Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile

EUROfusion

WPMAG final meeting 14-16/01/2026

AC losses and interfilament resistance measurements of unpatterned and commercially filamentized REBCO tapes

MAG-T.01.01-T043-D002

People involved in this task:
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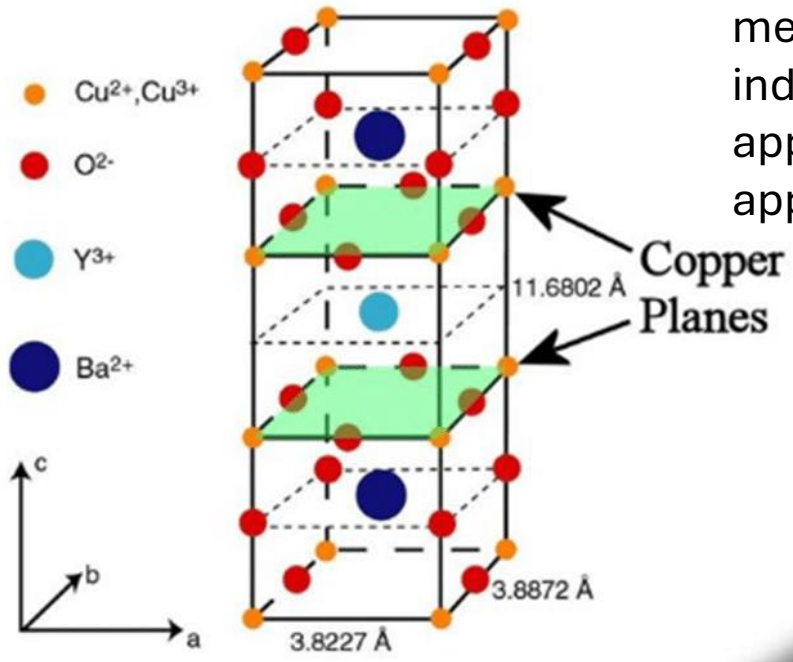
HTS-REBCO MATERIALS

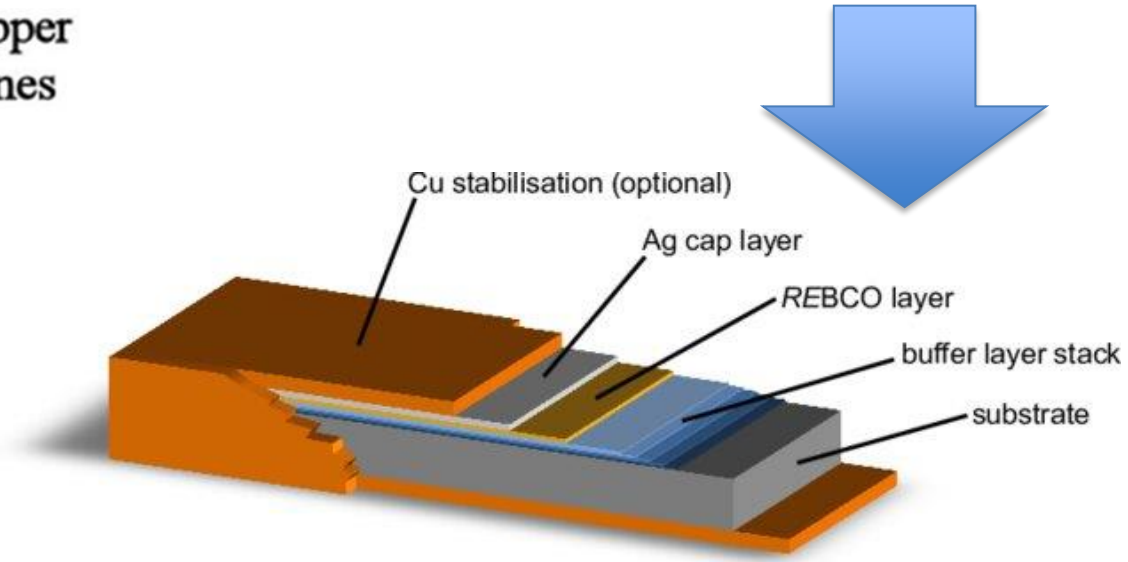
$YBa_2Cu_3O_{7-x}$ (YBCO)

Layered structure
Highly anisotropic material



The best superconducting performances are obtained mainly from the thin film configuration.

