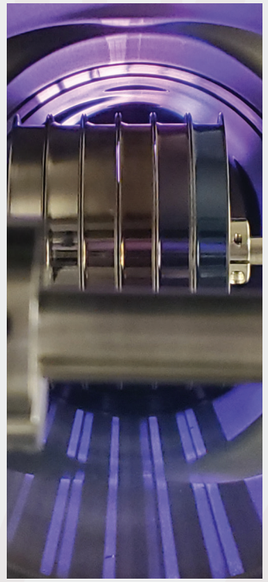
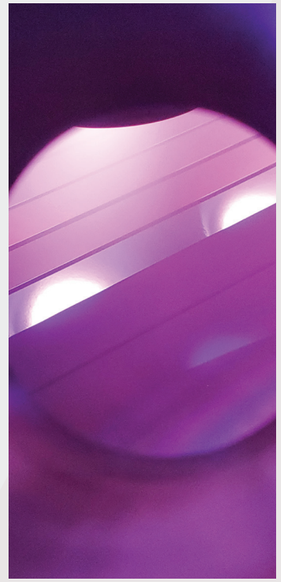
Verify Consistent Epitaxy Over Long Runs with RHEED Monitoring

We offer dual chamber systems for IBAD/Epi with the Stanford Process or dual ion beam processing. We can also provide single chamber ion beam sputtering IBAD tools. Verify consistent epitaxy over long runs and from run to run with real-time reflection high-energy electron diffraction (RHEED) monitoring after each chamber.

Soon, you will have the option to add a lanthanum manganate (LMO) deposition process (currently under development) to the system and deposit all three epitaxial buffer layer oxides in one run. The LMO layer provides a final lattice matching layer before depositing the REBCO layer.







Deposit Three Epitaxial Buffer Layer Oxides in One Run with LMO Deposition

Complete the stack with pulsed direct current (DC) or radio frequency (RF) magnetron sputtering on a heated substrate to form the LMO layer. This provides good epitaxial match to the REBCO with the required low grain tilt and twist.

PVD Products utilizes magnetron sputtering from a linear target. A large area, multi-zone substrate heater provides high-temperature and tight-temperature uniformity over several lanes of tape.

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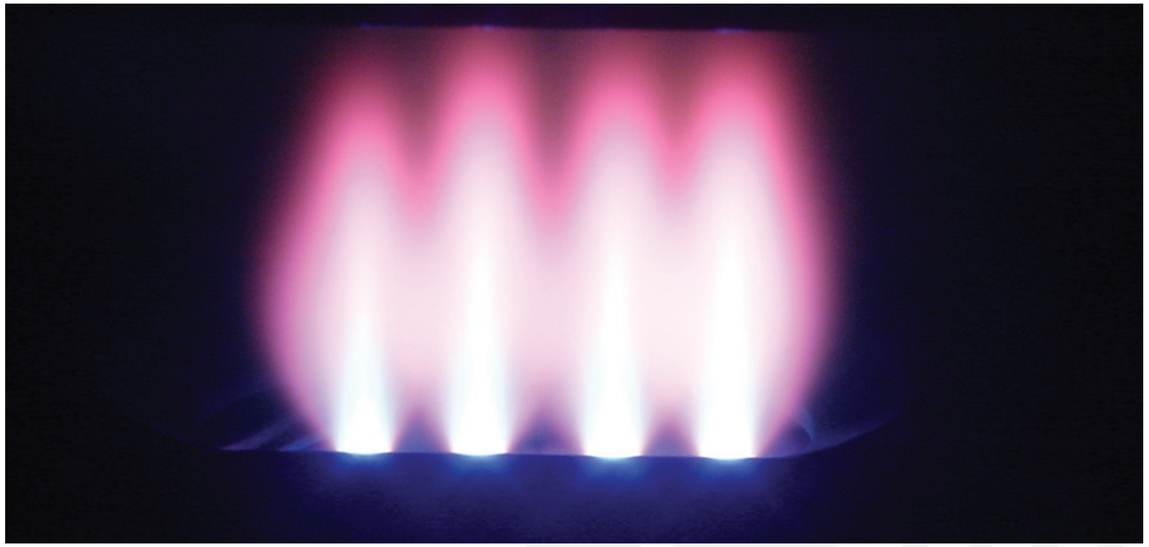

Simultaneous Coverage and Precise Temperature Control

As the heart of the coated conductor stack, the REBCO HTS layer requires the following:

- Good epitaxy
- Sufficient thickness for the carrying capacity required by a range of applications
- Low grain boundary angles (tilt and twist)
- Good performance at either high magnetic field (for magnet applications) **or** at self-field and more moderate temperatures for electrical power transmission

A variety of deposition techniques are applied to create this layer.

We sell and continue to develop PLD tools for the REBCO layer. This physical vapor deposition (PVD) method enables you to incorporate a variety of pinning centers for improved high-magnetic-field performance of the most demanding applications. Optimize the process recipe for power transmission applications by altering the composition of the target and deposition parameters—for example, by including various rare-earth elements in different targets.

Our deposition tools contain a high-powered excimer laser. The laser beam optical train allows simultaneous coverage across all lanes of tape. An infrared (IR) lamp-based heater with precisely controlled temperature provides exceptionally tight process window control. Tools can be duplicated for equivalent throughput to the rest of the line.

Contact and Encapsulation: How Silver and Copper Protect in Tandem

Silver and copper are the capping layers in the coated conductor stack. The silver contacts the REBCO and shunts the current in case of a superconductor quench. The copper layer provides a further shunt, as well as encapsulation from the environment.

The silver is deposited on both the top and bottom of the tape. The tape is then slit to its final width before applying the copper, so it also coats the edges.

PVD Products is developing a custom-made multi-pass (bi-directional) system with linear magnetrons for coating both sides with silver in one pass through the chamber. This same tool can be used for seed or thin layer copper deposition. Applying thin copper by magnetron sputtering protects the silver from the chemical environment if the factory carries out subsequent electrodeposition of copper. This means the silver layer can be thinner, resulting in significant materials savings.

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Deposition Systems from PVD Products Bring You:

- A **proven track record**, with more than 300 deposition and reel-to-reel systems shipped globally.
- **High-performance systems** that deliver rare-earth barium copper oxide (REBCO) in commercial volumes.
- The option to build **an entire production line** or individual process steps.
- **High uptime and production throughput**.
- **Turnkey installation** services.
- Support for a wide range of tape dimensions:
  - **Widths from 4 to 16 mm** (wider web on request)
  - **Thickness from 35 to 100 µm**
  - **Long length capability**
- **Ease of use** with fully automatic, recipe-driven operation.

R2R MgO Sputter IBAD

Talk to us at the booth

to discuss your coated conductor production equipment needs.

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