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HETEROGENEOUS DISLOCATIONS IN GaAs*

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ABSTRACT

Since high voltage electron microscopy enables thick samples to be investigated, it becomes a powerful technique for studying diffusional gradients and solid state interfacial phenomena. For example, it is possible to study in detail epitaxial thin films such as semiconductors[2] provided the operating voltage is below that which produces extensive (knock on) irradiation damage. Previous work on epitaxial silicon has shown the existence of dislocations associated with a phosphorus or boron concentration gradient after diffusion as well as precipitates near the emitter surface.[2]

Gallium arsenide is a semi-conductor which has not received as much attention as silicon. However, GaAs exhibits potentially useful electronic properties, e.g. the Gunn Effect.[3] A possible device for pulse generation can be derived from vapor depositional treatments producing the configuration sketched in Fig. 1. A device of this type may allow the development of communication equipment operating in the GH_z (10^9 cycles/sec) range of the electromagnetic spectrum. However, the use of such a device is limited because electrical breakdown occurs near the regions marked 1 and 2 (Fig. 1). It was anticipated that this breakdown is due to microstructural changes, not resolvable by light or scanning electron microscopy, associated with the vapor deposition treatment.

The problem requires obtaining foils so as to study the $n^+/n^-/n^+$ regions in the composite (Fig. 1). This is a very difficult task

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experimentally, because of the low probability of locating these interfaces in a thin foil. Consequently this project is a natural one for high voltage electron microscopy. Also recent results show that it is possible to improve resolution of closely spaced dislocations and to obtain quantitative analyses by utilizing high order systematic reflections.[4]

Specimens were prepared by chemically thinning. A small amount of material was removed from the epitaxial layer, bringing the interfaces closer to a free surface. This surface was then masked by apiezon wax and the thinning was completed from the reverse side; resulting in a foil with a large transparent area.

Examination was done in a 650 kV Hitachi microscope. Similar defects were found at the free surface and the epitaxial/epitaxial interface as shown in Figs. 2-4. These defects were dislocation "tangles" and glide dislocations emanating from defects which appear to be impurities. The glide dislocations consist mainly of long screw segments connected by short non-screw segments. Presumably these dislocations are generated heterogeneously at the impurities which formed during fabrication and were "punched out" by thermal stresses upon cooling. X-ray microprobe analysis indicates that the impurity is silicon. Details of the formation of these dislocation structures will be presented elsewhere (see also ref. 5).

Acknowledgements

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2. E. Levine, G. Thomas and J. Washburn, J. Appl. Physics, 38, pp. 81, 87 (1967).
3. J. A. Copeland, IEEE Spectrum, 4, no. 5, p. 71 (1967).
4. See this conference, R. Osiecki, L. De Jonghe, W. Bell and G. Thomas. Also R. Osiecki and G. Thomas, 29th EMSA Proc. 1971 in press.
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Figure Captions

Figure 1. Configuration of a GaAs Pulse Generating Device.

Figure 2. Glide dislocations emanating from a dislocation tangle located at the free surface.

Figure 3. Array located near epitaxial/epitaxial region. Analysis shows that the out-of-contrast dislocations in b and c are in screw orientation.

Figure 4. Array in which non-screw components are in contrast.

