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Sat-Mo-Or4-01: [Invited] Harnessing Data from Large-Scale 2G-HTS Wires Production by PLD Method: Insights from Thousands of Kilometers of Fusion-Grade Wires

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Faraday Factory Japan (FFJ) has established itself as a leader in the second generation of high-temperature superconducting (2G-HTS) wire production through continuous advancements in manufacturing capacity, innovative technology, and research excellence. In 2024, FFJ commissioned a state-of-the-art facility in Zama (Japan), enabling the production of over 1,000 kilometers of 12 mm superconducting tape annually. These 2G-HTS tapes are vital for high magnetic field applications, particularly in fusion energy systems, where they must withstand magnetic fields of 20 T and operate 4.2 K and 20 K.

Over the past five years, FFJ's contributions to the SPARC project and other compact fusion initiatives have driven a significant expansion in 2G-HTS wires production. This unparalleled manufacturing scale, the largest in the history of HTS wire production, has provided an extensive dataset for systematic analysis. These analyses have identified key opportunities to enhance production efficiency and refine research objectives, enabling advancements in 2G-HTS wire performance for real-world applications.

Innovative breakthroughs include the optimization of PLD target compositions to fine-tune microstructures and control impurities, leading to enhanced superconducting properties. By incorporating Y_2O_3 nanoparticles into the YBCO matrix and applying oxygen overdoping techniques, FFJ has achieved engineering critical current densities (Je) nearing 1,000 A/mm² at 20 K and 20 T. These enhancements are essential for supporting the demanding requirements of compact fusion systems, including tokamaks, stellarators, and levitating dipoles.

In parallel, FFJ continues the development of 2G-HTS wire solutions for the aviation sector. Such wires are engineered with artificial pinning centers to perform optimally at 65–70 K and under magnetic fields of 1–3 T. The innovations include multilayered architectures with integrated 1D and 3D pinning centers to minimize anisotropy and enhance the angular dependence of critical current (Ic). Additional advancements, such as double-stacked soldered tapes and multifilament wires manufactured through precision laser scribing, address the specific operational needs of electrical aircraft applications.

These accomplishments reflect FFJ commitment to advancing 2G-HTS wires technology, paving the way for transformative applications across energy, transportation, and industry.

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