

1) Introduction

In materials that undergo deformation twins the effect of grain size on mechanical properties can be complex. The focus of this investigation is to understand and model the effect of grain size on twinning. The work will reveal how best to incorporate twinning into structure property models.

2) Experimental

As-received CP Ti sheet was cold rolled and annealed to develop different grain sizes. Tensile tests were performed up to failure at room temperature at a strain rate of 10^{-3} s^{-1} . Separate tensile tests were carried out up to strains of 5%, 10% and 14%. Also, an in-situ tensile test was carried out on a coarse grained sample.

Table 1

Cold rolling Reduction, %	Annealing		Grain size, μm
	Temperature, C	Time, min	
52	600	5	6.6
30	650	9	18
30	700	15	35
30	700	120	70
30	700	360	94
52	850	600	204

3) Results

Figure 1 shows the effect of grain size on the number of twins per grain. It can be seen that the number of twins per grain increases with increasing grain size and strain.

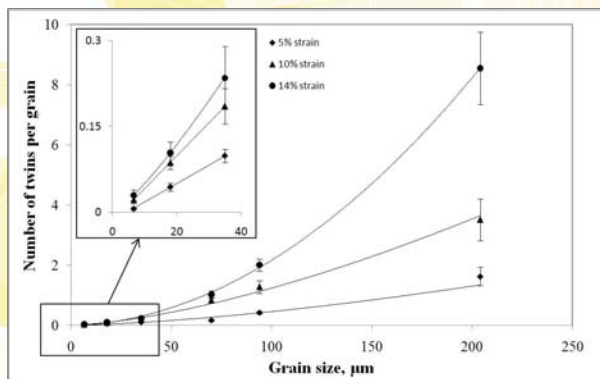


Figure 1

Figure 2 shows the increase in twin volume with grain size.

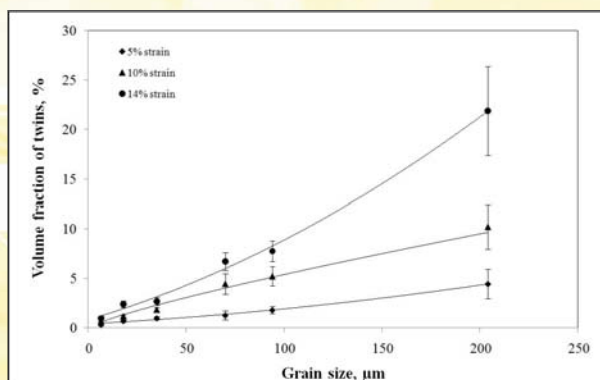


Figure 2

To understand the role of the grain size on the twin activity, it is necessary to know how the thickness evolves. Twin thickness μm can be determined with the following equations.

$$V_t = \frac{\chi}{Nt_v} \quad (1)$$

V_t = average twin volume
 χ = volume fraction
 Nt_v = number of twins per unit volume

$$V_t = \frac{\pi}{6} t l^2 \quad (2)$$

t = thickness of twins
 l = length of twins
 with an upper estimation, l can be equal to the grain size, d

Figure 3 shows the average twin volume (extracted from the equation 1) against the grain size. It is seen that the V_t has a linear relationship with the square of the grain size. Therefore, according to the equation 2, it can be concluded that the twin thickness has not change with the grain size.

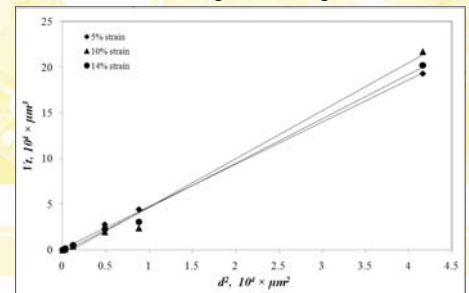


Figure 3

Also the thickness of twins was directly measured from the microstructure for some conditions and they were inserted to the equation 2 (Figure 4).

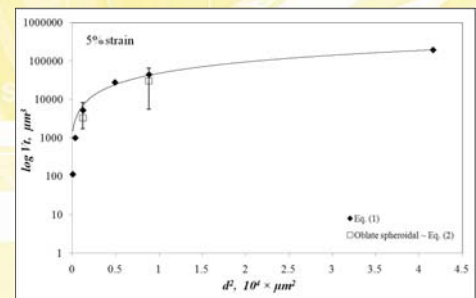


Figure 4

It is seen that both different methods for estimation of twin volume give approximately the same values.

However, the in-situ tensile test revealed that some twins are likely to thicken with increasing strain (Figure 5).

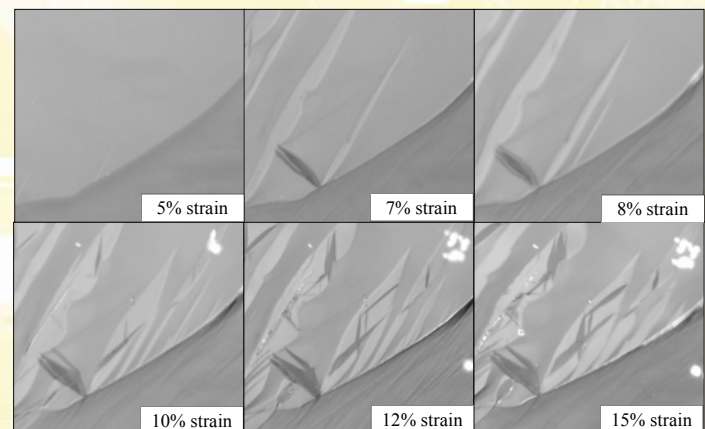


Figure 5

4) Conclusions

- 1- Number of twins per grain and volume fraction of twins increase with increasing the grain size.
- 2- Some twins tend to thicken with increasing strain.
- 3- Thickness of twins remain constant with changing the grain size.
- 4- Current findings can open new insight for a comprehensive twin modeling.