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The Structure and Faceting Behavior of Tilt Grain Boundaries in Aluminum

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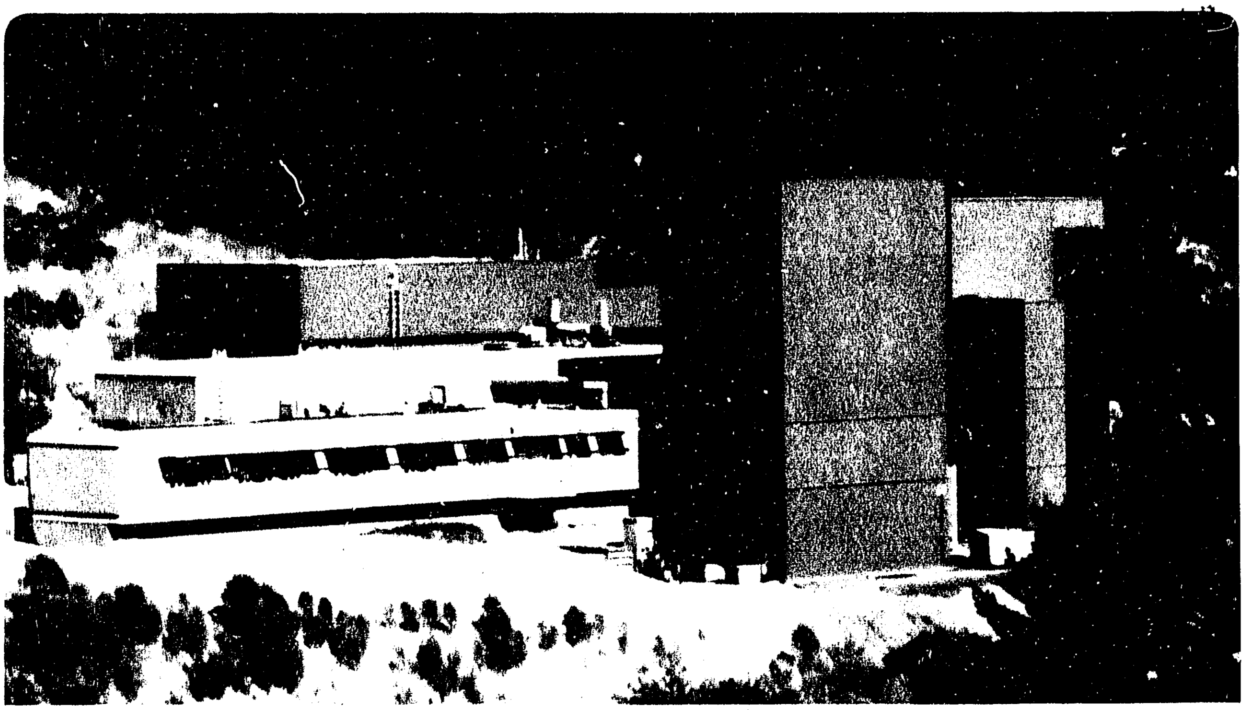

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THE STRUCTURE AND FACETING BEHAVIOR OF TILT GRAIN BOUNDARIES IN ALUMINUM

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This work describes a number of experimental observations on the structure and behavior of $\Sigma 99$ and other near-90° <110> tilt boundaries in bicrystals of aluminum. The continuous bicrystal structure employed in these studies is based on the symmetry properties inherent in heteroepitaxial growth. A thin film grown in this geometry consists of intertwined grains surrounding each other but with only two grain orientations (see Fig. 1).

There are no triple junctions impeding the thermal mobility of these grain boundaries. This geometry is particularly suitable for analysis by TEM methods since it maintains several of the characteristics of general grain boundaries, including its high angle misorientation near 90°, faceting, elastic strains and defects. Although most boundaries are curved, the curvature, after annealing, tends to be about a common axis normal to the thin film. Hence the boundaries are of pure tilt type and lend themselves naturally to HREM analysis. With the continuous bicrystal geometry it is thus possible to obtain information on both the atomic and the mesoscopic structure and behavior of these interfaces. In particular it is possible to relate the faceting behavior observed during thermal relaxation of the microstructure to the atomic structure of individual facets.

Observations on faceting of continuous bicrystal structures were made both by in-situ hot stage electron microscopy and by ex-situ annealing and subsequent thinning to electron transparency. The atomic structure of individual facets of particular importance was investigated by high resolution electron microscopy combined with image simulation and analysis. An example of microfacets imaged by HREM is shown in Fig. 2.

