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## Appendix

The grain boundary energies of metals are often found to be roughly  $\frac{1}{2}$  of their surface free energies (Ref. 43). The surface free energy of titanium is not available in the literature. However, the surface free energies of metals are related with their melting points. The higher the melting point, the higher the value of surface free energy (Ref. 43). This correlation can be seen in Fig. 19, which is drawn based on the data available in the literature (Ref. 45). By linear fit of the data in Fig. 19, the surface free energy of titanium can be estimated to be about 2.25 J/m<sup>2</sup>. If the grain boundary energy of titanium is taken as  $\frac{1}{2}$  of this estimated surface free energy, its corresponding value will be 0.75 J/m<sup>2</sup>. This estimated grain boundary energy is comparable with those of other metals whose melting points are close to titanium and experimentally measured value are available in the literature. For example, the grain boundary energy (Ref. 45) of  $\gamma$ -Fe is 0.756 J/m<sup>2</sup>.

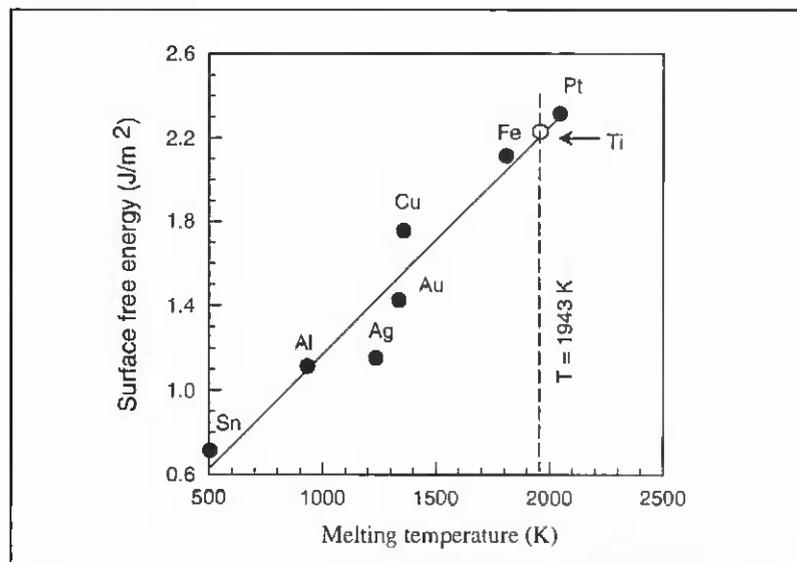


Fig. 19 — Estimation of the surface-free energy of titanium based on the data of other metals available in literature (Ref. 44).

