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Martensitic Transformation of $N_{2.18}Mn_{0.82}Ga$ Single Crystal

Kazuko INOUE*[1], Kazumasa OHSUMI[2], Katsuhiro KUSAKA[2], Takeshi NAKAGAWA[3]
[1]Fac. of Sci. & Tech. Ryukoku Univ., Seta, Otsu 520-2194, Japan
[2]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan
[3]Fac. of Sci., Kanazawa Univ., Kakuma, Kanazawa 920-1192, Japan

Introduction

An off-stoichiometric Heusler-type $Ni_{2.18}Mn_{0.82}Ga$ single crystal shows a shape memory effect [1]. It makes a thermo-elastic martensitic transformation at around 340 K, which coincides with a Curie temperature. The single crystal is expected to cause a magnetic field-induced shape memory effect [2].

To analyze precisely the mechanism of transformation, we made a synchrotron radiation white X-ray diffraction of the single crystal by changing the temperature from 400 K to 103 K. This method is suitable for our purpose because we are able to obtain the diffraction from the inner part of the bulk specimen by high intensity X-ray.

Experimental

The SEM image of the single crystal used for the present experiment is shown in Fig.1. The length was about 6 mm.

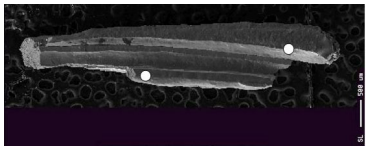


Fig.1. SEM image of the single crystal. White circles show the area used for measurement.

The beam line, BL-4B1, was used. The beam size of white X-ray was about 40μm at sample position. The sample was put in the small furnace for changing the temperature, and was surrounded by an IP with cylindrical shape of 10 cm diameter. We put the direction of the crystal growth along the central axis of the cylinder.

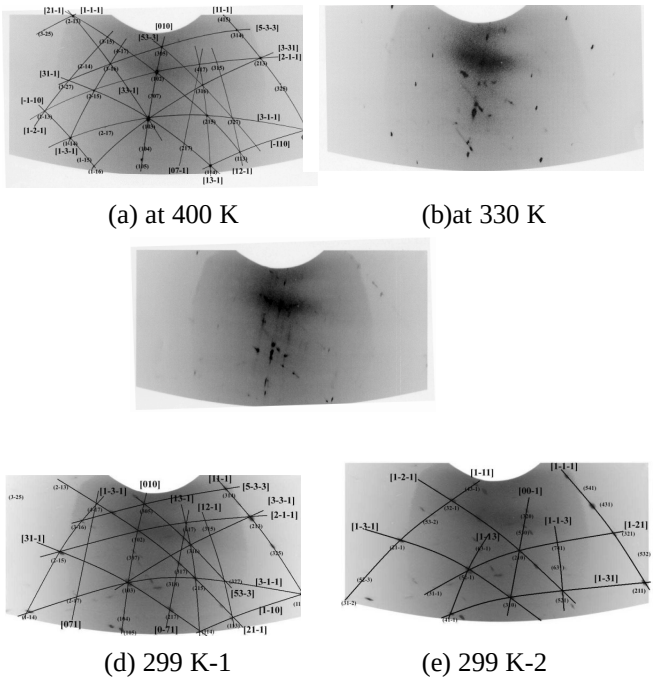
Results and Discussion

At 300K before heating, the structure was found to be tetragonal, which is consistent with the tetragonal Heusler structure in the martensitic phase determined by powder neutron diffraction [1]. For one index, two Laue spots slightly shifted coexist, which indicates that two tetragonal phases with slightly shifted axes coexist.

At 400K in the parent phase after heating, two Laue spots unite to one. Only one cubic Heusler structure exists.

For both tetragonal and cubic phases, the direction of the crystal growth was found to be nearly along [010] axis of each structure.

We observed the change of Laue spots with decreasing temperature from 400 K. The Laue spots at each temperature are shown in Fig. 2. At 400 K and at 299 K, indices and the zone axes are shown in the figures.



(a) at 400 K (b)at 330 K

(d) 299 K-1 (e) 299 K-2

Fig.2. Laue spots at each temperature.

At 330 K, Laue spots of cubic structure still remain. We see many other peaks appear around cubic [010] zone axis and some of them have a long tail. At 315 K, the spots corresponding to cubic structure almost disappear and the spots corresponding to the final tetragonal structure begins to appear, which have a tail along the zone axes of final tetragonal structure. The long tails parallel to cubic [010] zone axis appearing on left-hand side becomes tetragonal [010] axes at 299 K. Precise analysis about the significance of the tail is necessary.

At 299 K after cooling down, the twining tetragonal structures in the martensitic phase were detected. The twining plane was found to be (011) of the tetragonal structure.

References

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*inoue@rins.ryukoku.ac.jp