Localized distortions which appear to be an integral part of the faceted microstructure were made visible in high resolution images and could be mapped by a simple technique based on the moiré effect. An effort to obtain a quantitative description of the anisotropy and degree of faceting is currently underway. Such a description, in the form of a rose plot, could be an important characteristic of the microstructure by giving a statistical measure of its anisotropy through the construction of an average grain shape.

Future applications of the symmetry concepts underlying the continuous bicrystal geometry to controlled tri- or multicrystal structures will be described with emphasis on the possibilities of directly comparing the structure and behavior of facet junctions in continuous bicrystal with triple junctions encountered in all real polycrystal structures.

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Fig. 1 Bright field images in mirror-related Bragg conditions showing characteristic facets in continuous bicrystal structure of aluminum after annealing.

Fig. 2 High resolution image showing microfacets on 90° <110> tilt boundary in Al bicrystal.

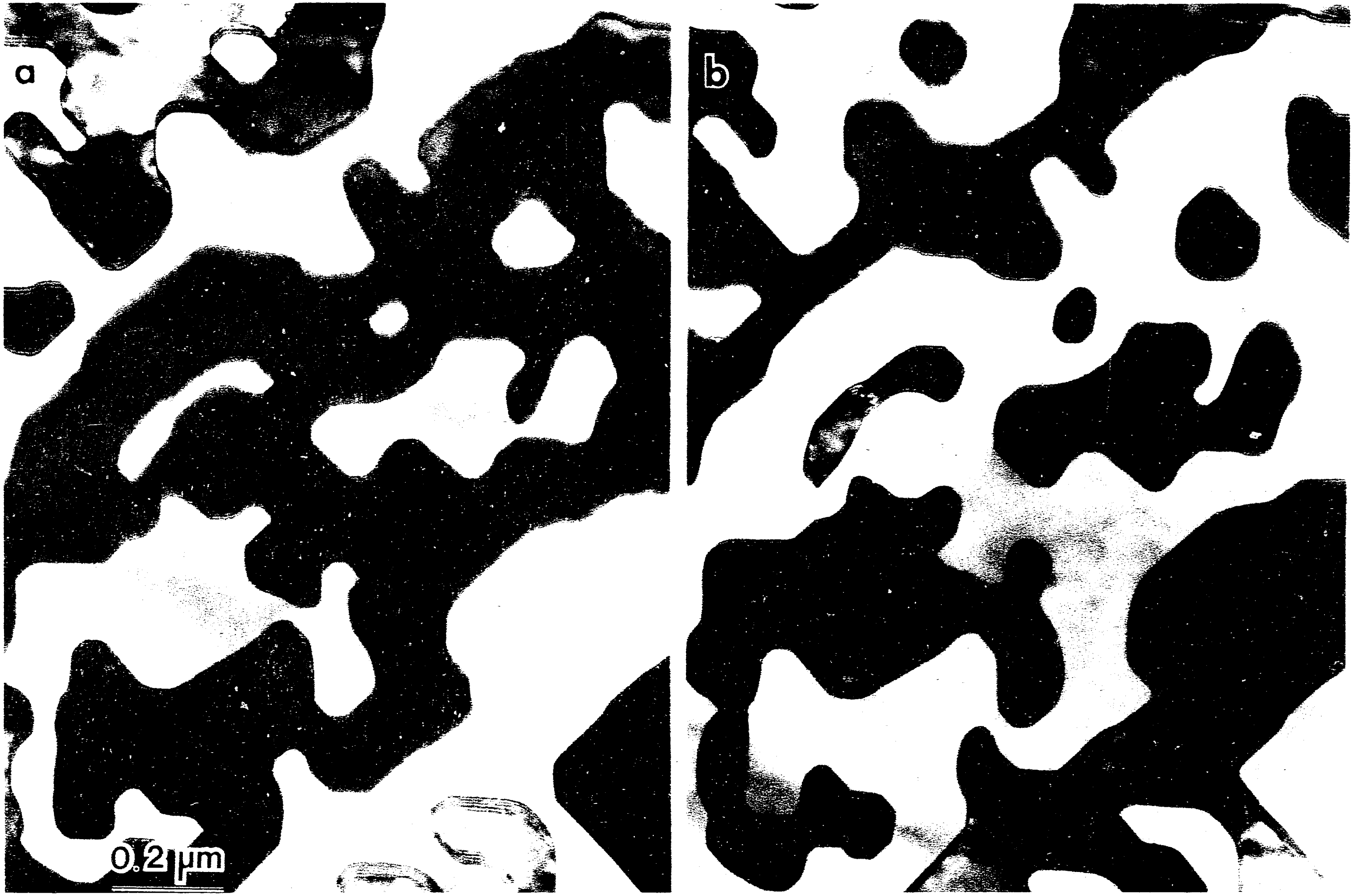

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Figure 1

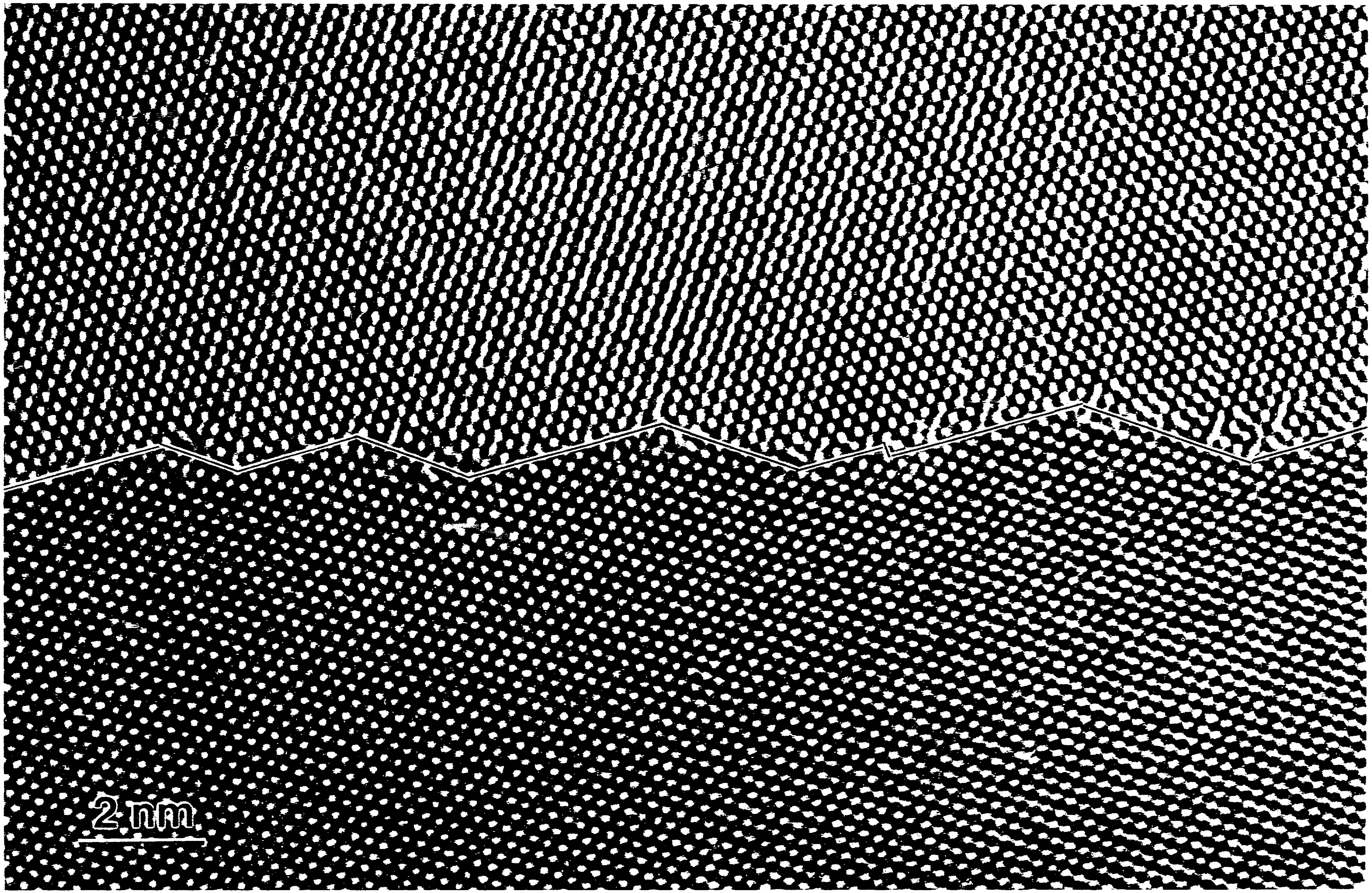

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Figure 2

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