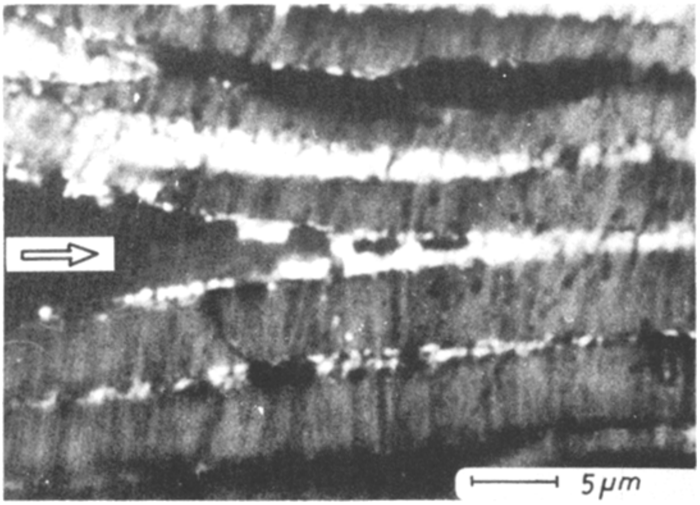

Figure 7 Deformation of craze matter in front of a crack tip (arrowed) in polystyrene.

coarse, fibrillar domains. In both cases, macroscopically brittle fracture behaviour must be expected. When a broad, diffuse shear zone is built up, for example during compression at higher temperatures and low deformation rate, fracture becomes more ductile. This kind of deformation will not be discussed in this letter. Some details about it can be found in another publication by the authors [12].

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Initial stages of growth and orientation of bismuth and antimony films

Bismuth and antimony are semi-metals in their bulk form and have primitive rhombohedral unit cell structures which can also be considered as hexagonal or deformed cubic structures. Palatnik *et al.* [1, 2] have carried out condensation experiments on these materials as a function of thickness and temperature, and postulated that in bismuth films deposited on amorphous substrates the nuclei are spherical and that the condensation occurs via a vapour–liquid–solid transformation for substrate temperatures $T_s > (2/3)T_m$ where T_m is the melting point of the bulk material. For $T_s < (2/3)T_m$, the transformation is directly from vapour to solid. On the other hand, in the case of antimony films, the

