

Comparison of $J_{\rm C}$ in GdBCO Tape Using Dc Magnetisation and Harmonic Ac Susceptibility Measurements

A.P. Smith^a, E. Surrey^b, S.H. Moon^c & D. P. Hampshire^a





^a Centre for Materials Physics, Superconductivity Group, Department of Physics, Durham University, DH1 3LE, UK ^bCulham Centre for Fusion Energy, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, UK ^cSuNAM Co., Ltd, Anseong, Gyunggi-do 17554, Korea

Introduction



Inset: $J_{\rm C}$ evaluated using Bean's model [2].

- Dc magnetisation is a technique regularly used to perform nondestructive measurements of the critical current density (J_c) in superconducting materials.
- Measurements of $J_{\rm C}$ using Dc magnetisation are highly sensitive to inhomogeneity in the applied Dc field [1]. If the field inhomogeneity is comparable to the self-field of the superconductor, $J_{\rm C}$ will appear to drop to zero.
- We have compared Dc magnetisation measurements of J_C to harmonic Ac susceptibility measurements of J_C for a rectangular GdBCO tape.



$J_{\rm C}$ from Ac Susceptibility of superconducting tapes



Fig. 3: Numerically calculated values for real and imaginary Ac susceptibility as a function of penetration parameter, γ

The real and imaginary susceptibility constants were calculated from the Harmonic measurements. The penetration parameter γ and J_C were then obtained using the analytic expressions [3]

$$\chi'(\gamma) = \frac{2\chi_0}{\pi} \int_0^{\pi} (1 - \cos\theta) S\left(\frac{(1 - \cos\theta)\gamma}{2}\right) \cos\theta \, d\theta$$

$$\chi''(\gamma) = \frac{2\chi_0}{\pi} \int_0^{\pi} \left[(1 - \cos\theta)S\left(\frac{(1 - \cos\theta)\gamma}{2}\right) - S(\gamma) \right] \sin\theta \, d\theta$$

Where χ_0 is the susceptibility at zero applied field, including demagnetisation factors, and γ is the penetration parameter,

$$=\frac{3\pi\chi_0 H_{ac}}{\left(3w-\frac{w^2}{l}\right)J_{\rm C}},\qquad S(x)=\frac{1}{2x}\left[\arccos\left(\frac{1}{\cosh x}\right)+\frac{\tanh x}{\cosh x}\right]$$



Fig. 4: Measured hysteresis loops combined using a harmonic analysis over the course of 1 Ac field oscillation compared to the theoretical predictions.



• T=80 K	• 77 Hz

Comparison of $J_{\rm C}$ measurements by Dc and Ac methods





Fig. 7: Comparison between Dc magnetisation and harmonic Ac susceptibility measurements of $J_{\rm C}$

• There is large discrepancy between J_C obtained via Ac susceptibility and Dc magnetisation measurements.

Conclusions

- An analysis of the harmonic Ac susceptibility has been used to determine *J*_C for a GdBCO tape.
- There is a large discrepancy between Ac and Dc measurements at high temperatures and applied fields.
- The error in J_C in Dc magnetisation measurements increases as the Dc field inhomogeneity becomes comparable to the self-field.

References

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- The data are available at: http://dx.doi.org/10.15128/r1m613mx56g and associated materials are on the Durham Research Online Website at http://dro.dur.ac.uk/

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