Critical Current Density in $Gd_1Ba_2Cu_3O_{7-\delta}$ Coated Conductor under the Influence of Flux Creep

Yuta Onodera[1], Takanobu Kiss[1,3], Suguru Gangi[1], Kazutaka Imamura[1], Kohei Higashikawa[1], Masayoshi Inoue[1], Masateru Yoshizumi[2,3], Teruo Izumi[2,3]

1. Graduate School of ISEE, Kyushu University, 744 Motooka, Nishi-Ku, Fukuoka 819-0395, Japan. 2. Superconductivity Research Laboratory, ISTEC, 3-2-1 Sakado, KSP, Kawasaki, 213-0012 Japan.
3. Industrial Superconductivity Technology Research Association (iSTERA), 3-2-1 Sakado, KSP, Kawasaki 213-0012, Japan.

1 . Introduction

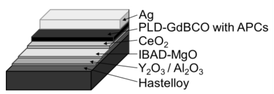
Evaluation of magnetic moment relaxation in CC tape strand is important for especially DC magnet applications such as MRI and NMR because it affects field homogeneity and temporal stability in the magnet. Magnetic moment induced in the tape strands becomes much larger than the case of conventional round wire and depends on the angle of external magnetic field. In addition, measurement time under the each condition should be also an issue .

In this study, we have investigated magnetic relaxation of APC introduced high performance GdBCO CC by using magnetic moment vector measurement including inclined external magnetic field. Then, we have analysed the results within a frame work of the percolation transition model. This allows us to describe *E-J* characteristics as well as magnetic relaxation analytically.

2 . Experiment

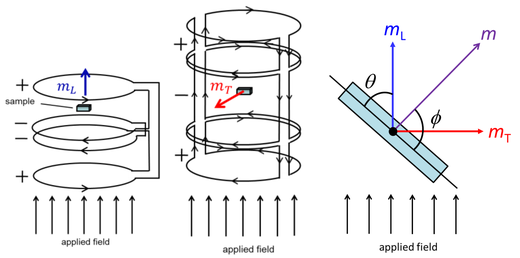
・sample

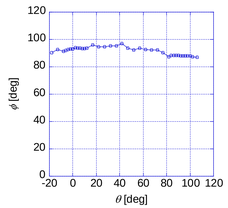
APCs	REBCO	Thickness of Supercond. layer	J_c @77K,s.f	I_c @77K,s.f
With APCs	**GdBCO + BHO** (SRL-ISTEC)	**3.2μm**	**2.1** MA/cm²	**685** A/cm-w



Sample is etched to 3mm x1mm rectangular form.

・measurement

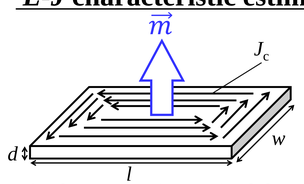




$$|m| = \sqrt{m_L{}^2 + m_T{}^2}$$
$$m_L = m\sin\theta$$
$$m_L = m\cos\theta$$

Magnetic moment m_L & m_T are measured by SQUID.
Its signal are obtained while picking a magnetized sample upward through these second-order gradiometers.

・*E-J* characteristic estimation



$$J = \frac{12m}{w^2 d(3l - w)}$$
$$E = -\frac{\mu_0 G}{2d(l+w)} \cdot \frac{dm}{dt}$$

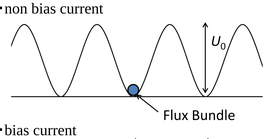
l = 3mm, w = 1mm, d = 3.2 μm.

3 . Results & Discussion

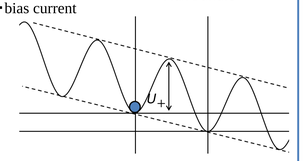
E-J characterisitic model

Flux Flow

・non bias current



・bias current



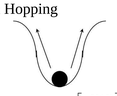
U_0 : pinning potential

Flux Creep

・Thermal Fluctuation

$$E_f(J) = \rho_{FF}\left(J - \hat{J}_c\right)$$

・Flux Hopping

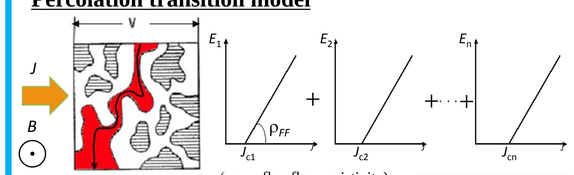


$$U_0 \propto J_c$$

$$E_{co}(J) = E_{co}\exp\left[-\frac{U(J)}{k_B T}\right]$$

$$U(J) = U_0\left|\sqrt{1-j^2} - j\cos^{-1} j\right|, \quad j = \frac{J_{depin}}{J_c}$$

