Uniformity and Inter-Filament Current Transfer in "Twisted-Stack" Cables Comprised of Exfoliated YBCO Filaments

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Multifilamentary YBCO cables are conductors of choice for high-field accelerator dipoles and compact fusion reactors. Even though the manufacturers of the second generation (2G) improved the filament uniformity over the last years, typical length of a 10 mm wide filament is in 100's meter range. The uniform length is further reduced if the filaments are sliced into narrower strips due to a higher probability of current blocking by a defect. Its is well recognized now, that in order to be competitive with the more established Nb3Sn technology, the filament width in a 2G wire cable needs to be reduced below 1 mm. There is a need for assembling a practical YBCO cable from short, 100's of meters, narrow filaments. Introducing effective current sharing is a way to alleviate the filament non-uniformity. Unfortunately, a traditional 2G filament incorporates an insulating substrate, which blocks the cross-filament current.

This paper reports on the progress in development of long lengths of a multilayer superconducting cable comprised of thin exfoliated YBCO filaments [1]. Exfoliated multilayer cable with electrically coupled, narrow (< 4 mm wide) filaments that are coupled to allow current sharing within the cable can potentially enable fast ramping stable high-field magnets for applications in fusion, energy storage and transportation. During the exfoliation process the insulating substrate is removed, leaving only the YBCO layer supported by a metal foil. Then the exfoliated YBCO tape is sliced into narrow, 1-2 mm wide filaments using a reel-to-reel laser slicing system. We present analysis of defects generated by exfoliation and laser slicing using a magneto-optic method.

We further discuss effect of current sharing in 1 and 2 mm wide stacks of exfoliated filaments. Current sharing effects are detected by change of a current-voltage curve of the cable. The current sharing is improved as the stack is heat-treated at 180^{o}C, which allows for the solder re-flow and better interconnection between the filaments. However, extended heat-treatment causes de-allying of the silver layer which increased the contact resistivity. A finite element model is used to predict the current-voltage curves in both untwisted and twisted cables. We conclude, that current sharing can be effectively used to mitigate the filament non-uniformity.
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[1] Vyacheslav, S. and F. Paul, Exfoliated YBCO filaments for second-generation superconducting cable. Superconductor Science and Technology, 2017. 30(1): p. 014006.