Approach for EMP testing of thin REBCO tapes without burnout in cryogenic and high-magnetic field environments considering current flow direction and bridge geometry

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The reliable operation of REBCO coated conductors in high-field devices for fusion, NMR, and accelerators is critically dependent on their electromechanical properties (EMP). This study discusses approaches for enabling critical current (I_c) (B, 20 K) and electromechanical properties I_c (B, T, ε/σ) testing under tensile load on thin standoff REBCO samples at high magnetic fields and cryogenic temperatures (20 K) without the common issue of sample burnout. A key challenge is the Lorentz force, which, acting on an unsupported tape, induces significant transverse stress, leading to in-plane bending, out-of plane deflection and premature delamination at striation-induced bridges. This can cause irreversible I_c degradation or quench. To mitigate this, we explore the directional dependence of Lorentz force against the bridge pattern by systematically controlling the force direction, we demonstrate a mechanism, preventing the detrimental buckling observed in conventional test setups. Our approach for EMP experiments shows that a strategically reversed force direction can shift mechanical stress away from critical regions, preventing burnout. Furthermore, we highlight the imperative of addressing transverse electromagnetic stress from screening currents, a hidden degradation mechanism. Preliminary modeling indicates that these forces can generate localized stresses during field ramping, potentially explaining premature delamination observed in experiments. Our work provides a clear roadmap for designing more resilient REBCO tapes and optimizing striation patterns for bridges by exploiting directional Lorentz to enhance a conductor's mechanical integrity in extreme electromagnetic environments at cryogenic temperatures.

Keywords: Thin substrate REBCO tapes, High field-current, Lorentz force, Tape's bridging, Electromechanical properties (EMP)