Measurement at 4.2 K of normal zone propagation velocity in commercial REBCO conductors

4MP7-09

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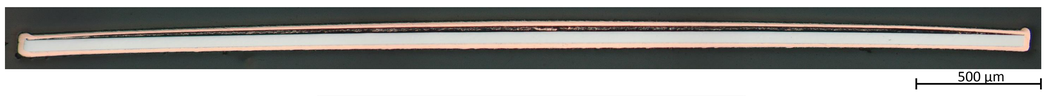
Motivation:

Because of the slow diffusion process of a quench in REBCO coils, the detection and protection are one of the major issues in the design of high field HTS magnets. No normal zone propagation velocity (NZPV) has been yet measured at 4.2 K in field in similar condition as in an impregnated magnet. In order to study the quench propagation in REBCO conductors at low temperature and in field, a campaign of measurements was carried out in the FRESCA test station at CERN. We performed a systematic measurement of the longitudinal NZPV in resin-impregnated commercially available REBCO conductors under different magnetic field intensity, and operating currents. In this paper, the experimental results are reported and discussed.

Conclusions:

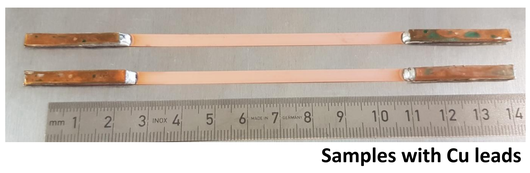
- Longitudinal normal zone propagation velocity (NZPV) in impregnated tape was measured at 4.2 K in perpendicular magnetic field and we found that the NZPV depends strongly on the perpendicular applied magnetic filed. This is in contradiction with literature that show a dependence only on the operating current.
- Specific voltage taps technology were developed using photolithography process to highly control the position, width and step size of the voltage taps.

Material: 4 mm wide 7.5 % Zr dopped YBCO SuperPower tape

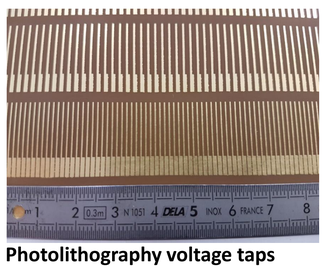


Sample preparation

Cu plates were soldered at each extremities of the tape on superconductor side for current input after impregnation



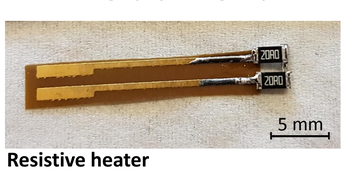
Samples with Cu leads



Photolithography voltage taps

Voltage taps (Vtaps) from photolithography process

- Very high control on Vtaps dimension and step size
- Multiple step size: 1.3 mm, 2 mm, 5 mm and 10 mm
- Multiple width: 0.3 mm, 0.5 mm, 1 mm, and 1 mm (respectively)

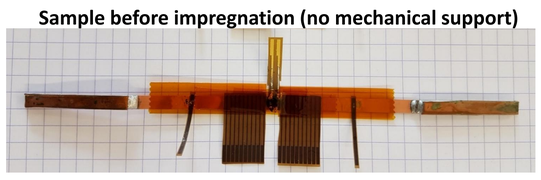


Resistive heater

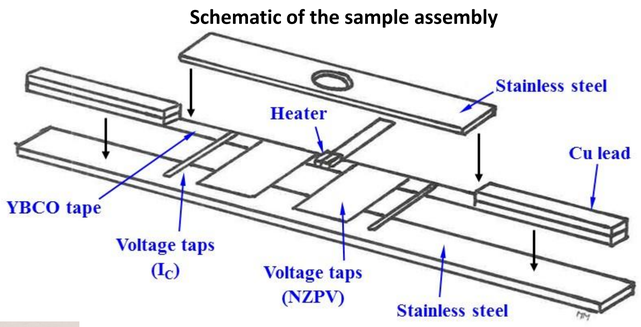
40 Ω heater (two 20 Ω resistors in series)

