§68. Simulation of Fluxoid in High Tc Superconductor for Application to Large Superconducting Coils

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Study of superconductivity can be categorized into three aspects; microscopic, mesoscopic and macroscopic phenomena. They are characterized respectively by the BCS theory, the Ginzburg-Landau theory and the macroscopic physical phenomena expressed in the form of the critical state model and flux flow–creep one. As far as is concerned application of superconductors in the form of flux and electromagnetic force utilizations, we do not need to consult the BCS theory. On the other hand, we have to be familiar with the mesoscopic electromagnetic phenomena of superconductivity because most of the macroscopic electromagnetic phenomena of superconductors are nothing else but the average of the mesoscopic behavior of fluxoids and they can predict macroscopic phenomena.

Encouraged by the success of the above studies, we extended this simulation method to the high temperature superconductor Bi-2212 which is known to have a strong 2-dimensionality [1-2]. It was assumed that the fluxoids exists only in the CuO_2 planes in the form of "pancake" fluxoids and that no fluxoid string exists between the CuO_2 planes. In this simulation, some CuO_2 planes are considered and the interaction between them was calculated. The behavior of the fluxoids was simulated by considering the electromagnetic, pinning and viscous forces acting on each fluxoid. The numerical results show that the macroscopic values such as the critical current density can be successfully predicted by the proposed method.

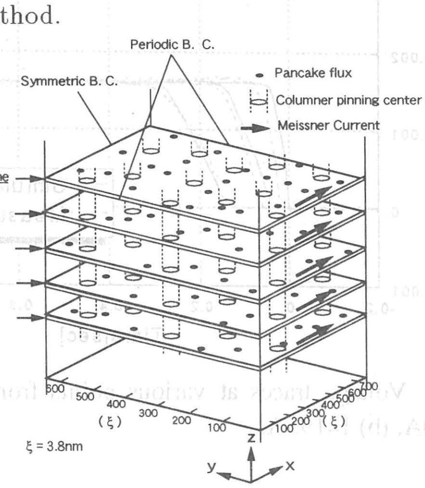

Fig. 1 Computational model

In this study we used Bi2212 as an object of simulation. Fig.1 shows the schematic drawing of the computational model. The thickness of the CuO_2 plane and the normal conducting layers are 1.3 nm and 0.57 nm, respectively. In this study, only 5 layers are taken into consideration and the periodic boundary condition was applied for the z-direction in order to reduce the computing memory. The pancake fluxoids exist only in the CuO_2 planes and are denoted with the small dots. The columnar pinning centers are assumed to be parallel to z-axis. The periodic boundary condition in the x-direction was applied at the boundaries x=0 with $x=L_x$. The symmetric boundary condition in the y-direction was applied at the boundary $y=L_y$.

The total magnetic flux density in the superconductor, the magnetic flux density by pancake fluxoids and the magnetic flux density by Meissner current are shown in fig. 2. The straight line in these figures fits the total magnetic flux density. The critical current density can be calculated by the slope of this line. Fig. 3 shows the calculational and experimental results of the critical current density. This figure denotes that the results of calculation quantitatively correspond with experimental ones.

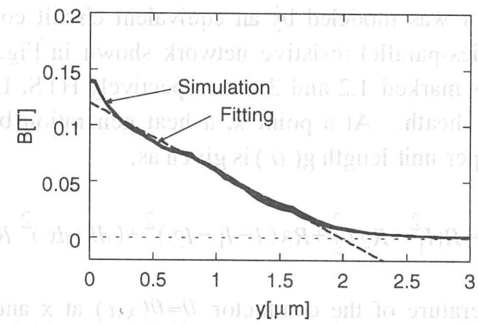

Fig. 2 The magnetic flux density in the superconductor

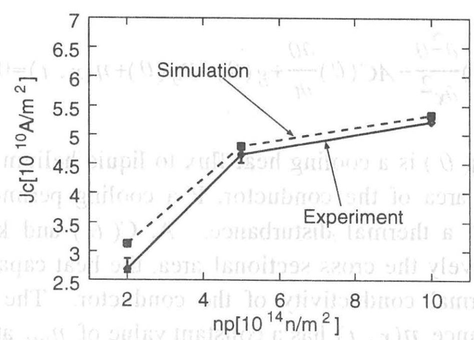

Fig. 3 Comparison calculational results with the experimental ones

In this study we improved the fluxoid dynamics method. For instance the control of the number of pancake fluxoids, their direction and the influence of the magnetic flux density by Meissner current. After that we estimated the magnetization of high Tc superconductor. As a result we obtained good agreements with Bean model, denoted the change of the critical current density by the irradiance.

References

[1] K. Takase, K. Demachi and K. Miya, *Cryogenics*, to be published.

[2] K. Miya, K. Demachi, K. Takase and H. Tsumori, *COMPEL*, (1998) to be published.