To have "large-scale" utility, **TAPE** has been fabricated by depositing YBCO on an alloy substrate with good mechanical properties, which can realize large-scale industrial production and has become the main approach of high-temperature superconducting applications at present.



AC LOSSES

AC losses matter in the scenario of HTS applications

$$Q_T = Q_{hyst} + Q_{eddy} + Q_{coupling}$$

The hysteretic nature of magnetization in type II superconductors results in a net energy loss when subjected to a field cycle

From the metallic substrate

Induced current between filaments

Reducing the AC losses is a key point and essential to their application and deployment

AC LOSSES

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Striation as one of the possible loss-reduction strategies:

- ❑ Tape divided into N strips:
- ❑ Electrical insulation between strips;

$$Q^{Striated} \approx \frac{1}{N} Q^{Non-Striated}$$

STRIATED SAMPLE

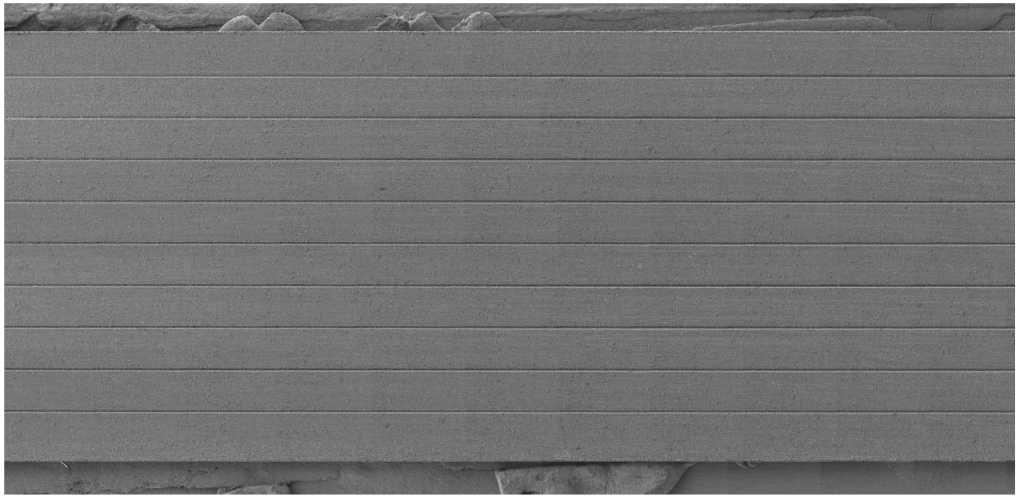
Shanghai Superconductor Technology

First Test Sample

Number of strips = 10;