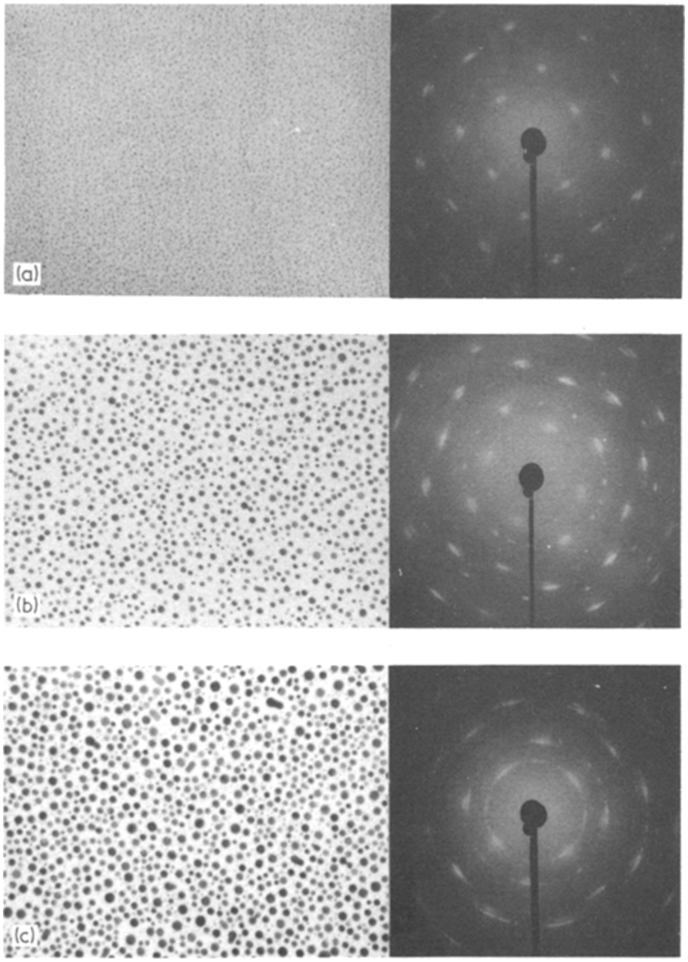

Figure 1 Electron micrographs and corresponding selected area diffraction patterns of bismuth films deposited on (001) NaCl at 180° C. Film thicknesses are (a) 30 Å, (b) 80 Å and (c) 100 Å. (× 36 000).

mechanism of condensation is vapour–liquid–amorphous solid for $T_s < (1/3)T_m$, vapour–crystal for $(1/3)T_m < T_s < (2/3)T_m$ and vapour–liquid–crystalline solid for $T_s > (2/3)T_m$. The significance of $(2/3)T_m$ can be understood as it is nearly the melting point of ultra-thin films of metals [3].

In order to compare the growth and orientation of bismuth films with those of antimony films, the effects of substrate material, temperature of deposition and thickness of the deposit on the crystalline size and orientation were studied in detail.

The bismuth and antimony films were prepared by vapour deposition in a residual air pressure of the order of 10^{-6} torr. The substrates were heated and maintained at the required temperature for a couple of hours before deposition. The films were backed with a carbon film before stripping from the substrates whenever necessary. The samples were observed under an electron microscope working at 65 kV in the transmission mode.

Bismuth and antimony were deposited onto (001) NaCl cleavages at temperatures ranging from 25 to 200° C. It has been observed that bismuth films show a change in the island shape and size with increase in temperature. The films become discontinuous above a temperature of 160° C for a thickness of about 300 Å [4]. In the case of antimony films, no appreciable variation is observed in the size of the grains once the films become continuous.

An increase in the substrate temperature improves the crystallinity of bismuth films. For example, an increase from 25 to 130° C results in a change from polycrystalline to well-orientated (012) films on (001) NaCl substrates. But antimony films deposited on (001) NaCl substrates

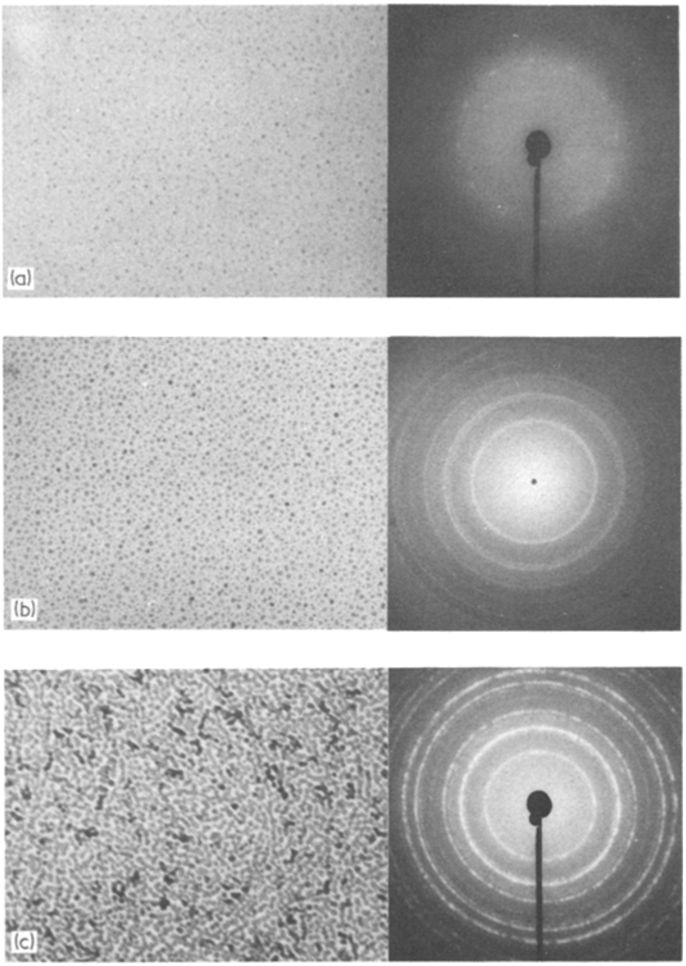

Figure 2 Electron micrographs and corresponding selected area diffraction patterns of antimony films deposited on (001) NaCl at 200° C. Film thicknesses are (a) 30 Å, (b) 60 Å, and (c) 100 Å. (× 36 000).

remain polycrystalline up to a substrate temperature of 200° C with a mixture of (011) and (001) orientations.