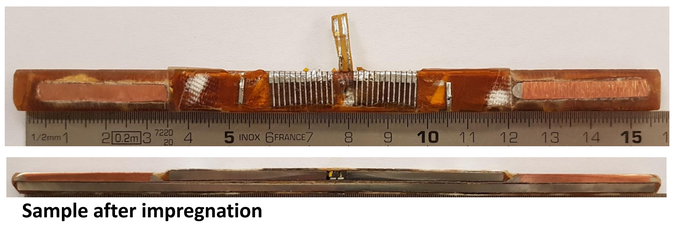
- Sample was covered with Kapton tape to prevent delamination after impregnation
- Sample was wrapped with fiber glass to reinforce the resin and reduce the resin thermal contraction.
- Sample was impregnated in CTD-101K epoxy resin
- After impregnation Cu leads were revealed to connect main current leads

Sample before impregnation (no mechanical support)



Schematic of the sample assembly





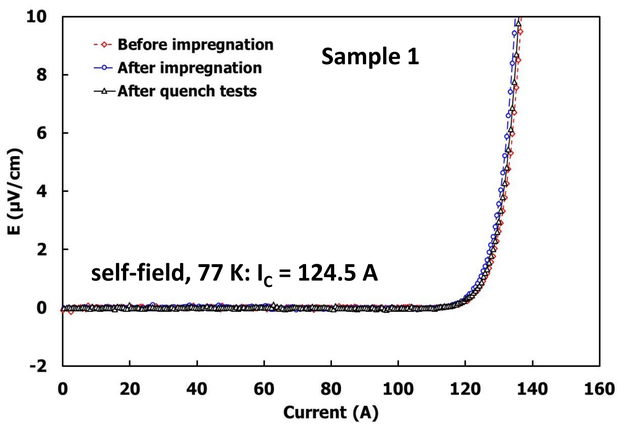
Sample after impregnation

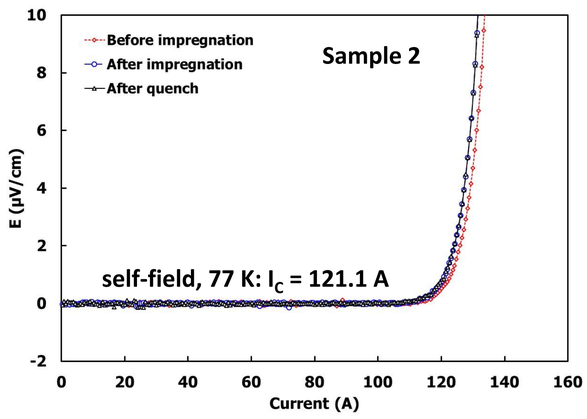
Two samples were identically made:

- Sample 1 with 2 mm step size Vtaps
- Sample 2 with 1.3 mm step size Vtaps

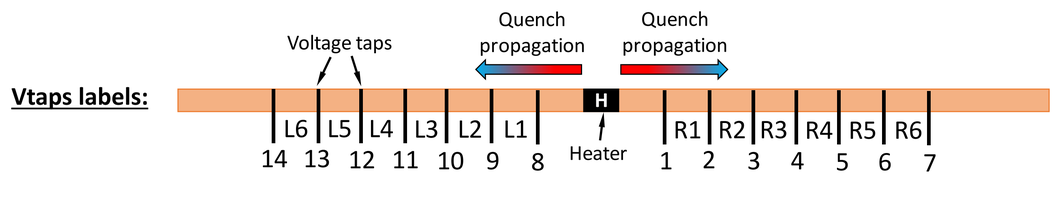
Results

I_C degradation after Tape impregnation is less than 1.5%

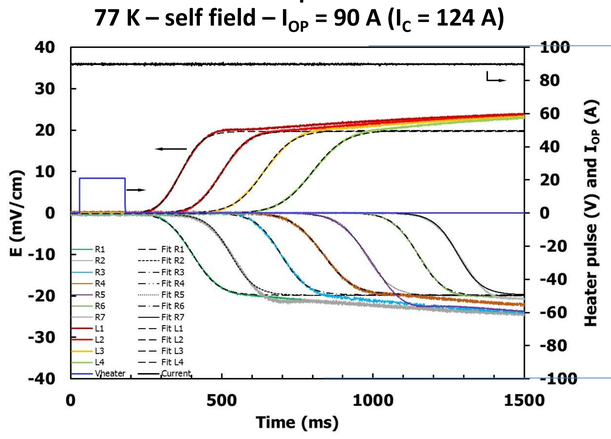




Quench propagation is symmetrical (4.2 K and 77 K)

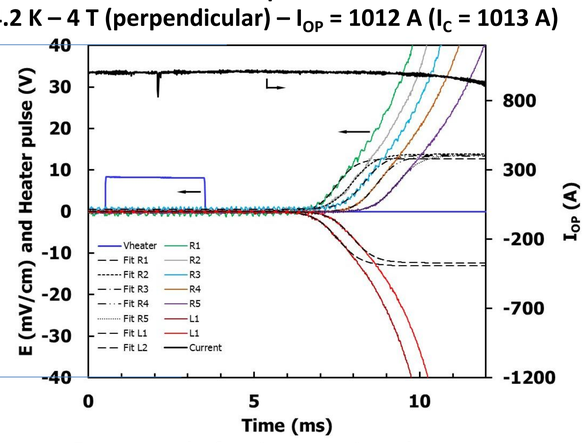


Sample 1
77 K – self field – I_{OP} = 90 A (I_C = 124.4 A)



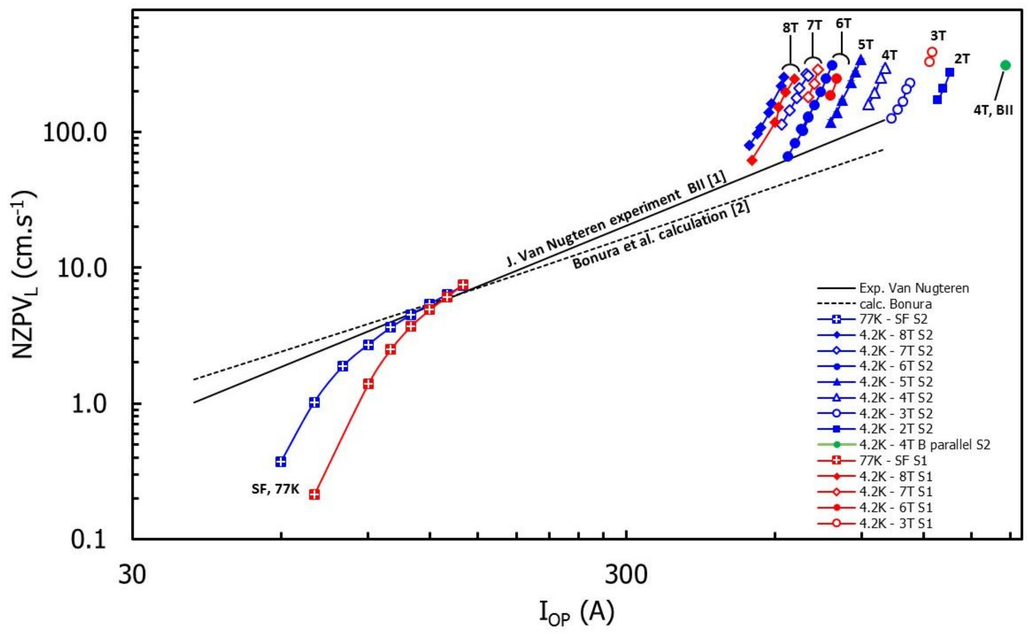
Slow quench: slow increase in voltage.
Sample is not in adiabatic conditions

Sample 2
4.2 K – 4 T (perpendicular) – I_{OP} = 1012 A (I_C = 1013 A)

