14.4-16 FORMATION OF LATTICE SUPERPERIODS IN POLYCRYSTALLINE SiC.

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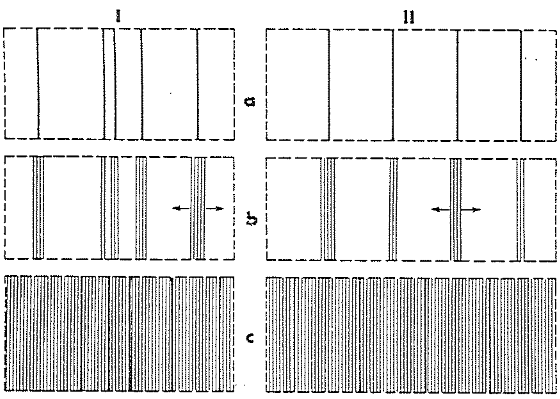
Silicon carbide is one of the most profusely polytypic materials known, and most of its polytypes are long-period. Yet no known theory explains long-period polytypism in a polycrystalline ceramic like SiC, since existing theories apply to single crystals (F.C. Frank, Phil Mag., 42, 1951) or to conductors (H. Sato & R.S. Toth, Phys. Rev., 127, 1962).

A model is presented to account for this phenomenon, based on observations made by means of high-resolution transmission electron microscopy and electron diffraction on SiC samples arrested in the process of transforming from the β phase to different α polytypes. The figure below summarizes the model and illustrates the role of coherent twin boundaries in the β phase, and their spatial configurations, in the transformation to either a merely faulted short-period polytype or a true long-period polytype.

A particular advantage of this model is that it eliminates the need to invoke an elusive long-range ordering force to explain the phenomenon. The formation of superperiodicity is to be seen as a statistical event. To support this model detailed order will be shown to be rare in the long-period polytypes investigated by high-resolution TEM.



Polytypic phase transformation in SiC.
Left Column: from random β twins to randomly faulted, basic α polytype; Right column: from regularly faulted β twins to a superperiodic α polytype. (Ogbuji, Phys. Stat. Sol. a 72, 1982.)

14.4-17 HIGH RESOLUTION ELECTRON MICROSCOPY & MICRO-DIFFRACTION OF MgO-METAL COMPOSITE FILMS.

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Composite single crystalline films of magnesium oxide (MgO) with gold, iron and titanium-crystallites embedded are prepared by a simultaneous deposition technique(Nagao et al. Jpn.J.Appl.Phys.,1986,25,L215). For gold-MgO composite films, gold-crystallites of 2-4 nm in size are embedded epitaxially and coherently in MgO matrix (Fig. 1). The identification of gold is possible with the diffraction contrast. The lattice fringes of gold or MgO are selectively imaged in the crystallites, depending on the amount of defocus and thickness of gold. Gold islands of one or two atomic layers are detected from the image analyses. Forbidden 110 lattice fringes are also observed due to the thinness(Fig.1, white arrows). The temperature-dependence of specific resistance of the films varies from negative(semiconductor-like) to positive(metallic) with increase of gold embedded. For iron-MgO films, as-grown films have crystallites of α-iron(b.c.c.) around 1 nm in size with three kinds of epitaxial orientations to MgO matrix(Fig.2). A heat treatment of the films at 1000°C for 3 min brings about a phase-transformation from α-iron to γ-iron(f.c.c.). The γ-iron crystallites quenched in the room temperature show a strain at the periphery, by which the γ-iron lattice is fitted with the MgO matrix. The strain is analyzed to be nearly two-dimensional with two-fold symmetry using the moiré fringes and nanometer area-diffraction patterns(Fig.3). For titanium-MgO composites, the films show characteristic diffuse spots in the diffraction patterns, which may be interpreted in terms of TiO_{1-x} with ordered vacancies including twins. A heat treatment of the films at 1000°C for 2 min brings about the formation of Mg_2TiO_4 crystallites with spinel structure homogeneously in the films. The study of the relation between atomic structures and properties of the composite films is now in progress.

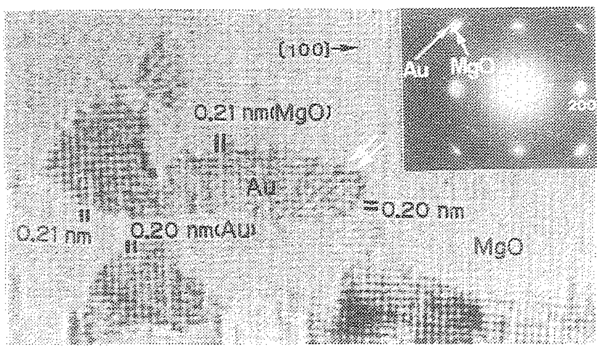

Fig. 1 Electron micrograph and diffraction pattern of gold-crystallites embedded in MgO(001) film taken with 1 MeV electron microscope.

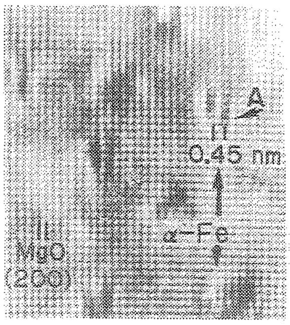

Fig.2 Electron micrograph of as-grown composite film of α-iron (A) and MgO.

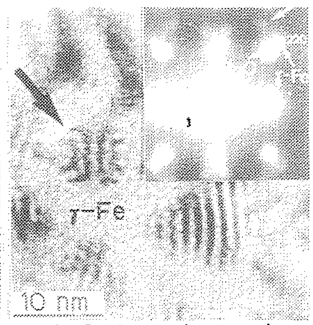

Fig.3 Electron micrograph and microdiffraction pattern of a γ-iron crystallite after heat-treatment.