The thickness of the films has a little effect on the grain size of the islands in the case of bismuth films deposited at room temperature, the grain size increasing with the film thickness whereas the grain size of the antimony films deposited on (001) NaCl seems to be independent of film thickness.

In the very early stages of growth, the effect of film thickness is quite prominent on the crystallinity of the deposit. Figs. 1a to c show a series of electron micrographs and the corresponding electron diffraction patterns of bismuth films deposited on (001) NaCl at 180° C It is evident that as the thickness of the deposit increases the films become of a (012) texture type, the azimuthal mis-orientation increasing with thickness. In the case of antimony films deposited on (001) NaCl cleavages at 200° C, very thin films (~30 Å) exhibit a single crystal diffraction pattern and a small increase in thickness results in polycrystallization of the deposit (Figs. 2a to c)

When deposited on (001) NaCl substrates, bismuth shows two orientations, (001) and (012). As the substrate temperature is increased to about 130° C, the (001) orientation vanishes leaving a pure (012) oriented film. In the case of antimony films deposited on (001) NaCl substrates, (001) and (011) orientations are prominent. An increase in the substrate temperature up to 200° C does not produce considerable change in the crystallinity of the films which consist of (001) and (011) orientations. It has been observed that the (012) orientation does not occur in the case of antimony films deposited on (001) NaCl substrates.

On mica cleavages, bismuth forms three orientations, (001), (011) and (012). At temperatures above 130° C the films are purely (001) oriented [5]. Antimony films on mica are made up of two orientations, (001) and (011) when deposited at room temperature. An increase in the substrate temperature up to 80° C results in a predominant (001) orientation. However the (011) orientation is still present. Further increase in the temperature results in the formation of polycrystalline deposits.

The initial stages of growth of bismuth and antimony films and their orientation on sodium chloride and mica cleavages differ considerably. The crystallinity of bismuth films improves continuously with increase in temperature whereas antimony films deposited at a comparatively lower substrate temperature are better oriented than those deposited at higher temperatures. Similar results have been reported by Mojejko *et al.* [6] and they attribute this to the changes in the size of the critical nuclei and also the number density of the nuclei. It seems more probable that the high mobility of the adatoms on the substrate surface is responsible for the polycrystallinity of thicker deposits as the initially oriented nuclei grow and the film passes from the nucleation stage to the growth stage.

The nature of growth and orientation of bismuth films seems to be different from that of antimony films. Increase in the deposition temperature improves the crystallinity of bismuth films whereas the antimony films do not show any improvement when deposited on sodium chloride substrates. However, antimony films show a better orientation on mica at 80° C which is destroyed with further increase in temperature. As the film passes from the nucleation stage to the growth stage, the initially well-oriented nuclei tend to become polycrystalline because of the high mobility of the adatoms on the substrate surface.

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Deformation properties of austenitic Fe–Ni–C alloy single crystals

Although numerous studies have been made to investigate the properties of austenitic single crystals in some ferrous alloys [1–6], the main purpose of these studies was to clarify the mechanism of martensite formation in the single crystal state. However no work has yet been reported on the deformation of austenitic Fe–Ni–C single crystals and the effect of martensite formation on the mechanical properties of the material, probably because of the practical difficulties in obtaining large crystals. In the present investigation it was thought worthwhile therefore to study some deformation properties of austenitic single crystals in two Fe–Ni–C alloys of different composition.

The previous work on the deformation of polycrystalline Fi–Ni–C alloys [7, 8] revealed that the mechanical properties of the material were considerably changed after the austenite