Processing of high-field long-length coated conductors via pulsed laser deposition onto bi-axially textured buffer layers

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Processing of long-length high-temperature coated conductors with high performance in magnetic field of several tens of Tesla still represents unavoidable milestone towards high field cables, magnets, magnetic energy storage, etc.

In present contribution, we show both a progress in reaching the highest "in-field" critical currents and a progress in up-scaling of length of high-field coated conductors to hundreds of meters. Routes for further progress are critically studied as well.

Currently developed technology is based on combination of a High-Rate, Multi-Beam Pulsed Laser Deposition used for growth of the superconducting layer with an Alternating-Beam-Assisted Deposition used in fabrication of bi-axially textured buffer layers of yttria-stabilized-zirconia. We demonstrate that this combination enables the best conductor performance in high fields if the "intrinsic" precipitation (random precipitation) of the yttrium-barium-copper-oxide superconducting material is optimally balanced with "extrinsic" precipitation originating from non-stoichiometric targets used in pulsed laser deposition.

Using optimized conditions we deposited several 4mm wide, 100-200 m long coated conductors. In non-precipitated conductors, critical currents measured were in between 250 and 400 A/cm-width (at 77 K in self-field). High-field coated conductors with critical currents above 1000 A/cm-width (at 4.2 K, 18 T, perpendicular field) were manufactured in lengths from 105 to 130 m. This seems to be the highest critical currents in longest lengths achieved so far.

Comparative analysis of different pulse laser deposition routes is performed considering technique of tape transportation, methods used for tape heating, arts of multi-zone laser ablation, throughputs, degree of material loss/transfer during deposition, flexibility in processing tapes of different widths.

Principles of multi-beam deposition are further developed regarding (a) stability of long-term target scan with a laser beam, (b) employment of multi-beam/multi-zone pulsed laser deposition under different tape heating/tape translation concepts, and (c) efficiency of material transfer between target and substrate. Deposition throughput is drastically dependent on method implemented for substrate heating and transportation. Cases of a reel-to-reel tape transport, a back-and-forth tape translation and transport of the tape wound onto rotating drum are considered.

Experimental and modeling results reveal a potential for further increase of integral deposition speed in multi-beam deposition due to use of lower fractions of laser pulse energy in each deposition zone. This opens a possibility to increase further a number of deposition zones. As a result the deposition speed and, consequently, the throughput may be gained further.