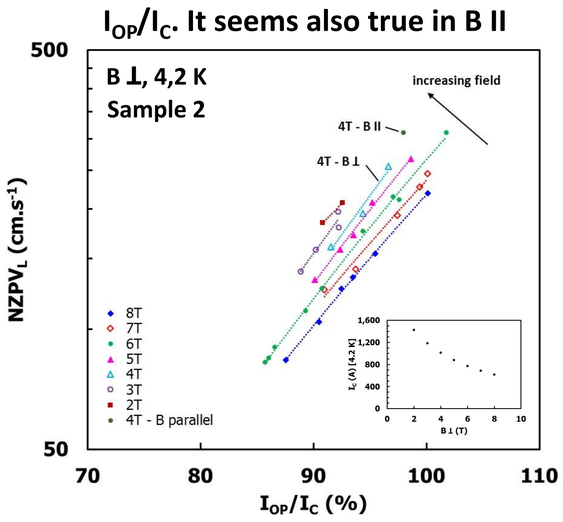


Fast quench: fast increase in voltage.
Sample is in adiabatic conditions

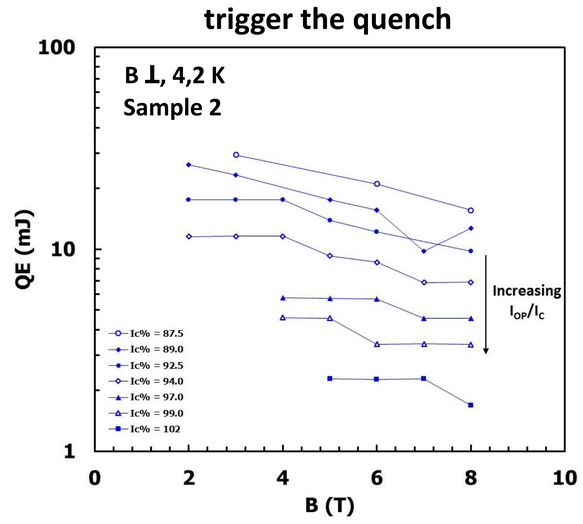
NZPV strongly depends on magnetic field in B⊥

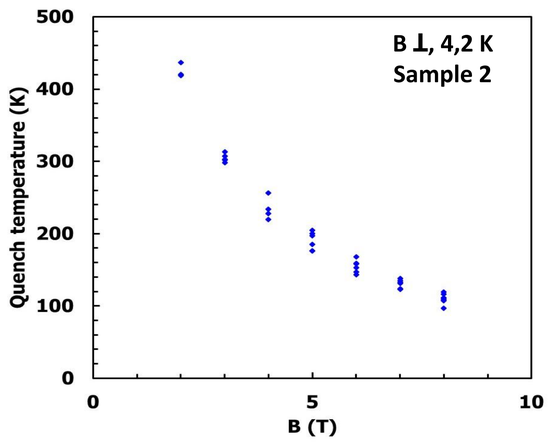


In B ⊥, NZPV depends mainly on I_{OP}/I_C. It seems also true in B II



A small energy is required to trigger the quench





Maximum quench temperature

- Quench temperature was calculated from voltage between Vtaps 1 and 8 and converted into temperature.

Acknowledgement: technical support: Oleg Kalouguine, Giuseppe Peiro, Julien Hurte, Jean Sebastien Denis Philippe, Michael Ky, Alban Stimac, Gerard Perrier, Andre Jacquemod, Bouchta Tbatou, Jonathan Davoust, Alain Gharib.

[1] J. van Nugteren, M. Dhallé, S. Wessel, E. Krooshoop, A. Nijhuis, and H. ten Kate, "Measurement and Analysis of Normal Zone Propagation in a ReBCO Coated Conductor at Temperatures Below 50K," Phys. Procedia, vol. 67, pp. 945–951, Jan. 2015.
[2] M. Bonura and C. Senatore, "An equation for the quench propagation velocity valid for high field magnet use of REBCO coated conductors," Appl. Phys. Lett., vol. 108, no. 24, p. 242602, Jun. 2016.