High Performance 2G-HTS REBCO Conductors with Engineering Current Density over 5 kA/mm^2 at 4.2 K, 14 T

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September 21, 2018 (STH60, HP135). An engineering critical current density above 5.4 kA/mm^2 has been achieved at 4.2K, 14T in thick REBCO films.

The problem of a strong degradation of the critical current density of REBCO (RE=rare earth, B=Ba, C=Cu, O=O) coated conductors with thickness has been a stumbling block that has impeded the practical realization of the full potential of REBCO superconductors ever since their discovery, such as utilizing the high critical current density and irreversibility field to achieve high in-field engineering current density conductors.

We report on recent advances in MOCVD growth of REBCO films with a very high thickness that have overcome this issue, demonstrated by achieving record in-field high engineering current densities (J_e) over all competing superconductor technologies and over a wide range of temperatures and fields. In this highlight, we focus on the record high in-field J_e at 4.2K of >4 μm thick Zr-doped REBCO films [1]. These results have been achieved by using an Advanced Metal Organic Chemical Vapor Deposition (A-MOCVD) system, which has been specifically developed to overcome the issue of J_c deterioration with thickness. The remarkably high J_e values achieved over a wide range of applied fields at 4.2K clearly demonstrate the strong potential of REBCO coated conductors for high-field magnet applications.

The conductors have been evaluated independently at LBNL and NHMFL on two separate samples at 4.2K and 14 T (B||c), resulting in J_c values of 12.2 and 12.3 MA/cm^2, respectively. The resulting pinning force is about 1.7 TN/m^3 achieved in films of a thickness of over 4 μm.

The equivalent critical current (I_c) values for a 4 mm tape width are 2.25 and 2.12 kA/4mm at the measured temperature and field of 4.2 K and 14 T (B||c). This level of performance is two-fold higher than the highest prior reported value for REBCO and more than 5-fold higher compared to commercially available HTS tapes [2,3].

The achieved J_c values naturally have a direct impact on the engineering current density (J_e) – which is one of the major criteria utilized for applications operating at 4.2 K. Taking into account the thickness of the hastelloy substrate (50 μm), buffer (0.2 μm), silver stabilizer film (3 μm) and copper plating (40 μm), the engineering current density is above 5 kA/mm^2 (5.48

and 5.13 kA/mm^2, respectively). The magnitude of this performance is best understood when compared to competing technologies – it is about five-fold the value of Nb_3Sn and nearly four-fold the value of all other superconductors besides REBCO reported to date. This remarkable level of performance is a clear demonstration of the strong potential the HTS technology has for a multitude of applications at moderate to high fields at 4.2 K operating temperature.

As an illustration, the achieved J_e values vs. applied field are superimposed on a plot of J_e vs. B of currently available superconductor technologies at 4.2 K (Lee [3]), in Figure 1. The J_e values of the thick REBCO tape are significantly higher than all other reported conductors in Figure 1. For example, at a field of 15 T, the J_e is more than five-fold higher than that of Nb_3Sn which is currently the primary choice for applications operating at high fields. This level of J_e performance, coupled with high irreversibility field of REBCO, clearly demonstrates the potential of REBCO coated conductors for both moderate and high field applications. More details can be found in reference [2].

The high level of in-field performance of thick REBCO coated conductors at 4.2K translates well to other operation temperatures as well, if the composition and pinning centers are properly optimized. In a separate study aimed at applications operating at moderate fields and temperatures, such as superconducting motors, we have demonstrated engineering current densities J_e of 7068, 4535 and 2928 A/mm^2 at 3T and 30, 40 and 50K, respectively. More details can be found in reference [4].

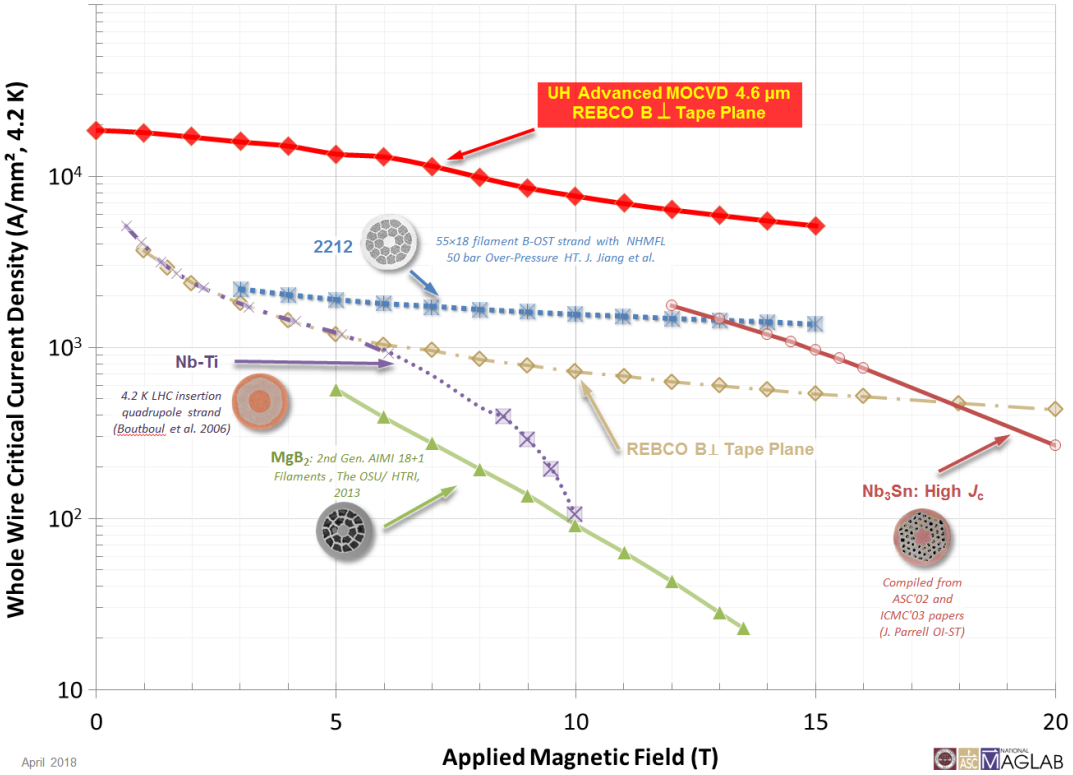

Fig. 1. Engineering current density vs. field of thick UH REBCO tape and other technical superconductors at 4.2 K [3].

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