The effect of austenite crystal volume on the M_s temperature of austenitic Fe–Ni–C alloy single crystals

It is well known that the start temperature of austenite to martensite transformations (M_s) in Fe alloys is influenced by austenitizing temperature and deformation of the austenite matrix [1–6]. Cech and Turnbull [1] found that the size of the austenite grains in Fe–Ni alloys has a considerable influence on the martensite transformation temperature and therefore concluded that nucleation is heteregenous in these alloys. Dependence of the M_s on austenitizing temperature in an Fe–Ni–C alloy was investigated by Maki *et al.* [4] who found that any increase in this temperature raises the M_s. Since austenite grain size of the polycrystalline samples is also dependent on austenitizing temperature, this result shows a possible relation between the M_s temperature of martensitic transformations and austenite crystal volume which can easily be examined in single austenite crystals by varying the size of the single crystal specimens. Although some aspects of the martensite formation have been investigated in single austenite crystals of an Fe–Ni–C alloy [7], no work has yet been reported to explain the dependence of the M_s temperature to austenite crystal volume in carbon-containing Fe alloys most probably due to the experimental difficulties in obtaining sufficiently large austenite single crystal samples of these alloys.

In the present work, austenite single crystals of two different Fe–Ni–C alloys were obtained by spark cutting large grains from recrystallized samples and the influence of austenite crystal volume on the M_s temperature was examined. Fe–24 wt % Ni–0.45 wt % C and Fe–17.1 wt % Ni–0.81 wt % C alloys which had sub-zero transformation temperatures, were supplied by United Steel Co Ltd, UK, in the form of 10 kg ingots. Small samples of the material were prepared for recrystallization in the form of cylinders of 2 cm diameter and 1 cm length and were cold-rolled ~ 3% and annealed 12 h at 1300° C in a vacuum of 10^{-5} Torr. Deformation of the samples prior to the annealing process was found to be an effective way of increasing the grain size of the polycrystalline austenite and by using this method recrystallized grains were obtained with diameters up to 1 cm. Large austenite grains were first cut with a wire spark cutter in rectangular shapes with various dimensions, then held in special steel jigs and ground with 0.5 μm diamond paste to make opposite faces precisely parallel and to remove the surface layer. Dimensions of austenite single crystals were measured with a micrometer and they were transformed to martensite by cooling in liquid nitrogen–methanol bath. The characteristic audible sound emission of martensitic transformation in Fe–Ni–C alloys was used as an indication of the transformation start and the M_s temperatures were measured by using an Fe–Constantan thermocouple.

The measured variation of the M_s temperatures with austenite crystal volume are shown in Fig. 1 for the two Fe–Ni–C alloys. As seen in the figure the M_s temperature was raised for both alloys with increasing austenite crystal volume. The result indicates that the M_s temperature is depressed in smaller single crystals and relatively easier activation of the transformation is possible in bigger austenite volumes. This shows the thermally stabilized character of austenite in small crystals as pointed out earlier by Maki *et al.* [4] after the examination of polycrystalline samples of an Fe–Ni–C alloy.

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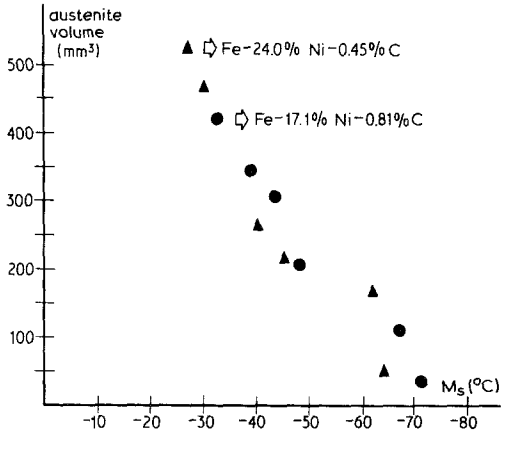

Figure 1 Variation of the M_s temperature with the austenite crystal volume in Fe–24 wt % Ni–0.45 wt % C and Fe–17.1 wt % Ni–0.81 wt % C alloys.

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Effect of alumina dispersions on the thermal conductivity/diffusivity and thermal stress resistance of a borosilicate glass

Hot-pressed glass–crystal mixtures are used as model materials for studies of the properties of brittle matrix composites. Properties such as elastic behaviour [1–3], strength [2, 4] and fracture toughness [3, 4] have been studied extensively for glass matrices with an alumina-dispersed phase. However, such composites in their own right are also candidate materials for engineering applications involving thermal stress. This note presents data for the thermal conductivity and thermal diffusivity of glass–alumina mixtures, which permits an assessment of the effect of the crystalline phase on thermal stress resistance.

The specific glass–alumina specimens in this study were prepared in a programme addressing the fracture toughness [3] of a borosilicate glass with alumina dispersions. The glass consisted of 70 mol % SiO_2 plus B_2O_3 and Na_2O in a molar ratio of 0.67. The alumina dispersions were spherical with a diameter of $25 \pm 7\,\mu m$. Details for the specimen preparation and microstructure were presented earlier [3]. This particular glass–alumina system was selected because of the close match between the coefficients of thermal expansion of the two phases, in order to minimize or eliminate the formation of micro-cracks due to internal stresses; such cracks could have a significant effect on the thermal conductivity [5].

The thermal diffusivity of the composites was measured over the temperature range from room temperature to about 600° C by the laser-flash diffusivity technique [6] using equipment described in detail elsewhere [7], with the transient temperatures of the specimens during the test being monitored by *IR*-detectors. The thermal conductivity was calculated from the thermal diffusivity using values for the density of the alumina and the glass of 3.987 and 2.454 g cm^{-3}, respectively, and literature data for the specific heat of alumina [8] and a borosilicate glass of composition similar to the glass of the present study [9].

Fig. 1 shows the experimental data for the thermal diffusivity as a function of temperature for a number of compositions for which the volume fractions were determined from the composite densities after hot-pressing [3]. For some of these compositions, Fig. 2 shows the calculated values of thermal conductivity. The

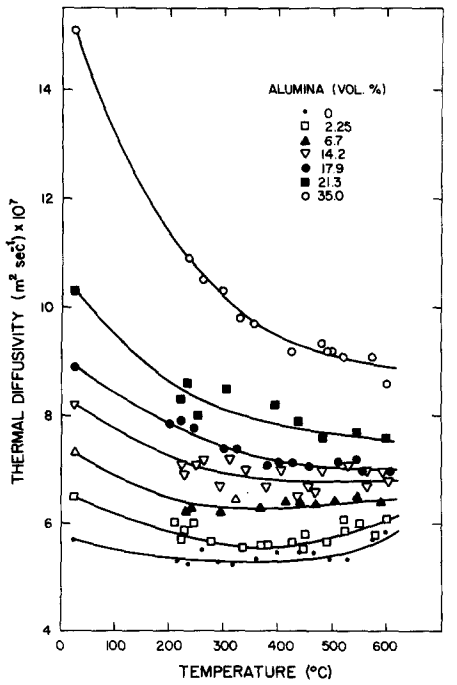

Figure 1 Effect of temperature and composition on thermal diffusivity of glass–alumina composite.

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