width of a single strip ≈ 355 μm

Spacing between strips ≈ 37 μm



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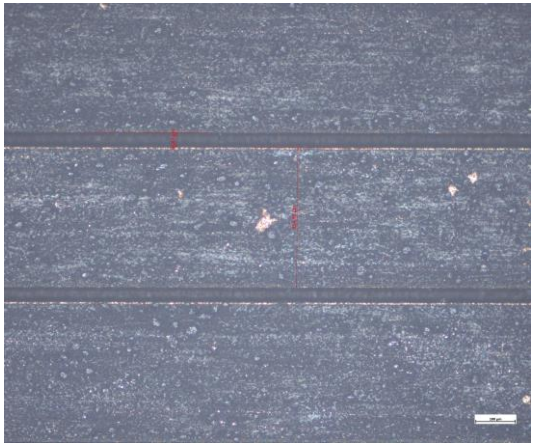
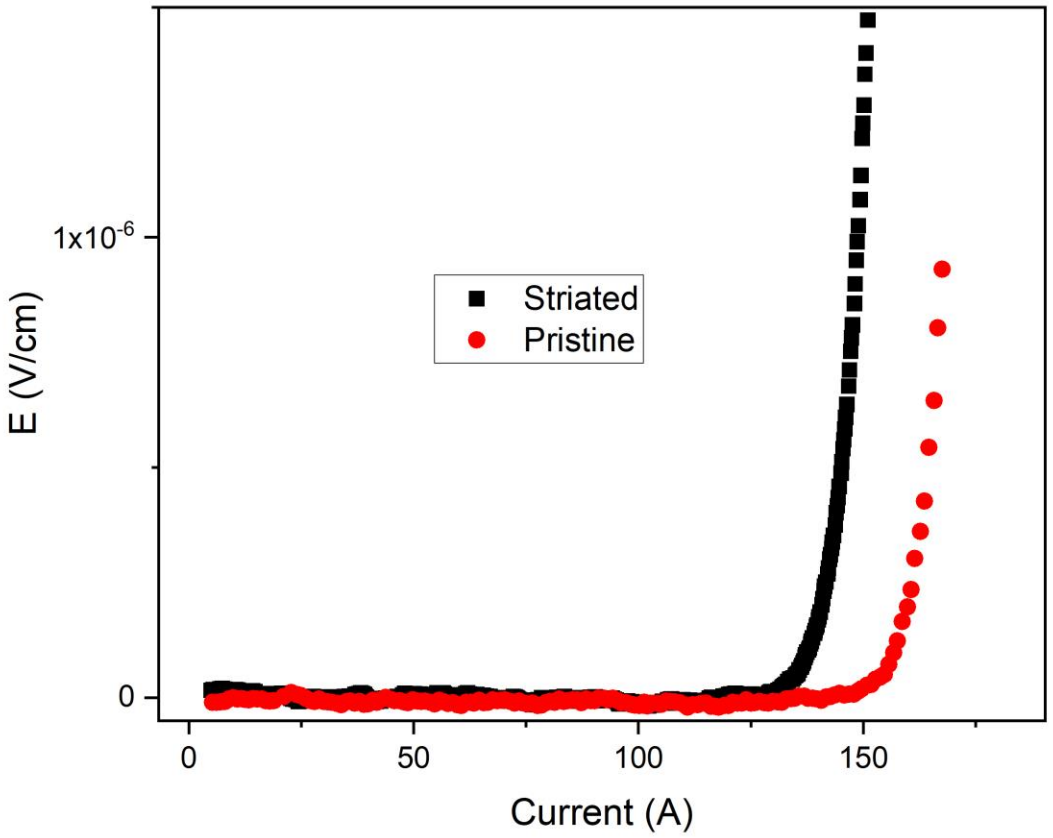


We have a reduction of the superconducting material of about 11.2%

STRIATED SAMPLE – IV measurement

77 K @ self field



I_C Non striated ≈ 175 A n = 35

I_C striated ≈ 150 A n = 28

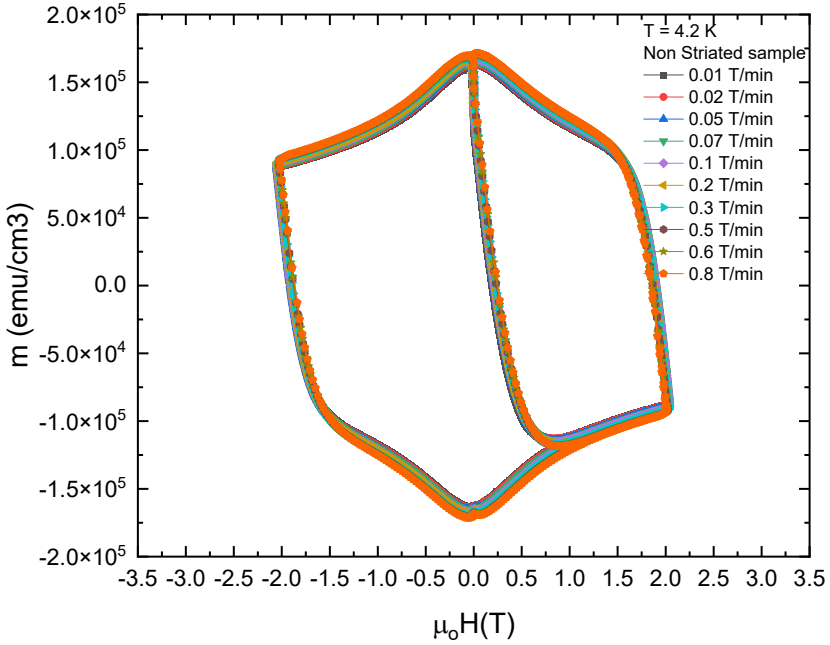
Reduction of the superconducting critical current of about 16.0 %

