§10. Investigation of Magnetic Structure under Microwave Heating Using by Neutron Diffraction Measurements

Takayama, S., Fukushima, J. (Nagoya Univ.),
Sato, M.,
Takeda, M. (JAEA)

Microwave irradiation to materials is a newcomer for our civilization with a history of only half century. The temperatures of the surroundings are colder than that of targets, that can easily be imagined by a home microwave oven. It clearly suggests that the energy transfer mechanism in microwave heating is quite different from the traditional heating process. Recently, we have developed new methods to form nano-structures consisting of small magnetic domains of 5 ~ 20 manometers with random orientations, when some ferromagnetic materials are exposed to the magnetic field at microwave frequencies. These domains spread beyond boundaries of starting crystals of several tens microns to bulk materials in the order of millimetres. The series of experiments will answer the mechanism that the change of crystal structure generated by microwave energy directly or it created by the cooling. The most expected result is the first case. It suggests that the microwave magnetic field supplied the energy directly to the electrons of the materials; especially it couples with electron spin motions.

High frequency alternated magnetic field applied to a sample placed on the H-field node in the TE103 single mode cavity with the cross-section of 27.2mm x 85 mm. The generator supplied microwave to the cavity at the frequency 2.45 GHz. The microwave power varied from 50 to 1500 watts controlling by the DC power supply consisted of AC-DC inverter. The waveguide was evacuated to 10^{-4} Pa by turbo molecular pump with 100 l/s pumping speed. The infrared pyrometer measured the temperature of the sample through the 6mm hole drilled through the end plunger of cavity. The cavity has thin sidewall of aluminum to get enough transparency of the neutron particles for the diffraction measurement.

Polarized neutron diffraction profiles were measured by using the thermal neutron triple-axis spectrometer TAS-1 installed at the 2G beam port of the research reactor JRR-3 at the Japan Atomic Energy Agency (JAERI) in Tokai. To measure the spin dependent magnetic scattering, Bragg reflected neutron intensities from the sample are recorded with the incident neutrons polarized by means of magnetized Heusler alloy monochromator. The spin state of the incident neutrons could be selected by operating a direct current flipper to be either parallel (flipper on) or antiparallel (flipper off) with respect to the guide field. The energy of the inicident neutrons was 14.7meV and pyrolytic graphite filter was inserted to remove the higher order contaminations. The sample was at RT and fully magnetized under one Tesla magnetic field applied vertically to the scattering plane by an electromagnet on the sample table.

The sample composed of one micron under Fe_3O_4 powders packed by static press up to 60% of the theoretical density. The size of the sample was 8mm diameter and 4 mm thick pellet that was small enough not to disturb the criterion for fundamental resonance in the cavity. It was put in the E-field or H field maxima in the cavity supported by thermal insulator made of a lightweight alumina silica fiber board. It was evacuated in one hour before the microwave application.

The neutron diffractions spectrum was measured under e-field and H-field of microwave. Figure 1 shown the polarized neutron scattering profile of Magnetite (111) Bragg reflection with one Tesla after heating under E-field and H-field. The parallel intensity depend on spin motion. The parallel intensity on H-field decreased in the parallel intensity on E-field of 30%.

It suggests that the microwave magnetic field supplied the energy directly to the electrons of the materials; especially it couples with electron spin motions.

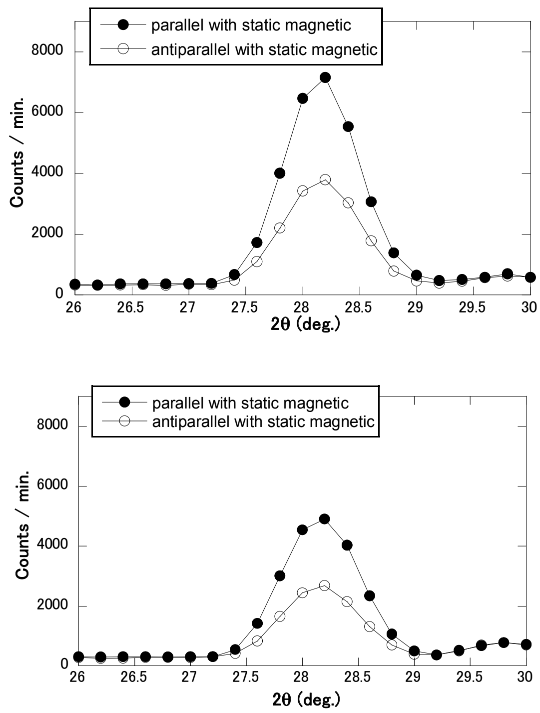

Figure 1: The polarized neutron scattering profile after heating under E-field (upper) and H-field (under).