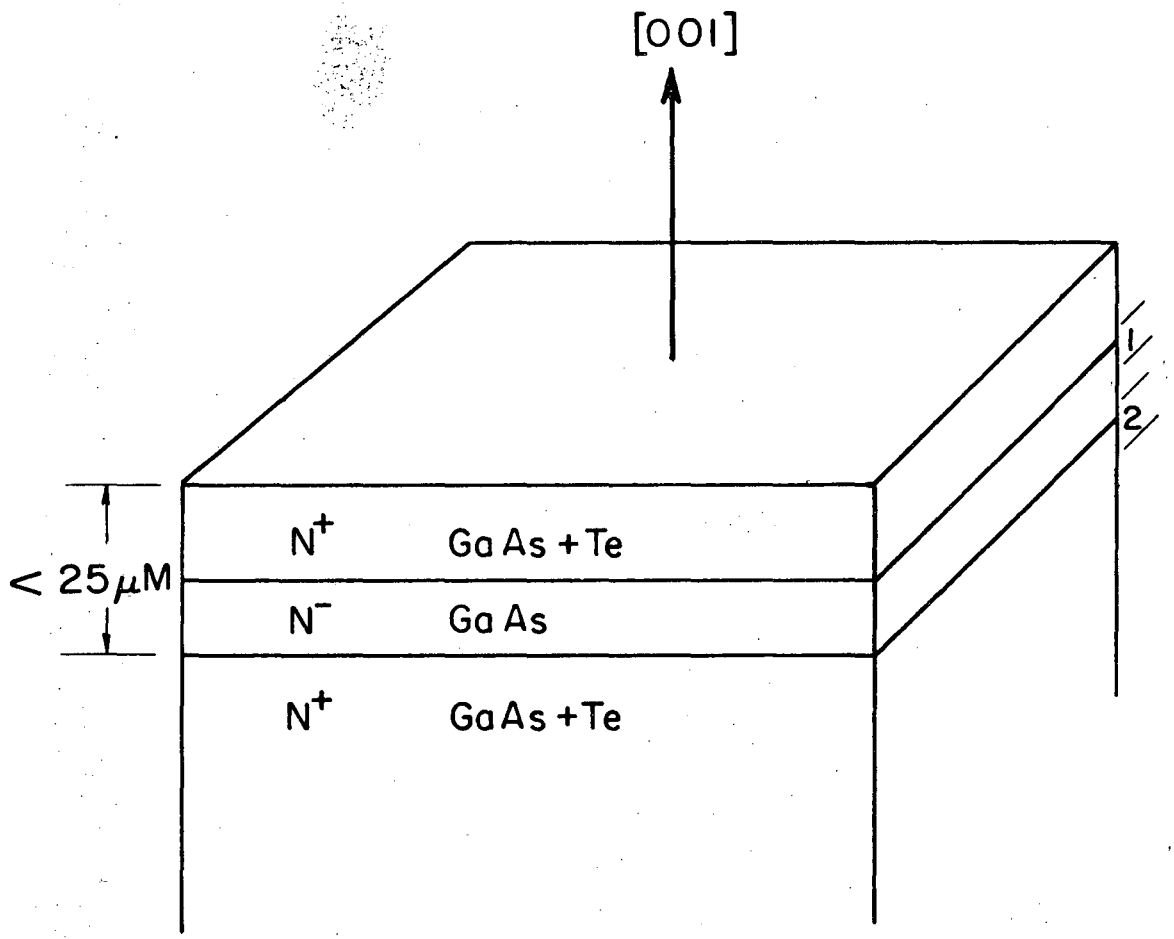

Fig. 1

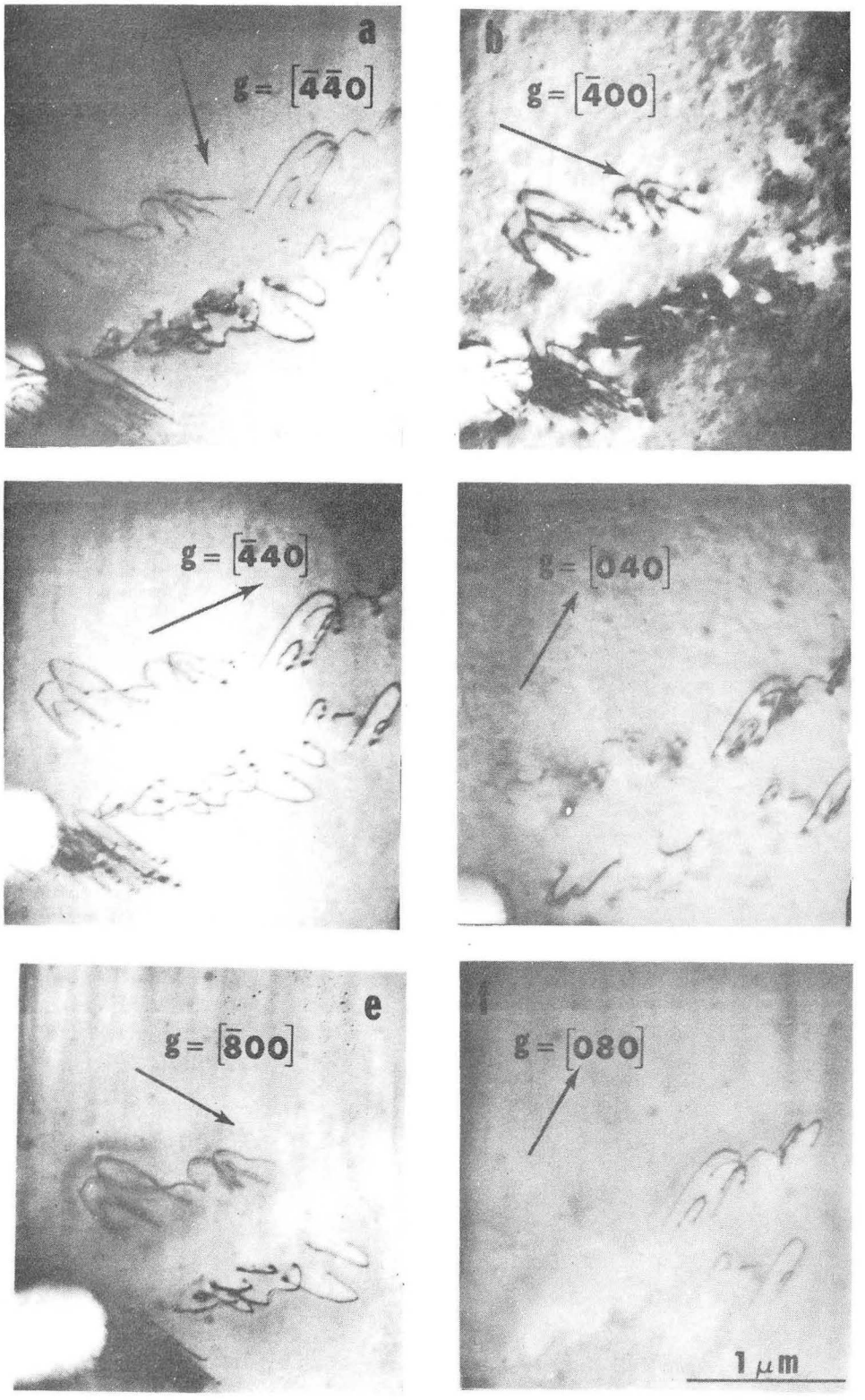

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Fig. 2

