The dipoles produced by deformation in the easy-glide region have been observed to split (in fact, the structure which appears to indicate the break-up of dipoles into small loops was noted in a few electron micrographs) into rows of loops by pipe diffusion, in the temperature range where volume diffusion is negligible. The quenched-in point defects probably provide the driving force for the process of conversion to and growth of tetrahedral stacking faults from the rows of loops. This view can be supported by the frequent observation of more tetrahedral rows in oxygen-treated gold than in carbon monoxide-treated gold, because there are more nucleation sites in the latter material. In the present crystallographic notation, the dislocation loops formed from the primary dipoles should be elongated along [110] or [011] with Burgers vector \( \frac{1}{2}[101] \). These loops would reduce their line energy by rotating into the (101) plane, normal to their Burgers vector. The sequence of \( \frac{1}{2}[101] \) loops on (101) plane can be converted to the rows of tetrahedral stacking faults by dislocation reactions provided by Kuhlmann-Wilsdorf.


Fiberless Region Defects in Unidirectionally-Solidified Al-Al_3Ni Eutectic

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It has been well-established that many alloys of binary and ternary eutectic composition can be solidified unidirectionally to produce aligned microstructures. A large body of research has been directed at the study of the three-dimensional defect structure of controlled eutectics with the ultimate goal being a complete understanding of the origins of the various composite morphologies observed to date.

Fig. 1 illustrates a transverse section of an aligned Al-Al_3Ni specimen containing several large, fiberless regions interspersed throughout a more regular microstructure. Metallographic observation of specimens sectioned from several controlled ingots revealed that the fiberless region defects occurred frequently enough to warrant investigation. This communication reports the results of a study aimed at eliminating these defects from the aligned microstructure.

**EXPERIMENTAL PROCEDURE**

A eutectic composition Al-Ni alloy was prepared as follows: 99.96 pct pure aluminum and 99.95 pct pure nickel were melted in an aluminum oxide crucible under an argon atmosphere, and cast into \( \frac{1}{8} \) in. diam pins. For this study, the eutectic composition was taken to be 6.16 ± 0.01 pct by weight. The as-cast pins were remelted and then unidirectionally solidified in a graphite crucible drawn out of a vertical resistance furnace at a growth rate of 5.7 cm per hr. The temperature of the molten zone was held

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**Fig. 1**—Transverse section of an Al-Al_3Ni unidirectionally solidified eutectic specimen illustrating several large, fiberless regions which interrupt the aligned microstructure. Magnification 585 times.

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at approximately 700°C and an argon atmosphere was maintained to minimize oxidation. Metallographic preparation consisted of polishing with 600 grit Al₂O₃ and 0.5μ MgO, and using 5 pct aqueous HF as an etchant.

RESULTS AND DISCUSSION

Fig. 2 is a longitudinal section of the controlled eutectic illustrating the observation that the fiberless regions form as the result of the interaction of unknown inclusions with the aligned microstructure. The magnitude of this defect can be realized from the fact that the fiberless region shown in Fig. 2 extends 110μ through the aligned structure. Fig. 3 is a transverse view of an inclusion. Three-dimensional serial sectioning on transverse planes was employed to study the morphology of the inclusions and the extent of typical fiberless regions. Results of the sectioning confirmed that the formation of inclusions always preceded the fiberless regions, as shown in Fig. 2.

The electron microprobe was employed in an attempt to identify the elements present in the inclusion. Spectral scans performed on the inclusion with LSD, KAP, ADP, and LiF analyzing crystals revealed the presence of strong aluminum and carbon characteristic X-ray peaks, and the absence of any substantial nickel peaks. These data were confirmed with Al, C, and Ni X-ray images and line scans across the inclusion.

According to Hansen, Al₄C₃ and AlC are the only known forms of aluminum carbide. A qualitative point count was conducted on an inclusion with the microprobe in an attempt to determine the exact chemical composition of the particle. This technique did not yield definitive results due to the small size of the inclusions and because of carbon deposition by the electron beam. However, the qualitative microprobe data obtained is strong evidence to support the hypothesis that the inclusions are aluminum carbides. This hypothesis is supported by thermodynamic calculations which show that carbon exhibits a much greater tendency to combine with aluminum rather than nickel. Furthermore, Hansen states that the solubility of carbon in molten aluminum is small even at temperatures as high as 1500°C, the tendency being to form Al₄C₃.

The only source of carbon present during solidification was the graphite crucible. Macroscopic examination revealed carbon present on the surface of several unidirectionally-solidified ingots, indicating a crucible reaction during solidification. It can be postulated that the bulk of the carbides form in the liquid zone near the mold wall where the concentration of carbon is highest. Once formed, the carbides are swept into the melt by convection, where they interact with the advancing solidification interface. This view is supported by metallographic examination which revealed an essentially uniform distribution of carbide particles from the surface to the center of a controlled ingot. The carbide particles probably block the growth of Al₄Ni fibers as the interface advances because such fibers are restricted in crystallographic growth direction. The nonfaceted aluminum matrix is less restricted in growth direction, and can grow around the inclusion forming a fiberless region. As growth continues, rods at the boundary of the fiberless region thicken due to the presence of excess nickel rejected when the inclusion blocked the growth of several Al₄Ni fibers. The boundary fibers cannot change growth direction to...