Phonon excitations in an Iron-Manganese-based Elinvar alloy

Y. Ikeda [A]

[A] *Institute for Materials Research, Tohoku University*

Invar and Elinvar phenomena are significant scientific achievements in the application of structural materials to improve the thermal stability of mechanical properties. In recent years, further updates on the performance have been reported in iron-manganese-based alloys, where the temperature coefficient of Young's modulus is at least 10^{-5} K^{-1} around room temperature by adding a small amount of a third impurity element, such as molybdenum [1, 2]. We suggest that a possible mechanism is the additional softening of elastic constants compensating for the normal hardening in the Elinvar temperature region. To approach this problem, we focus on pioneering work by Endoh et al. using neutrons; they found a shallow anomaly in the transverse acoustic phonon dispersion around the Γ point in the cubic Fe-Mn alloy [3]. The phonon anomaly was observed only in the Γ_3 mode and indicated structural instability. In our experiment, we aim to clarify the phonon anomaly in Elinvar alloys for a Mo-added Fe-Mn alloy.

Single crystalline samples were prepared using the Bridgeman method. The crystal orientation was checked using the Laue method and aligned to measure transverse acoustic phonon modes around the reciprocal lattice vector $\boldsymbol{G}$ of (2, 2, 0) for the phonon propagation wave vector parallel to [1-10]. The size of the sample is approximately 20 mm x 5 mm in diameter. Trial neutron experiments were conducted using 6G-TOPAN with a coarse resolution mode (B-30'-30'-30'). E_f was fixed at 30 meV, and a PG filter was used to reduce higher-order contamination. The sample was placed in a cryofurnace, and the temperature was controlled between 100 K and 450 K.

As shown in Fig. 1, we succeeded in observing phonon excitations around a Γ point. The roughly evaluated sound velocity of Fe-25Mn-3Mo is almost consistent with that of Endoh's results for a cubic Fe-Mn. For Fe-25Mn-3Mo, the damping of the excitation spectra seems to increase with changing energy transfer. Although further investigation is needed, such characteristic phonon spectra could be a key factor in achieving unusual elastic properties in Fe-25Mn-3Mo alloys.

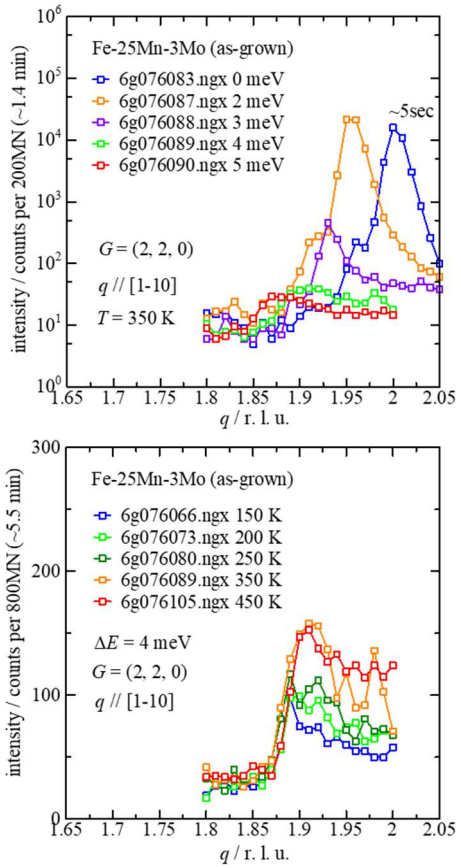

Fig. 1. Neutron scattering profiles of Fe-25Mn-3Mo (as-grown).

[1] T. Masumoto, S. Ohnuma, K. Sugawara, and H. Kimura, Mater. Trans. **58**, 701 (2017).
[2] K. Sugawara, S. Ohnuma, and T. Masumoto, Mater. Trans. **59**, 897 (2018).
[3] Y. Endoh, Y. Noda, M. Iizumi, J. Phys. Soc. Jpn. **50**, 469 (1981).