RESEARCH REPORTS

MAGNETIZATION MEASUREMENTS OF MANGANESEGOLD ALLOY IN PULSED MAGNETIC FIELD

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1. Introduction

A way of common knowledge for studies of magnetic property is a electromagnet method. However, for the studies of magnetic property of matter with large anisotropy or exchange energy, the strength of the magnetic field induced in the magnet is not succesful.

On the other hand, from the magnetic measurements in low magnetic fields, Meyer *et al.*[1] found that the magnetization of Au_2Mn alloy has a transformation from antiferromagnetic to ferromagnetic due to the application of magnetic field, and that the transition point increased continuously from 10.5 to 13 kOe as the temperature fell from room temperature down to 100°K. Later, However, by the magnetization measurements in very strong magnetic fields and in the temperature range from 418°K down to 77°K Zavadskii *et al.*[2] showed that the transition took place at 15 kOe, independent of temperature. The present authors wished to solve the discrepancy of these two results by measuring the magnetization of a Au_2Mn alloy in pulsed high magnetic fields at 80°K and 4.2°K. The saturation magnetization and the antiferro-ferromagnetic transition field are also determined. Further, on the basis of these results, the screw angles are estimated by Nagamiya's theory.

2. Specimen and experimetal method

Electrolytic manganese with purity 99.9 per cent and gold with 99.99 per cent purity were mixed in proper ratio. The mixture was sealed in an evacuated silica tube, and heated in an electric furnace at 1100°C for 5 minutes, and then cooled down to 700°C in the furnace. Further it was annealed at 700°C for 3 days, and then cooled to room temperature in the furnace. A column-shaped specimen, 3.0 mm in diameter and 3.0 mm in length was prepared from this crystal. The magnetic susceptibility of this specimen in low magnetic field showed that the specimen is antiferromagnetic with Neel temperature at 365°K. The

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pulsed magnetic fields were obtained by the discharge of capacitors (4000 V, 2000 UF) on to a solenoid mentioned below. The magnetizing coil, 10 mm in inner diameter, 25 mm in outer diameter and 70 mm in length, had 758 windings of enamelled copper wire of 1 mm in diameter as shown Fig. 1. The field had

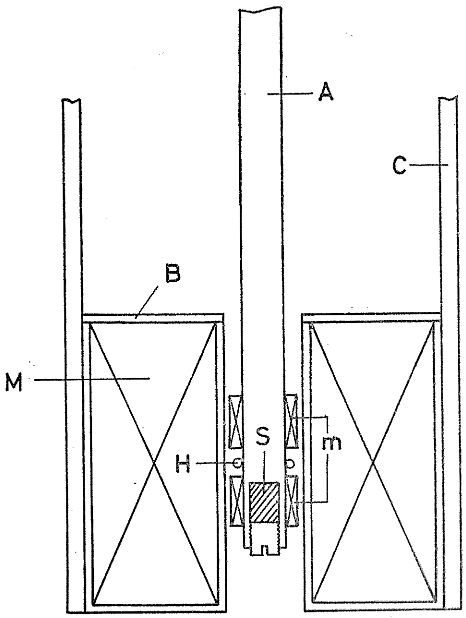


FIG. 1. Magneizting and Measuring coils.
A: acrylic resin
B: brass cover
C: support of coil (Ni-Cu alloy tube)
M: magnetizing coil
m: search coil for magnetization
H: search coil for field
S: specimen

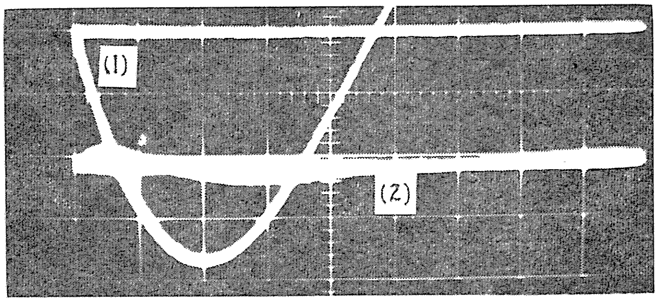
a period of 16 m. sec. Magnetization measurements were carried out by the induction method, as shown in Fig. 1. A pair of two search coils, which had 4 mm in length and 53 windings of enamelled copper wire of 0.05 mm in diameter, were connected in series and in antiphase their axis lying along the magnetizing solenoid, and they were placed at intervals 10 mm each other. Then, the e.m.f. induced with the specimen was integrated by the usual kind of R·C integrator, which has a period of 0.1 sec, and was measured by the oscillograph. Further the magnetoresistance change of the search coil is represented by

$$\rho_H/\rho=\alpha H, \tag{1}$$

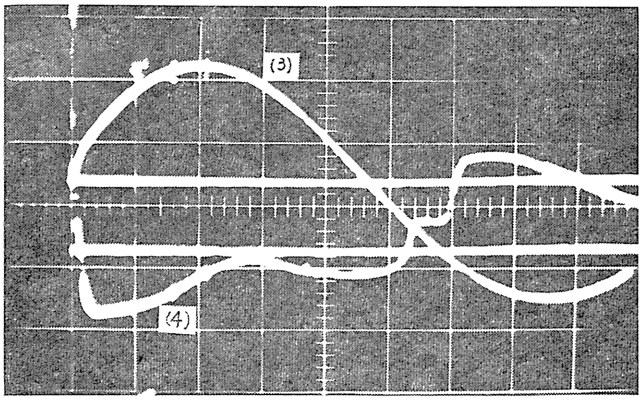
where α is a constant and it is estimated to be 0.33 10^{-5} Oe^{-1}. The values of magnetization obtained from the patterns of oscillograph were corrected by this results. If as the specific resistance of Au_2Mn alloy we take 3.8 $10^{-6}/cm^{2)}$, the skin depth of the magnetic field is obtained to be 1.96 cm. For this specimen, therfore, the non-uniforming of the field inside the specimen can be neglected. Nickel metal with purity 99.99 per cent was used as the standered specimen.

