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HTS Coils Without and With HTS Tapes: Direct Deposition and Patterning on Wide Surfaces and Tapes

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Abstract **– At Renaissance Fusion we are dramatically simplifying the manufacturing of High Temperature Superconductors (HTS) coils for magnetic confinement fusion and other applications. We are able to bypass the paradigm of HTS tapes and cables. We consider an option where we directly deposit and pattern multi-layer HTS coil on vacuum vessels or other wide surfaces. After the deposition, a laser selectively removes HTS material from narrow tracks or "grooves" to geometrically constrain the supercurrents. The result is a large, superconducting printed circuit, properly patterned to generate the 3D magnetic field of choice. Surfaces include flexible meter-wide tapes, rigid plates, and rigid cylinders, not necessarily of circular cross-section. This approach could streamline several HTS applications, from Magnetic Resonance Imaging to magnet undulators for synchrotrons, to wind turbines, to magnetic and magneto-inertial fusion. In particular, it could resolve the coil problem of stellarators: fusion devices similar to tokamaks – steadier, more stable, but featuring complicated 3D coils. There has been a tendency to adopt complex "coil winding surfaces" and then simplify the coils on those surfaces. At Renaissance Fusion we do the reverse: we adopt simple, piecewise cylindrical surfaces, at the cost of more complex current patterns on those surfaces. Such cost is negligible for us: just a different programming of the laser engraving. Plans are presented for a cylindrical demonstrator of a stellarator field. Flowing mesoscale liquid metal walls will fully cover its interior to demonstrate the ability, in a reactor environment, to shield structural materials and delicate HTS from fusion neutrons, as well as extract heat and breed one of the fusion fuels: tritium. Progress is presented in designing and building Physical and Chemical Vapor Deposition machines for the in-house production of said demonstrators and of meter-wide tapes. In later case, newly modified principles of quasi-equilibrium heating developed earlier for wide-area PLD will be implemented. Research needs, challenges, job opportunities and areas of possible collaboration are also discussed.**

Keywords (Index Terms) **– High temperature superconductivity, HTS coils, fusion, stellarator, laser patterning, coil patterning**

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