FUSION'S FAST TRACK: EXCIMER LASERS SUPERCHARGE HTS-TAPE PRODUCTION

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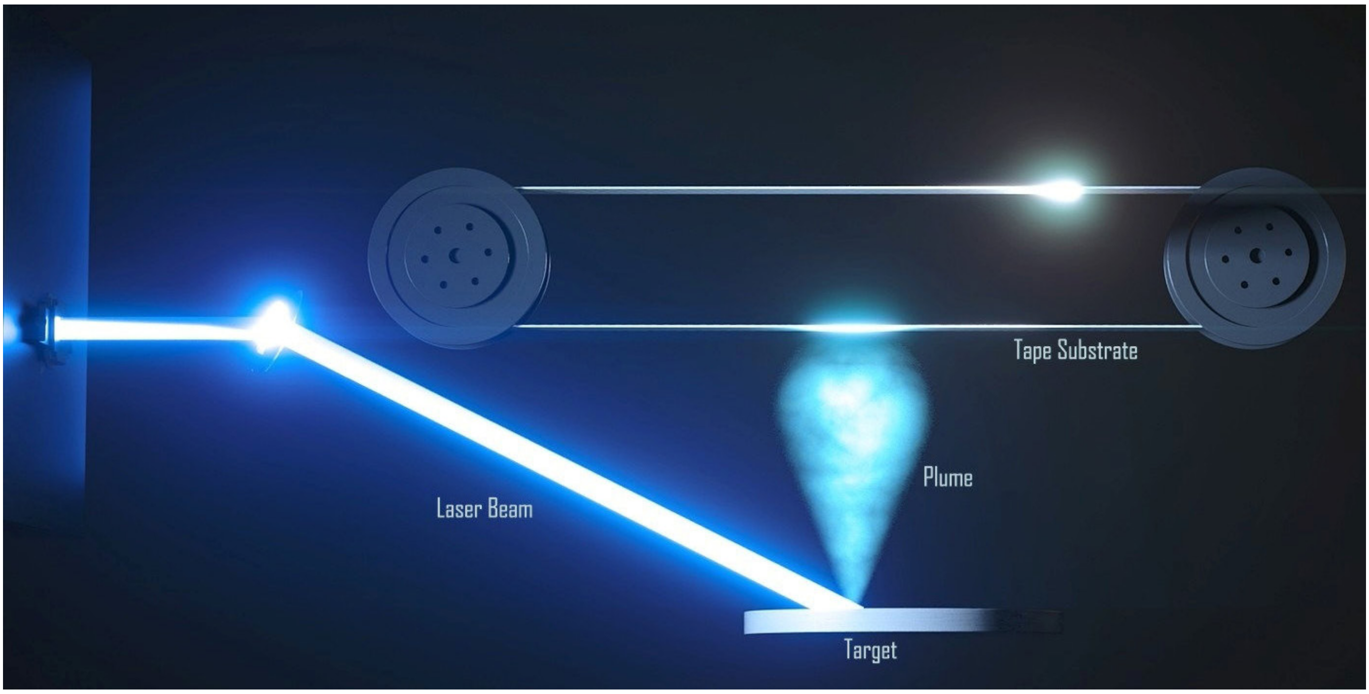

Pulsed Laser Deposition grows the delicate REBCO layer by the metre

Nuclear fusion as a clean, virtually limitless power source is on the road to commercialisation. At the heart of this ongoing energy revolution lies REBCO (Rare Earth Barium Copper Oxide) tape, a high-temperature superconductor (HTS) that can carry immense electrical currents with zero resistance at unprecedented mgnetic field strength of 20 tesla and beyond. But producing REBCO thin films on tape substrates at scale and with the crystalline properties needed for magnetic fusion reactors has long been a bottleneck. Enter Pulsed Laser Deposition (PLD), a technique that is quietly transforming the landscape of HTS manufacturing driven by ever increasing excimer laser power levels.

FUSION-PROOF HTS-TAPES WITH PLD

HTS-tapes have a multi-layer structure. Typically, a Hastelloy substrate providing mechanical stability is coated with buffer films followed by the current underpinning the REBCO layer which is then protected by thin Ag and Cu coatings (Figure 1). The rate and performance determining process is the growth of the REBCO layer usually applied in the chemical composition $YBa_2Cu_3O_7$. The final HTS-tape is about 60 µm thick and 12 mm wide (Figure 2) and is produced in batch lengths of many 100 m.

As a coating method for multi-element oxides, PLD offers unique advantages in controlling REBCO film quality, grain boundaries, and nanostructural defects that act as flux pinning centers. The latter are essential for achieving high critical current even at the very high-magnetic fields present in a fusion reactor. Albeit PLD-made tapes need to be scaled to bring fusion energy to life.

