

ON THE  $\epsilon$  TO  $\tau$  TRANSFORMATION IN  $Mn_{1.1}Al_{0.9}$  ALLOY

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It was shown recently<sup>1,2</sup> that high temperature disordered phase  $\epsilon$  (hcp) transforms on cooling first to an ordered orthorhombic phase  $\epsilon'$  and then martensitically to a tetragonal phase  $\tau$  (fct). The orientation relationships between structures were found to be

$$\begin{array}{lll}
 (0001)_{\epsilon} & // & (100)_{\epsilon'} & // & (111)_{\tau} \\
 (1\bar{1}00)_{\epsilon} & // & (001)_{\epsilon'} & // & (112)_{\tau} \\
 (11\bar{2}0)_{\epsilon} & // & (010)_{\epsilon'} & // & (\bar{1}10)_{\tau}
 \end{array} \quad (1)$$

The martensitic transition occurs by shearing the crystal for  $1/3 [010]_{\epsilon'}$  on every second  $(001)_{\epsilon'}$  plane. In the  $\tau$ -phase of the pure alloy<sup>2</sup> ( $Mn_{1.1}Al_{0.9}$ ) as well as in those with small addition of the third component (C, Cu),  $\{111\}$  twins, anti-phase boundaries and stacking faults were found by transmission electron microscopy as the most prominent structural defects affecting magnetic properties of the alloy<sup>3,4</sup>. In the present work the origin of the  $\{111\}$  twins is investigated with respect to the thermomechanical history of the specimen.

An alloy with the nominal composition of 55 at.% Mn was prepared by induction melting of high purity materials. After homogenization at  $1000^{\circ}C$  for 2 days the alloy was quenched in an ice water, sliced in thin discs and then electropolished in a mixture of 20% perchloric acid and 80% ethanol at about

-10°C. Examinations were carried out in a Philips EM 301 electron microscope operating at 100 kV.

In quenched specimens very large grains of the hexagonal phase, tens of micrometers in diameter, were found. Electron diffraction taken of these grains showed very weak and diffuse superstructural reflections. During subsequent heating in the electron microscopy the intensities of these reflections gradually increased until at a certain degree of order, e.g. after heating at 470°C for 15 minutes, a sudden change of the structure took place. Such a change of the structure was usually local, attached to the wedge of a hole or to some other structural imperfection in the foil. Furthermore, it was observed that shear occurred only when the direction of the shear was not inclined too much with respect to the normal of the foil. These local changes of the structure are characterized with more or less dense parallel planar faults which are shown in Fig.1a, as seen edge on. Fig.1b and Fig.1c show the electron diffraction taken of the left/up and right/down part of the region shown in Fig.1a, respectively. The streaks in the first case can be interpreted as due to randomly distributed stacking faults on the  $(100)_{\epsilon'}$  planes originating from the  $(0001)_{\epsilon}$  planes while the streaks in the second case are obviously due to very fine order twins (microtwins) with the twinning plane  $\{111\}_{\tau} // (100)_{\epsilon'}$ , i.e. originating from the same plane. Consequently the relative orientation relationship between these two structures can be written as

$$\begin{array}{l} [011]_{\epsilon'} // [011]_{\tau} \\ \text{and } (100)_{\epsilon'} // (111)_{\tau} // \text{ twin plane .} \end{array} \quad (2)$$

Although the relationship (2) corresponds to that found by

previous authors<sup>1</sup> it has to be pointed out that the slip for  $1/3$  on the  $(100)[001]\epsilon'$  shear system results in formation of  $\{111\}$  order twins. The situation is shown schematically in Fig.2 as seen in the plane of the shear. Obviously the formation of fine  $\{111\}$  twins prevents the transformed region against drastic changes of the shape caused by the simple shear transforming the orthorhombic structure to the tetragonal one. Consequently these twins can be considered as the lattice invariant deformation of the martensitic transition  $\epsilon' \rightarrow \tau$  (transformation twins) with respect to the so-called deformation twins which appear subsequently as a result of stress relieving on those  $\{111\}\langle 112 \rangle \tau$  shear systems which do not originate from the  $(100)[001]\epsilon'$  shear system.