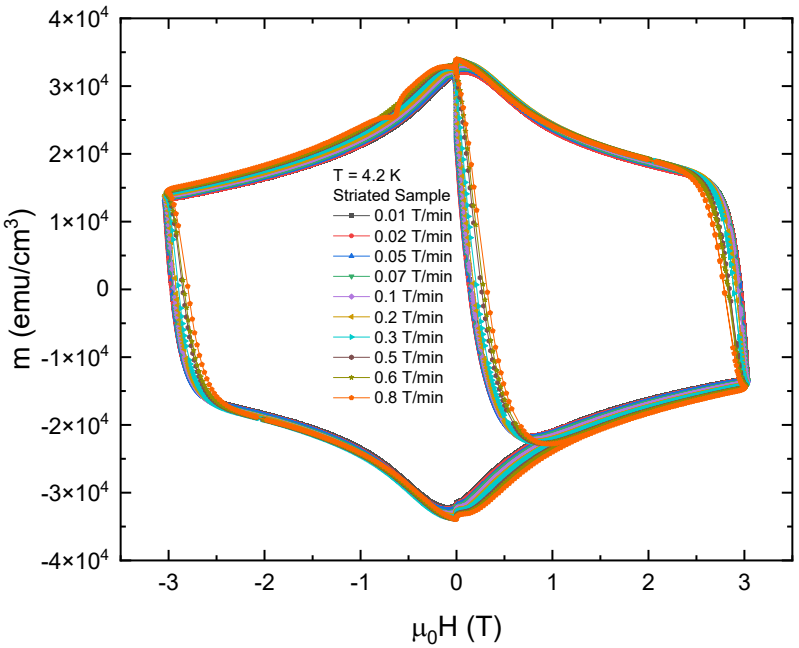
STRIATED SAMPLE M(H) hysteresis loop

$$Q = \oint \vec{M} \cdot d\vec{H}$$

Applied magnetic field perpendicular to the ab-plane

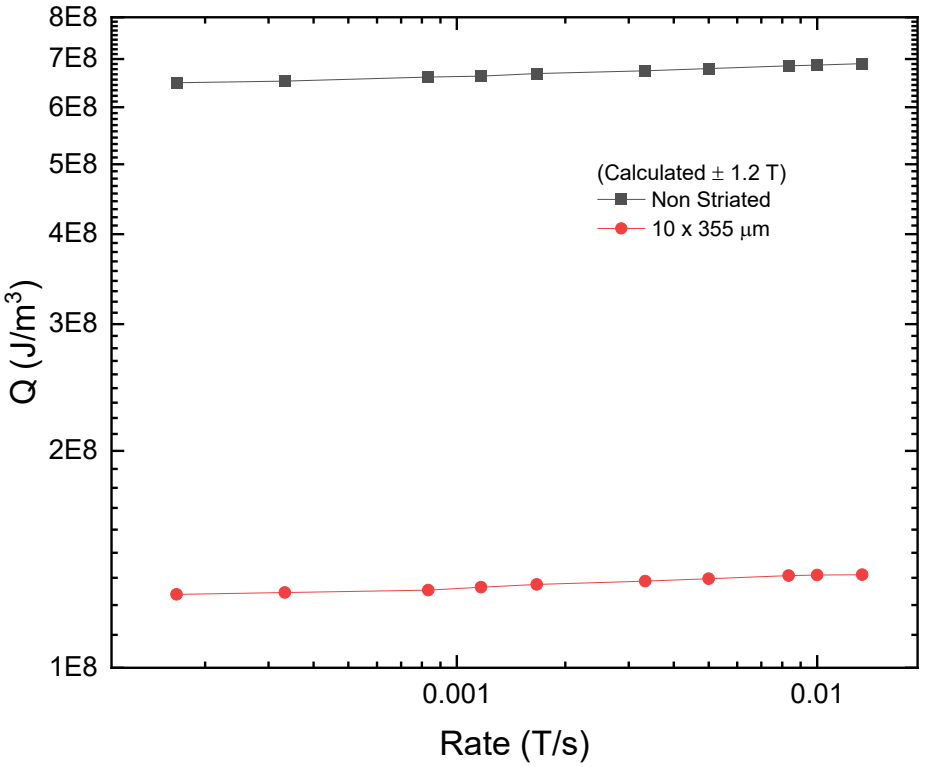
Preliminary measurements @ 4.2 K at different field sweep rates from 0.01 T/min to 0.8 T/min