Percolation transition model

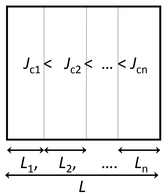


Induced electric field (ρ_{FF} : flux flow resistivity)

$$E(J) = \int_{J_{cm}}^{\infty} E_e(J;J_c)P(J_c)dJ_c$$

$$E_e(J;J_c) = \rho_{FF}(J - J_c)$$

$$P(J_c) = \frac{m}{J_0}\left(\frac{J_c - J_{cm}}{J_0}\right)^{m-1} exp\left[-\left(\frac{J_c - J_{cm}}{J_0}\right)^m\right]$$

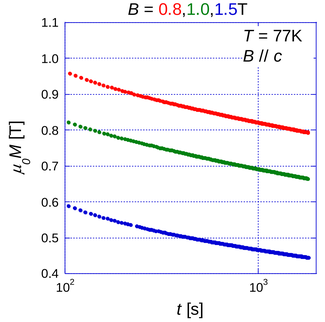


- m : determin the shape of the J_c distribution
- J_{cm} : minimum value of the J_c distribution
- J_0 : the J_c distribution width

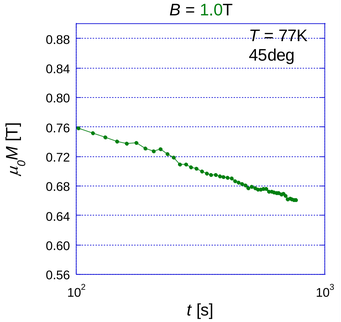
[1] T.Kiss et al., Physica C 392-396(2003)1053

Experimental magnetic relaxation

90degree

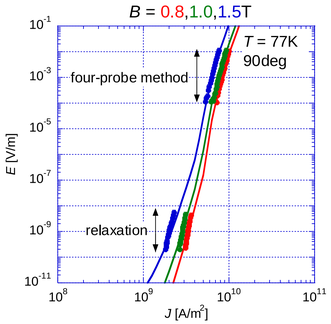


45degree

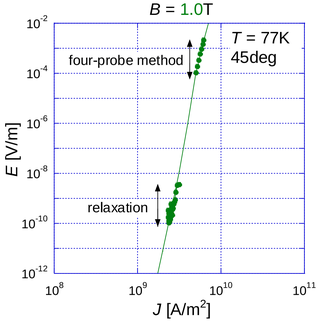


E-J characterisitic

90degree

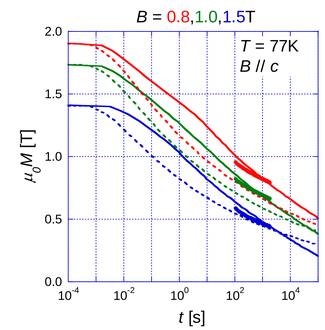


45degree

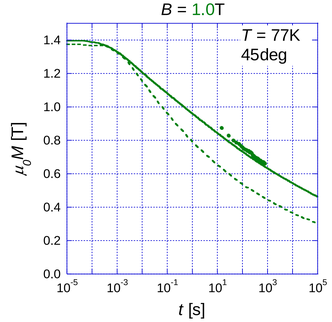


Analytical Magnetic relaxaton

90degree



45degree



solid line : analytical expression
dashed line : *n*-value model

4 . Conclusion

- Magnetic relaxation can be described quantitatively from *E-J* curves measured by standard four-probe method by using the percolation transition model taking into account flux creep with a distribution of activation energy.
- Clear deviation from the *n*-value model has also been confirmed from the experimental results.
- We have also succeeded in obtaining magnetic relaxation under inclined external field by using magnetic moment vector measurement.
  - The vector measurement will allows us to investigate magnetic relaxation under low angle close to parallel to CC surface.

5 . Acknowledgement

This work was supported by the "METI: Development of Fundamental Technology for HTS Coils" and "JSPS: KAKENHI (24760235)".