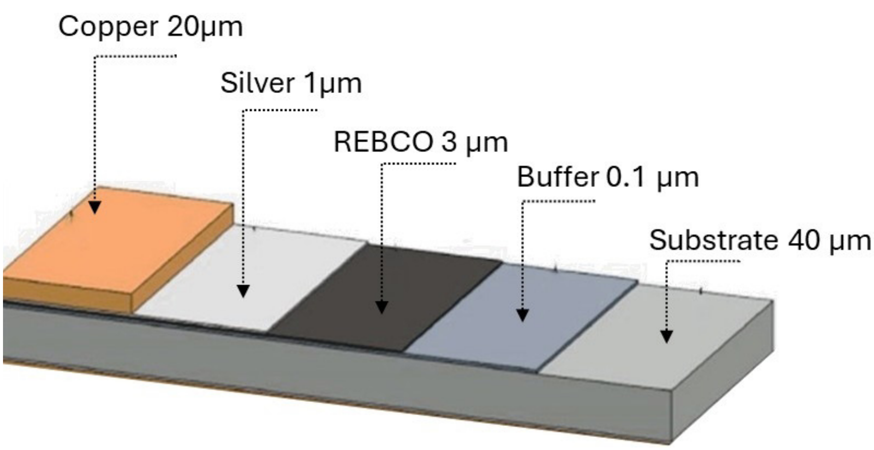

Figure 1: Sketch of a typical HTS-tape layer sequence

SURGING TAPE DEMAND DRIVEN BY FUSION

Unlike conventional superconductors, REBCO

Figure 2: REBCO layer on short tape sample

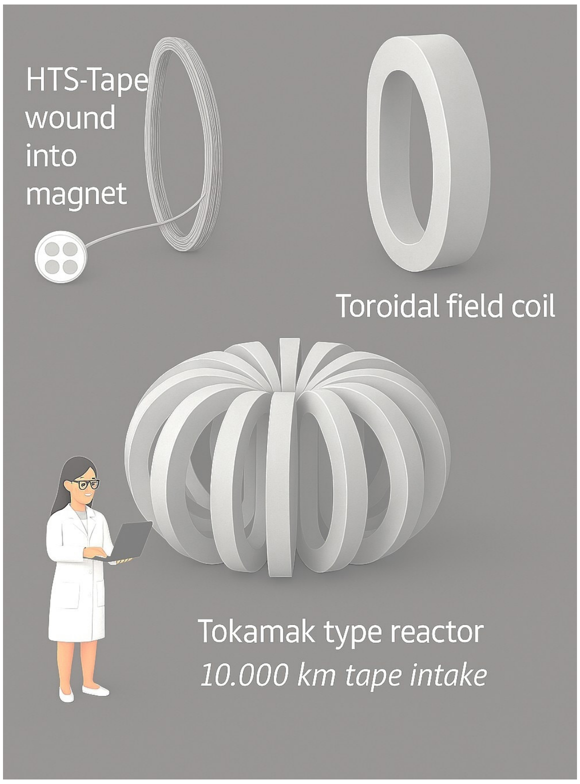

Figure 3: HTS-tapes power up magnetic fusion reactors

tapes made via PLD maintain superconductivity at fusion relevant field strengths of above 20 T and temperatures around 20 K, making them ideal for next-generation magnetic confinement reactors like tokamaks and stellarators.

The HTS-tape architecture — thin films on flexible metal substrates — enables winding into compact, high-field coils, crucial for space-constrained fusion devices consuming thousands of km of REBCO-tape (Figure 3). As fusion moves toward commercial viability, PLD tape production offers a scalable path to build magnets that are smaller, more efficient, and capable of sustaining the extreme conditions required for plasma confinement and ignition. Their deployment is a cornerstone in advancing magnetic confinement fusion toward practical energy generation. As a matter of fact, multiple REBCO based reactors are projected by fusion start-up companies to generate grid energy by 2035.

By then, fusion energy development is expected to consume massive amounts of REBCO tape, with estimates of up to hundreds of thousands of kilometers depending on the scale and pace of reactor deployment. With about $10 billion in private fusion investment today and major players like Commonwealth Fusion Systems, Energy Singularity, Proxima Fusion and Tokamak Energy scaling up, REBCO tape intake will continue to surge.

SUPERCHARGING PLD TAPE MANUFACTURING

Today's REBCO tape annual capacity is about 10,000 km and is provided predominantly by 300 W excimer laser powered PLD systems. As a breakthrough technology designed to scale up HTS tape production and keep fusion magnet manufacturing in line with the reported fusion milestones, the latest LEAP 600C excimer laser model from Coherent was launched in June 2025 during the Laser World of Photonics Fair in Munich, Germany.

Delivery of 600 W of laser power at the proper 308 nm wavelength, doubles the tape throughput compared to the existing PLD manufacturing systems.

Novel on-the-fly active injection technology triples the tape deposition runtime in high-throughput environments. This ensures extended, industrial-scale batch production of tapes with minimal downtime. As current tape costs (~$100/kA-m) must drop significantly for widespread deployment also into other HTS-tape applications, LEAP features the lowest cost-per-watt ever achieved in an excimer laser of such high power-class.

Fusion is the power of the sun and has never been closer. While humankind is eagerly awaiting clean fusion energy, there is one small step towards the first net energy reactor and now one giant leap for HTS tape manufacturing.

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