Flux line lattice in $ErNi_2B_2C$

H. Kawano-Furukawa, R. Nagatomo, S. Konno, S. Ohira-Kawamura H. Yoshizawa[a] and H. Takeya[b]

Ochanomizu Univ., ISSP NSL Univ. of Tokyo[a] and NIMS[b]

In ferromagnetic superconductors, an internal magnetic field H_{int} mediated by the ferromagnetic moments may lead a spontaneous vortex phase [1,2,3]. But there is no experimental report for a realization of the phase so far.

$ErNi_2B_2C$ ($T_c \sim 10.5$ K, $T_N \sim 6$ K, $T_{WFM} \sim 2.3$ K) is one of possible candidates for the spontaneous vortex phase, because H_{c1} of the system shows an abrupt decrease below T_{WFM} and it seems to become zero at around 1.8K, which satisfies the condition of the spontaneous vortex phase [4,5,6,7]. To check this possibility, we started to study the flux line lattice on $ErNi_2B_2C$ by a small angle neutron scattering (SANS) technique.

In this study, we used un-anealed single crystals of $ErNi_2^{11}B_2C$ ($T_c \sim 8.6$ K) grown by a floating zone method. The SANS experiments were performed at the SANS-U spectrometer in JRR-3, JAERI, Japan. External fields H_{ext} were applied parallel to both the crystallographic b axis and the incident neutron beam. Neutrons with wavelength $\lambda_n = 11$ Å were selected by a velocity selector, and an area detector at the end of a 16 m long evacuated chamber counted neutrons scattered by the FLL. To maximize neutron transmissions the sample were cut with 1 mm thickness along the neutron beam.

Figures show temperature dependence of FLL diffraction patterns observed under $H_{ext} = 6400$ Oe. The upper panels show data measured after field cooled processes (FC) but the bottom ones were recorded after field cooled and oscillated processes (FCO). Down to 4K, all figures show rhombic FLL patterns. However, at lower temperatures, these two processes give different results. Namely, the FLL patterns after the FC processes remain the rhombic FLL but those after the FCO processes show cubic one. From this result, we lead two conclusions: (1) the rhombic FLL in FC process is due to vortex pinning and (2) an oscillation field of 800 Oe is enough to release the vortex pinning. From the present study, we succeeded in construction of a phase diagram of the FLL structure on $ErNi_2^{11}B_2C$.

We are on the process to verify the spontaneous vortex phase in this compound and the further experiments are planed.

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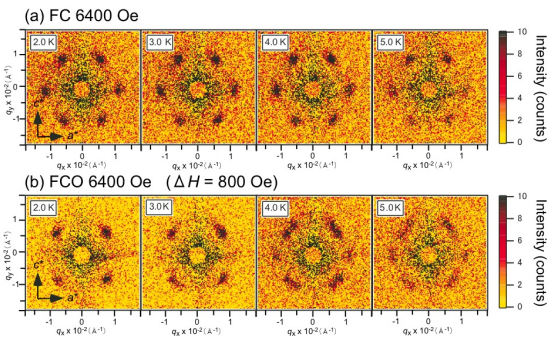

Fig. 1. Temperature dependence of FLL patterns after FC and FCO processes.