3. Experimental results

The magnetizations of Au_2Mn alloy were measured in pulsed magnetic field at 80°K and 4.2°K. The typical oscillogram of the magnetization was shown in Fig. 2. and the difference between induced e.m.f. V(4) and V(2) versus H



(a)



(b)

FIG. 2. Oscillation curves of magnetization at 4.2°K.
(a): Curve 1 for the magnetic field and curve 2 for the measuring coil without the specimen (0.02 V/cm)
(b): Curve 3 for the magnetic field (0.05 V/cm) and curve 4 for the magetization of Au_2Mn (0.05 V/cm).

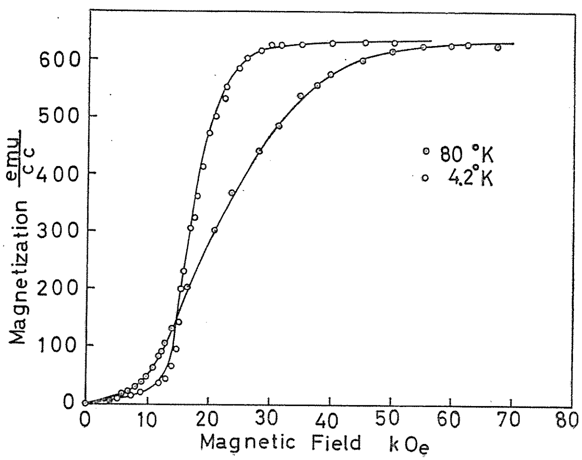


FIG. 3. Magnetization curves of Au_2Mn.

curves, using only the first maximum corresponding to the maximum field, were given in Fig. 3. The saturation magnetization M_s was obtained to be 658 e.m.u/cc. If we use a=3.37 Å, c/a=2.60 and the saturation value, the magnetic moment of a manganese atom is estimated to be 3.38 μ_B. If we take the maximum point of the curves of field dependence of differential magnetization dM/dH, as the antiferro-ferromagnetic transformation point, the critical fields H_c corresponding to the point are obtained to be 13 kOe at 80°K and 15 kOe at 4.2°K, respectively. These results support Meyer's data rather than that of Zavadskii.

We can conclude that the critical fields for the antiferro-ferromagnetic transformation is depend on the temperature and the screw angle shows the temperature dependence as discussed in § 4.

4. Discussion

Using the theory derived by Nagamiya *et al.*[3] and Herpin *et al.*[4], we shall show that the temperature dependence of H_c consist with the data of neutron diffraction study which the screw angle gradually decreases with decreasing temperature. According to their theory the relation among the screw angle φ, magnetization in the c-plane, and the critical field H_c, was given as

$$\chi = \left(\frac{\mu_0}{2H_0}\right)/[1+2\cos\varphi(1+\cos\varphi)], \tag{2}$$

$$\frac{H_c}{H_0} = \sqrt{(1+\beta)(2+\beta)} - (1+\beta), \tag{3}$$

$$\beta = (1+2\cos\varphi)^2,$$

and shown in Fig. 4 roughly.

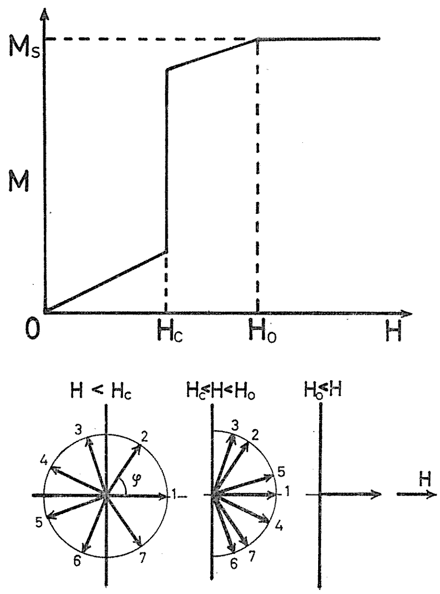


FIG. 4. A model picture of magnetization curve in the c-plane of Au_2Mn alloy at 0°K.

In this expression H_0 is the field intensity for saturation, and μ_0 the saturation moment. When we take $H_0 = 30$ kOe and $\mu_0 = 3.38$ μ_B, the screw angle φ were obtained to be 45° at 80°K (neutron diffraction result 46°) and 40° at 4.2°K (neutron diffraction result 44°) respectively, and they are good agreement with the neutron diffraction study.

5. Conclusion

Pulsed high magnetic field (about 110 kOe) was made by means of condenser discharge method and magnetization of the manganese-gold alloy was measured in the field. The saturation magnetization of Au_2Mn alloy was obtained to be 658 e.m.u./cc. The critical fields for the antiferro-ferromagnetic transformation found to be 13 kOe at 80°K and 15 kOe at 4.2°K. The screw angles φ were estimated to be 45° at 80°K and 40° at 4.2°K.

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