STRIATED SAMPLE M(H) hysteresis loop

Preliminary measurements @ 4.2 K at different field sweep rates from 0.01 T/min to 0.8 T/min



Comparison of Losses per cycle (J/m^3) (calculated between ±1.2 T) of the two samples as a function of the sweep rate (in T/s).

$$Q^{Striated} \approx \frac{1}{N} Q^{Non-Striated}$$

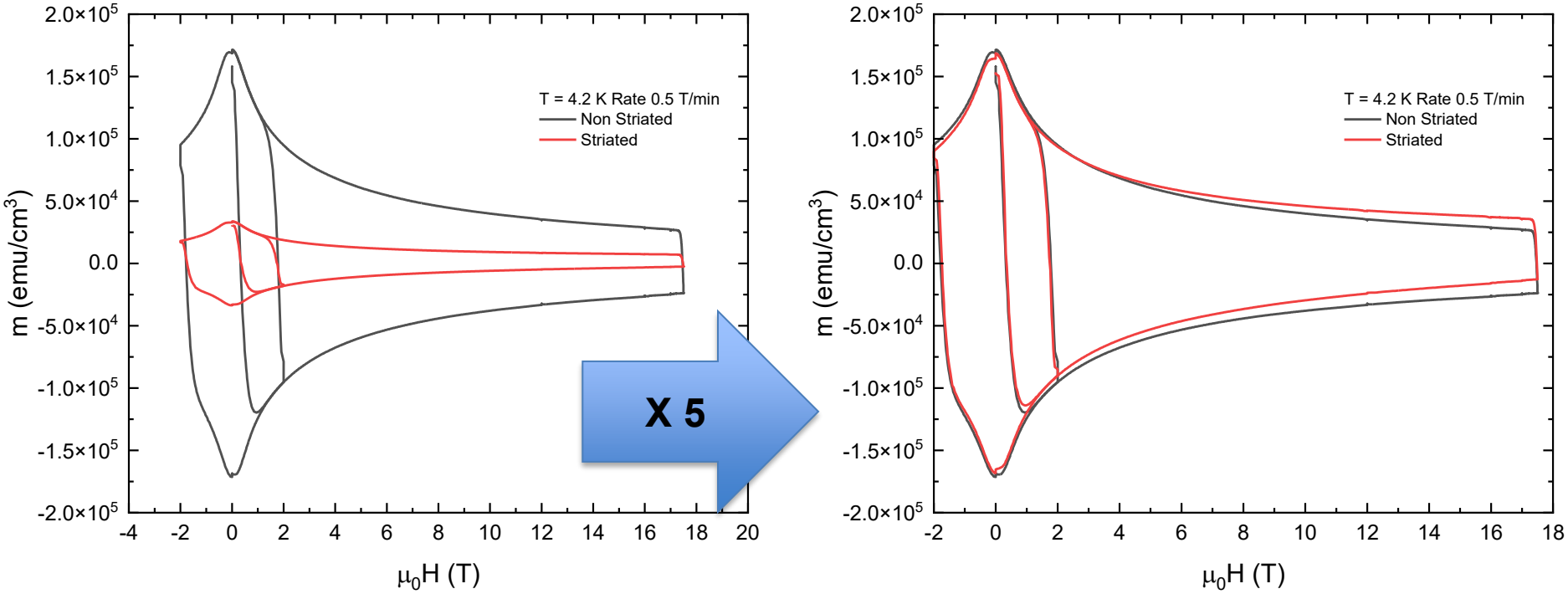
$$\frac{Q_{hyst}^{Striated}}{Q^{Non-Striated}} \approx \frac{1}{N} \approx \frac{1}{10}$$