#### References

1. S.Kojima, T.Ohtani, N.Kato, K.Kojima, Y.Sakamoto, I.Konno, M.Tsukahara, and T.Kubo, Proc.AIP Conference on Magnetism and Magnetic Materials - 1974, American Institute of Physics, N.Y.,1975
2. J.P.Jacobovics, T.W.Jolly, Physica 86-88B(1977),1375
3. G.W.Jarrett, Part II Thesis, University of Oxford (1976)
4. J.Van Landuyt, G.van Tendeloo, Transactions on Magnetism, vol.MAG-14,15(1978)

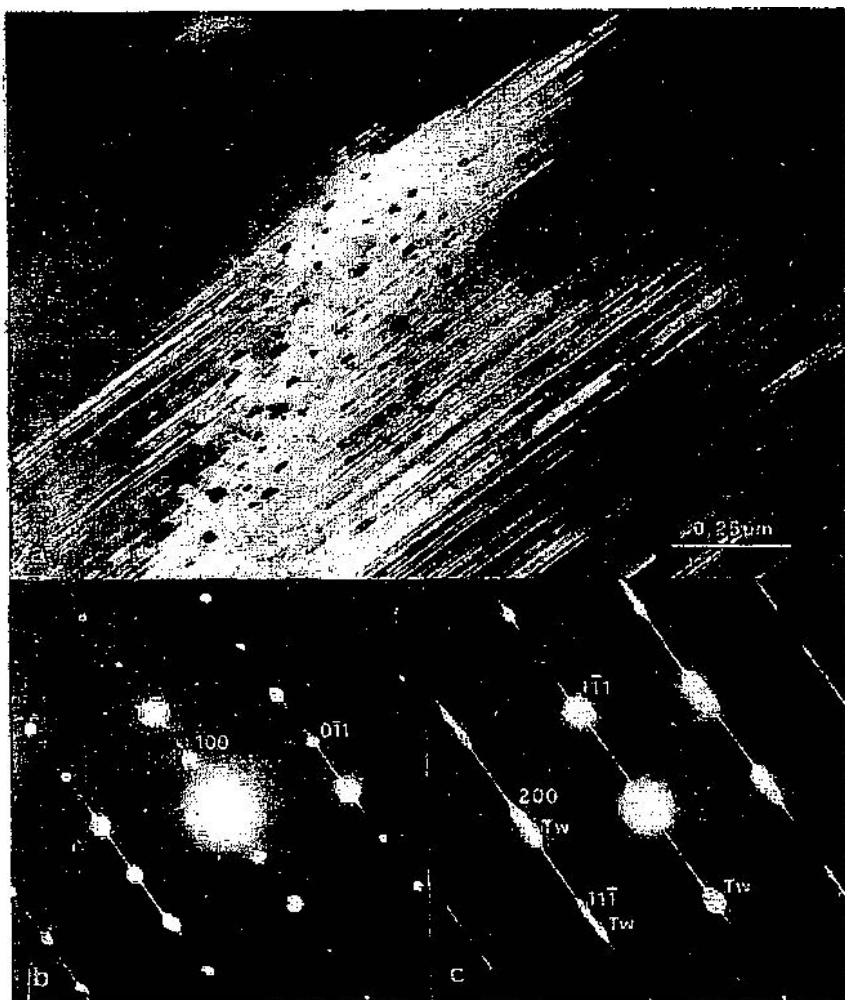
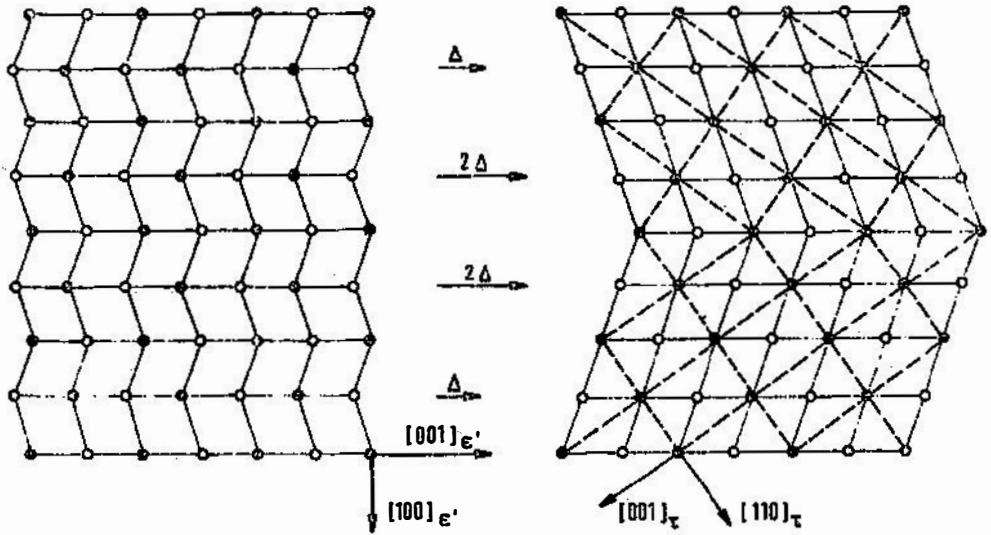


Fig. 1 (a) Parallel planar faults as seen edge on/  
 (b) and (c) electron diffraction patterns  
 taken of the left/up and right/down part  
 of the region shown in Fig. 1a, respectively.



**Fig.2** Formation of the order tetragonal twin by glide on the  $(100)[001]_{\epsilon'}$  shear system