MATERIALS

Between Crystals

from a Correspondent

Two aspects of grain boundary structure came under scrutiny in Amsterdam recently. Although most useful materials occur in the form of polycrystalline aggregates, relatively little is known of the atomic structure in the vicinity of the boundaries between the various crystals. The available information was reviewed on September 22 during the meeting of the Institute of Metals.

There seem to be two distinct aspects to grain boundary structure. There is a general structure which is a direct consequence of the super-position of the periodicities of the adjacent crystals, and superimposed on this there may be imperfections, or irregularities, which can critically affect certain materials parameters. Indeed, considering the importance of dislocations within the crystal, it is tempting to draw an analogy to postulate the existence of dislocations in, or intersecting, the grain boundary.

Two approaches were adopted in the theoretical description of the general structure. Dr W. Bollman (Battelle, Geneva), from purely geometrical arguments, and Dr G. Hasson (École des Mines, St Étienne), by computing the minimum energy configuration for an assumed interatomic pairwise potential, concluded that a grain boundary of arbitrary orientation would be expected, on the atomic scale, to consist of straight sections, where the matching between the crystal lattices is good, connected by sections of poor matching.

Dr H. Mykura (Warwick University) pointed out that adjacent crystals normally bear no special crystallographic relationship to each other. Nevertheless, the observations of macroscopic facets (of good intercrystalline fit) by optical, electron and field-ion microscopy indicate that boundaries tend to be arranged in a direction such that they contain a high proportion of atoms common to both lattices (coincidence boundaries), which is clearly energetically reasonable. Precipitation of second phase particles occurs preferentially at grain boundaries containing ledges where the atomic fit is bad and at dislocations in the grain boundary.

Several contributors, using transmission electron microscopy, had observed linear defects at the grain boundary. Dr D. Dingley (University of Bristol) compared some electron micrographs with a computer simulation of the image expected from the combined strain fields of a dislocation and grain boundary, and confirmed the defects to have simple lattice burgers vectors. On the other hand Drs D. Smith (University of Oxford) and B. Loberg (Chalmers University) by studying specimens by both electron and field-ion microscopy have observed, at a grain boundary, dislocations with burgers vectors which are not simple lattice vectors of either crystal, which suggests that segments of the dislocation lie in the plane of the boundary.

Certain phenomena seem to depend sensitively on the structure of the grain boundary. For example, Dr M. Biscondi (École des Mines, St Étienne) showed that, for a given shear stress, the rate of grain boundary sliding is slower for boundaries of high coincidence than for the more disordered boundaries. Dr C. A. P. Horton (Central Electricity Research Laboratories,

Leatherhead) suggested that the occurrence of grain boundary sliding and crystal deformation were closely related. Presumably, dislocations generated within the crystal can migrate to the grain boundary, and grain boundary sliding is achieved by displacement of segments of the dislocation in the plane of the grain boundary.

Grain boundaries are known to act as efficient sources and sinks of vacancies during the high temperature creep of polycrystalline materials. This behaviour cannot be explained in terms of the general equilibrium structure, and implies the existence of a self-perpetuating defect. Dr E. D. Hondros (National Physical Laboratory) showed that such vacancy sources can be rendered inactive by the adsorption of certain impurities to the grain boundary, while in other circumstances even low angle subgrain boundaries seem to act as efficient source/sinks.

There was therefore substantial evidence, supported by many other contributors, that both aspects of grain boundary structure are necessary, although the precise nature of the defects is still a subject for debate.

SOLID STATE

More and Better Devices

from a Correspondent

THE latest progress in solid state devices was the theme of a conference held at Exeter by the Institute of Physics and the Physical Society from September 15 to 18. Most contributions were concerned with semiconductors, and covered topics from materials to computer aided design.

Three contributions from the group under Dr C. Hilsum (Royal Radar Establishment, Malvern) described pioneering work on indium phosphide. Miss A. Royle described the growth of large single crystals with electron densities from 10^{14} to 10^{18} electrons/cm³ and mobilities up to $3,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$. Semi-insulating InP had now been made. The preparation of vapour phase grown InP layers was described by Dr B. D. Joyce, who said that they had achieved low electron densities and a mobility of $4,740 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ ($60,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ at 77 K), which is the highest reported for this compound. Dr J. R. Morgan described a three level transferred electron microwave oscillator using the ultrapure InP layers. Oscillations up to 28 GHz had been observed while at 8.5 GHz a 7 per cent efficiency had been obtained. No continuous wave output had yet been realized. A broad tuning range and reasonable efficiency indicate that this three level oscillator has good prospects.

Dr G. H. Schwuttke (IBM) showed, with the aid of X-ray topograms, the propagation of dislocations in a defect free silicon wafer, as it progressed through the various stages of oxidation, epitaxy and diffusion involved in the making of an integrated circuit. He was able to correlate the electrically defective devices with the highly dislocated regions in the wafer. When the wafer is laid horizontally in the furnace instead of vertically, as is the normal practice, and very rapid changes of temperature are avoided, the number of dislocations can be reduced considerably and a device yield as high as 90 per cent is achieved. He said that 1970 was the year of large scale integration (LSI) for