We obtain a factor of 1/5 ≠ 1/10!!!!

Probably due to the narrowed interspacing between strips

STRIATED SAMPLE M(H) hysteresis loop

Comparison between the two samples at the same field sweep rate, 0.5 T/min



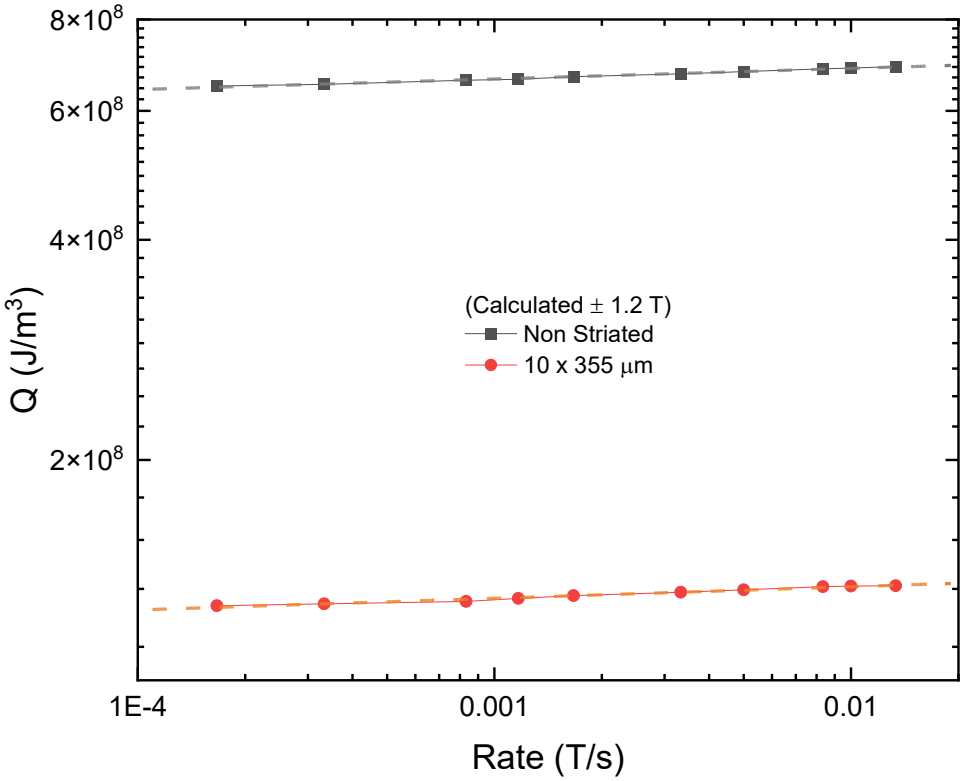
$J_C(B)$ behavior is the same for both samples → No degradation after "laser processing"