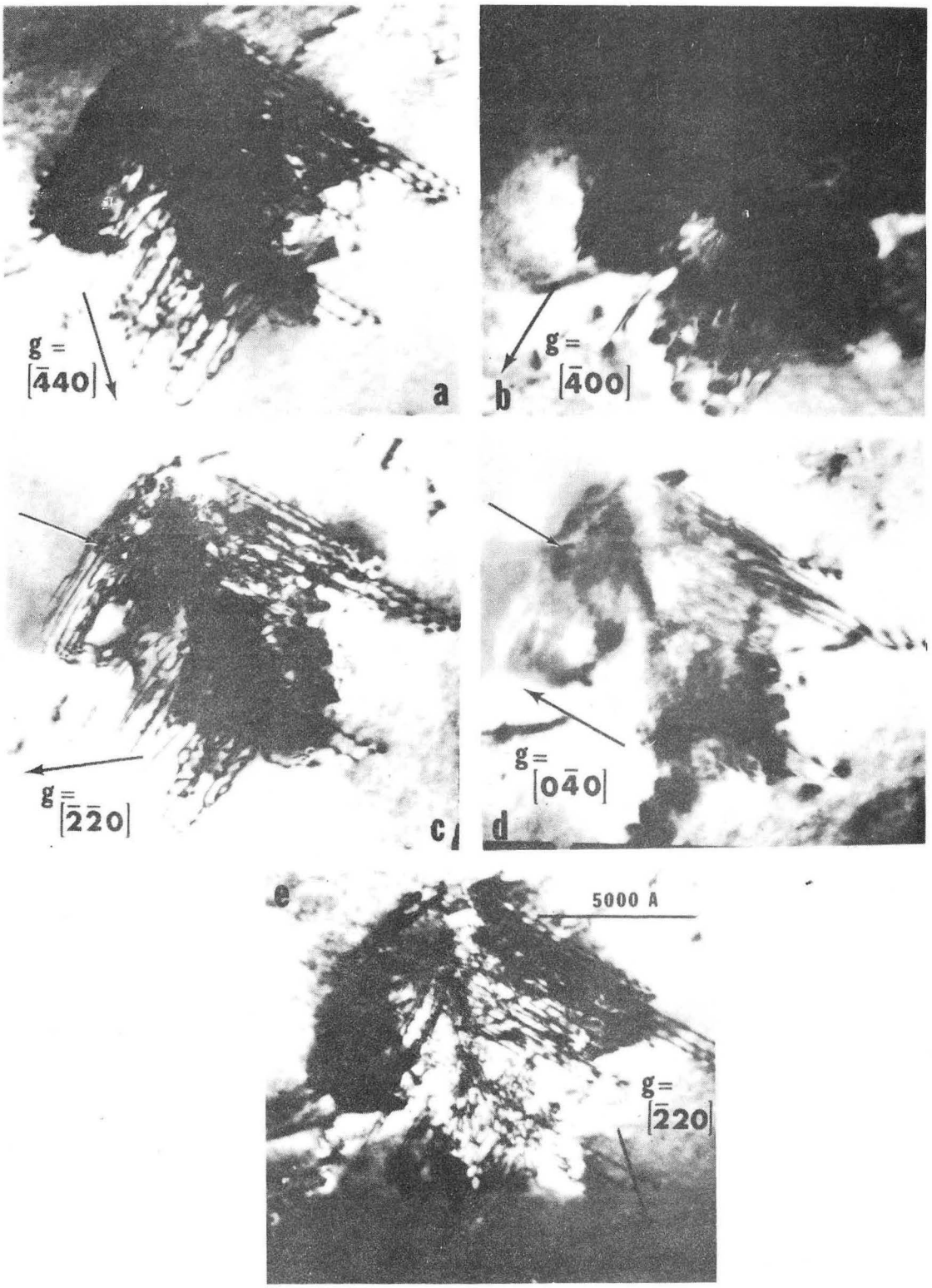

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Fig. 3

