【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅱ)

Title of Project : Control of Dynamics of Quantized Vortices and Progressing to Materials Science

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Research Area : Science and Engineering, Engineering, Material engineering, Inorganic materials/Physical properties

Keyword : (A) Crystal structure/Microstructure control

【Purpose and Background of the Research】

A nano-composite/hetero-epitaxial thin film that consists of two materials or more has a big possibility of inventing a new functionality material. There are a lot of promising targets; an efficient superconducting film approaching the theoretical limit of loss-less supercurrent; a multiferroic film interacting the magnetic phase and the ferroelectric phase in the same film; a quantum-dot solar cell film dramatically raising conversion efficiency. This technology enables to draw out the best interaction between a characteristic length/quantum effect and a material by producing an interface, a local strain, a steep change/pattern of electronic state, etc. in the crystal. In this research, the route to improve the loss-less supercurrent to the theoretical limit by using the nano-composite /hetero-epitaxial film technology is investigated. The obtained findings will be also progressed to variety of functionality materials.

【Research Methods】

Parameters defining the superconducting phase are a critical temperature T_c, an upper critical field B_{c2}, and a deparing current density J_0. The energizing of large current is necessary for the measurement of J_0 though T_c and B_{c2} are measured under a small current. But, it is very difficult to achieve a critical current density J_c that almost equals J_0 because the flux pinning of quantized vortices comes off by Lorentz force quickly before reaching J_0. In this research, exceeding the limit of J_c/J_0 = 1-10 %, a new physics of J_c/J_0 = 30-50 % is developed under large Lorenz force. An introduction of strong pinning centers is studied from the viewpoints of "optimized pinning structure", "thin film technology", and "microscopic characterization".

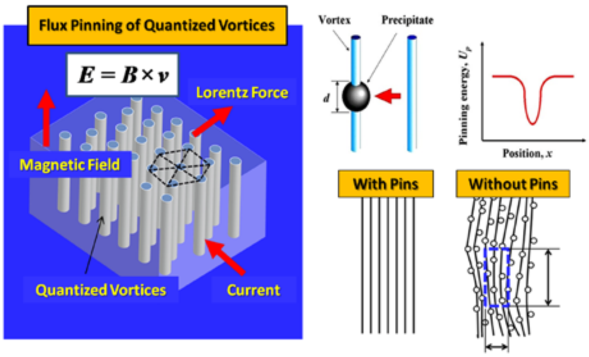

Fig.1 Flux pinning of quantized vortices.

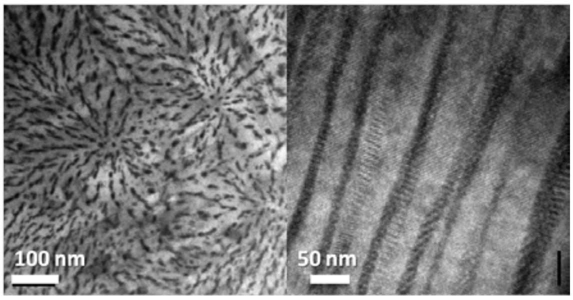

Fig. 2 Advanced flux pinning structure.

【Expected Research Achievements and Scientific Significance】

Showing the route that achieves J_c/J_0 = 30-50 % is the monument of the flux pinning technology. Acquiring the experiences of a nanostructure design, an evaluation from an atom/molecular level, and a large-scale calculation, etc. is effective for development of other functionality films.

【Publications Relevant to the Project】

K. Matsumoto, P. Mele, "Artificial pinning center technology to enhance vortex pinning in YBCO coated conductors", *Supercond. Sci. Technol.* **23**, pp. 014001－pp. 014013, 2010.

Tomoya Horide, Kaname Matsumoto *et al.*, "Control of the glass-liquid transition temperature in $YBa_2Cu_3O_{7-x}$ films", *Phys. Rev.* B **79**, pp. 092504－pp. 092507, 2009.

【Term of Project】 FY2011-2015

【Budget Allocation】 159, 600 Thousand Yen

【Homepage Address and Other Contact Information】

http://w3.matsc.kyutech.ac.jp/energy/index.html