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Phonon Softening and Time Dependence of Elastic Peak Appearing Prior to the Martensitic Transformation in Au–47.5 at% Cd

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There are two distinct martensites called γ_2' and ζ_2' phases near the equi-atomic composition in AuCd alloy system. The phonon dispersion relation of the $[\zeta\zeta 0]TA_2$ branch was measured by inelastic neutron scattering in a $Au_{52.5}Cd_{47.5}$ alloy which produces γ_2' martensite. The difficulty of strong neutron absorption was overcome by the use of an isotope ^{114}Cd. The softening was observed at the Brillouin zone boundary and at $\zeta = 0.35$. An elastic peak was observed at $\zeta = 0.35$, but not at the zone boundary. The peculiar time dependent behavior was observed in the elastic peak.

KEYWORDS: martensitic transformation, $Au_{52.5}Cd_{47.5}$, phonon softening, precursor phenomenon, time dependence, neutron inelastic scattering

1. Introduction

AuCd is one of a typical martensitic alloys. Near the equi-atomic composition, the parent structure is B2 (CsCl type structure) and there are two distinct martensite phases, ζ_2' and γ_2' occurring at low temperature.[1)] The former one appears close to the composition of $Au_{50}Cd_{50}$ and the latter one close to the composition $Au_{52.5}Cd_{47.5}$. The crystal structure of the former was recently determined to be trigonal.[2)] From the knowledge of the low temperature structure, a phonon softening at $1/3[110]TA_2$ branch was predicted and then observed in an inelastic neutron scattering experiment.[3)] The crystal structure of the γ_2' martensite was determined to be orthorhombic by Ölander[4)] and refined by Ohba *et al.*[5)] From the structural consideration, the orthorhombic structure is obtained by alternative movements of $\{110\}$ plane. Therefore the phonon softening at the Brillouin zone boundary ($\zeta = 0.5$) of $[\zeta\zeta 0]TA_2$ is expected in the $Au_{52.5}Cd_{47.5}$.

The phonon softening picture is the simplest and direct precursor phenomenon to understand the martensitic transformation. Although there are several alloys which show martensitic transformation, the softening which directly relate to the martensite structure is not always observed.[6–9)] Since the Au_xCd_{1-x} alloy system produces two distinct martensites for slightly different composition, it is one of the most suitable and interesting systems to observe the relation between the phonon softening and the structure of the martensite.

Furthermore, there is interest in studying the elastic scattering also. In $Au_{50.5}Cd_{49.5}$, which produces ζ_2' martensite, elastic peaks were observed at $1/3\langle 1\bar{1}0\rangle$ as a precursor associated with the phonon softening.[3,10,11)] They correspond to the low temperature ζ_2' phase. In $Au_{52.5}Cd_{47.5}$, an elastic peak at $1/2\langle 1\bar{1}0\rangle$ is expected from the structural consideration, if the similar mechanism is considered.

In the present paper, the phonon dispersion relation of the $[\zeta\zeta 0]TA_2$ and the elastic scattering was measured in $Au_{52.5}Cd_{47.5}$ alloy.

2. Experimental

The single crystal of parent phase $Au_{52.5}Cd_{47.5}$ was grown using an isotope ^{114}Cd to minimize the neutron absorption. The isotope was provided by Advanced Materials Tech. Careful heat treatment, that is, a furnace cool, was employed to prevent the formation of mixtures of γ_2' and ζ_2' martensites.[12)] The size of the sample was 3 mm in diameter and 50 mm long with [001] direction along the long axis and had sample mosaic of 10′. The lattice parameter at $T = 400$ K is $a = 0.332$ nm. The transformation temperatures in this experiment were determined by measuring the intensity of 110 reflection of the parent phase. The transformation temperatures M_s and M_f were 312 K and 300 K, respectively, and A_s and A_f were 318 K and 334 K, respectively. The experiment was carried out at H4M spectrometer of the High Flux Beam Reactor at Brookhaven National Laboratory. The details of the experiment were described in the reference.[3)] The fixed final energy of the neutron was either 14.7 meV or 13.5 meV.

3. Results and Discussion

The transformation temperatures determined by the above method are shown in Fig. 1. The transformation temperatures mentioned above are different from those previously measured by Differential Scanning Calorimetry (DSC). The transformation temperatures measured by DSC are as follows; $M_s = 348$ K and $M_f = 346$ K and the reverse transformation temperatures are: $A_s = 370$ K and $A_f = 374$ K. The measurements of DSC were performed for the sample from the same ingot of $Au_{52.5}Cd_{47.5}$. The inhomogenity of the sample

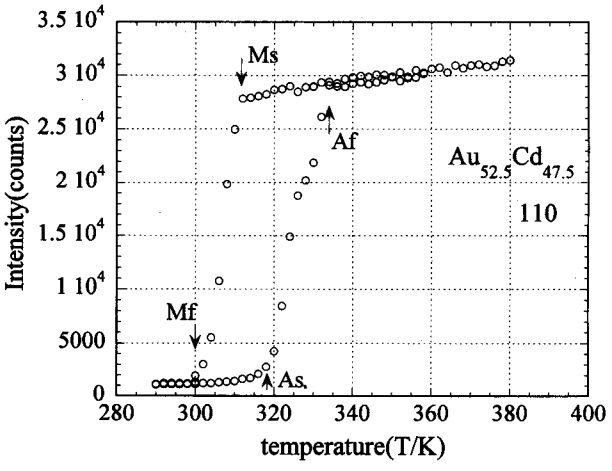

Fig. 1. The transformation temperatures measured by 110 reflection of the parent phase.