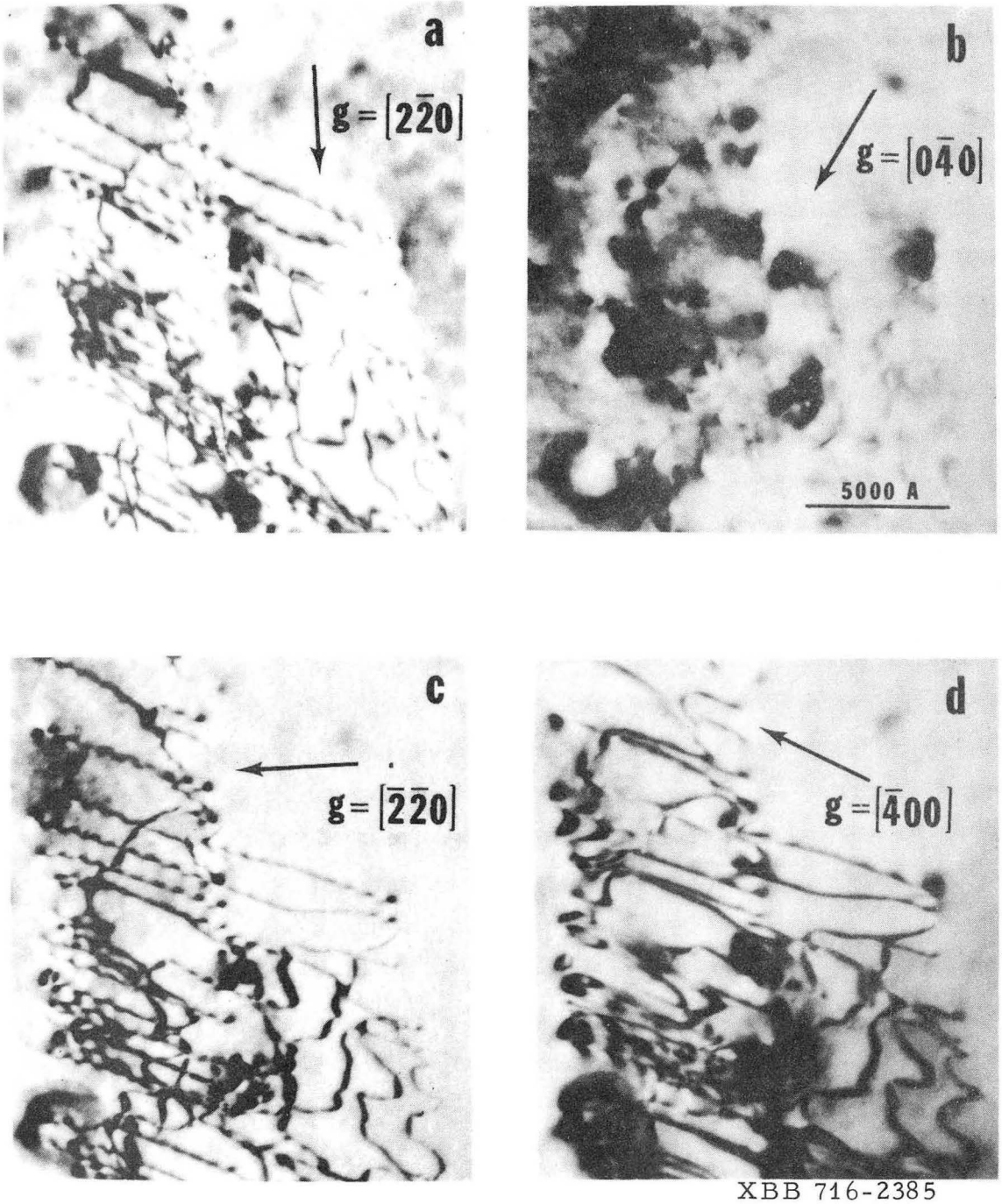

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Fig. 4

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