STRIATED SAMPLE Power Law behavior

Power Law losses vs. field sweep Rate

$$Q \propto \left(\frac{\partial B}{\partial t}\right)^{p}$$

The value of **p** is significant in understanding the dynamics of the system



$p^{NonStriated} \approx 0.0145$

$p^{Striated} \approx 0.0159$

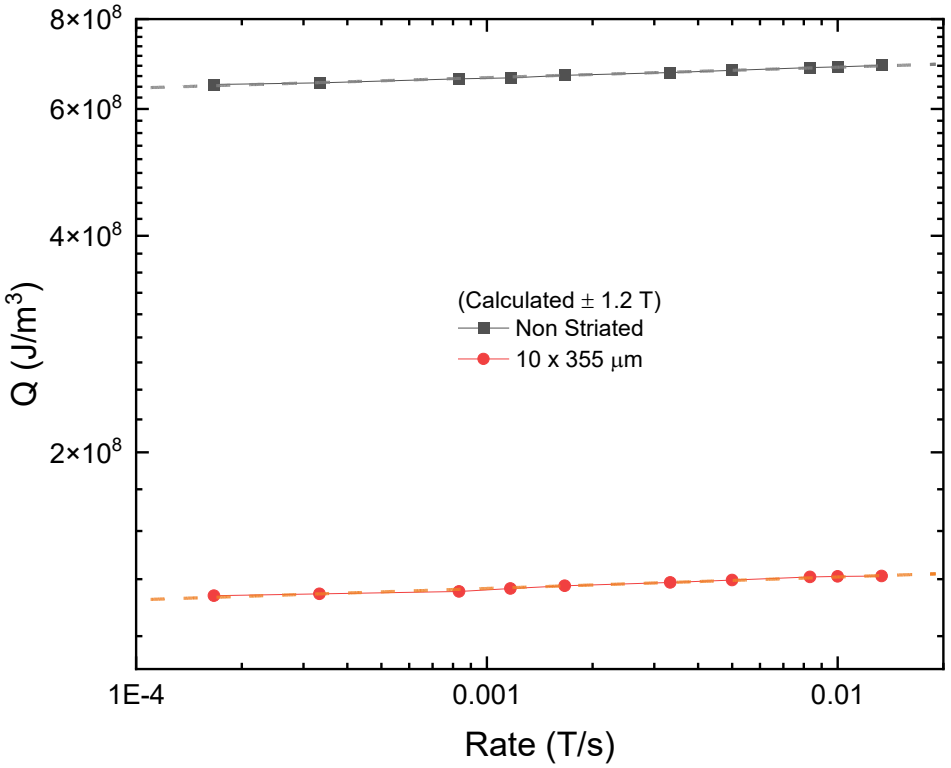
Very low value of p

STRIATED SAMPLE Power Law behavior

Power Law losses vs. field sweep Rate

$$Q \propto \left(\frac{\partial B}{\partial t}\right)^{p}$$

Very particular behavior of the losses



$p^{NonStriated} \approx 0.0145$

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G. de Marzi et al Supercond. Sci. Technol. **31** (2018) 055011

N Banno, N Amemiya, Cryogenics **39** 99 (1999)

$$E = E_C \left(\frac{J}{J_C}\right)^{n} \qquad p = 1/n$$

$p^{NonStriated} \approx 0.0145 \rightarrow n \approx 68$

$p^{Striated} \approx 0.0159 \rightarrow n \approx 62$

CONCLUSIONS & …

1) Successfully obtain a striated sample with 10 strips with a width of w = 355 μm and around 39 μm interspacing;
2) Good value of the critical current @ 77 K in self field (I_C striated ≈ 150 A n = 28), with no sign of degradation of the superconducting properties, confirmed also by the J_C vs applied magnetic field;
3) Reduction of the losses by a factor of 5 compared to the pristine sample;
4) The effective width of the strips seems to be like $w_{eff} \approx 2 \times w$ (magnetic coupling)
5) The coupling between the strips appears to be negligible ($p < 1$)
6) Weak dependence of the losses → the value of the exponent of the power law behavior is directly related to the E-J exponent n (p=1/n).

& PERSPECTIVES

1) Losses vs sweep rate at different temperatures
2) Losses at high magnetic field.
3) Losses vs applied magnetic field
4) Change the geometry of the sample (number, width and spacing)

Thank you for your attention