THE FRANKLIN INSTITUTE • PHILADELPHIA 3, PA. • LOcust 4-3600
LABORATORIES FOR RESEARCH AND DEVELOPMENT

November 5, 1964

OTS PRICE

XEROX $ 1.00 FS
MICROFILM $ .50 MF

National Aeronautics and Space Administration
Washington 25, D. C.

Reference: Contract No. NASr-145

Subject: Quarterly Progress Report Q-B2028-8 covering the period July 22, 1964 to October 21, 1964

Dear Sirs:

Effect of Orientation on the Bend Fatigue Behavior of Beryllium

Bend fatigue crystals examined were oriented for either basal or prism slip. The specific differences which exist in the surface slip structure and the underlying dislocation substructure are now considered. The basal bend fatigue crystal shows a uniform and relatively fine slip structure extending over the entire central gauge section. Closer to either grip, deeper slip steps occur, indicating that stress concentrations exist at these locations. That the average slip step height is small may be verified by electropolishing and replication of the surface as a function of depth; no persistent slip structures are seen below a depth ~1μ from the original surface. The operation of basal slip is confirmed from an examination of the foils prepared from the outer surface layers. It is noted, however, that all three 1/3 [$\bar{2}$110] vectors are operative within the basal plane.

The surface slip structure on crystals oriented for prism slip in bend fatigue is characterized by slip on both the prism and basal planes, and by the presence of a distinct brownish discoloration, the intensity of which increased with increasing number of cycles. It is interesting to note that the discoloration is confined to the upper and lower bend surface through which edge dislocations having the 1/3 [$\bar{2}$110] Burgers vector emerge. The duplex slip structure is accompanied by the appearance of fracture lines which run across the bend surface. (Fig. 1) The overall direction of these fissures corresponds to [0002], the direction of intersection of the prism plane with the bend surface.

Repeated examination by polishing and replication has revealed the presence of persistent slip bands to a depth of at least 5μ. After the removal of ~5μ from the bend surface, a number of SiO replicas were prepared using the Victawet technique followed by tungsten oxide shadowing.

B2028

With a controlled direction of shadowing, it is possible to differentiate between the surface intrusions or extrusions giving rise to the persistent slip structure. Prepared in this way, intrusions show dark contrast on the micrographs towards the direction of shadowing, while the situation is reversed for extrusions. Examination of the micrographs revealed that in all cases, the persistent slip bands on both the prism and basal planes correspond to intrusions. Examples of these intrusions are illustrated in Figure 2(a) and (b). The intrusions are in the form of rows of pits, an observation consistent with similar reported studies on other metals. The presence of slip on both the prism and basal planes is reflected in the complex nature of the underlying substructure.

A paper titled "Fatigue Studies of Single Crystal Beryllium" (J. F. Breedis, A. Lawley and J. A. Zeiger) and based on certain aspects of the current research program was presented at the Second International Conference on Beryllium Technology, held at The Franklin Institute, October 15-17, 1964. The paper considers in detail the dislocation substructure in both bend and axial fatigue for the two orientations studied.

In the remaining period of time (to 12/31/64) on this contract, the following experiments will be completed.

(i) A repeat of the bend fatigue (basal slip orientation) test is in progress on a second crystal. Pieces of the bulk fatigue crystal will be annealed at temperatures up to ~500°C, followed by thin film transmission microscoph of the surface layers. In the case of foils prepared from the previous bend fatigue crystal, the damage was seen to anneal out while under actual examination in the electron microscope. The current annealing experiments on bulk material will indicate whether (1) the recovery phenomenon is restricted to thin foils or (ii) recovery does actually take place on bulk fatigued beryllium at temperatures close to ambient, as a consequence of extremely localized deformation in the surface layers.

(ii) A second bend fatigue (prism slip orientation) crystal will be examined to provide further detail concerning fracture lines, intrusions, extrusions, and the influence of cross-slip.

National Aeronautics and Space Administration November 5, 1964

(iii) A detailed analysis of the loop vectors will be completed. The indications are that the Burgers vector lies out of the basal plane; should this be positively established, this would be of specific importance in relation to the brittleness problem in beryllium.

Very truly yours,

H. Conrad
Technical Director

A. Lawley, Manager
Physical Metallurgy Laboratory

Approved by:

J. R. Feldmeier
Director of Laboratories

encl.
Figs. 1&2

B2028

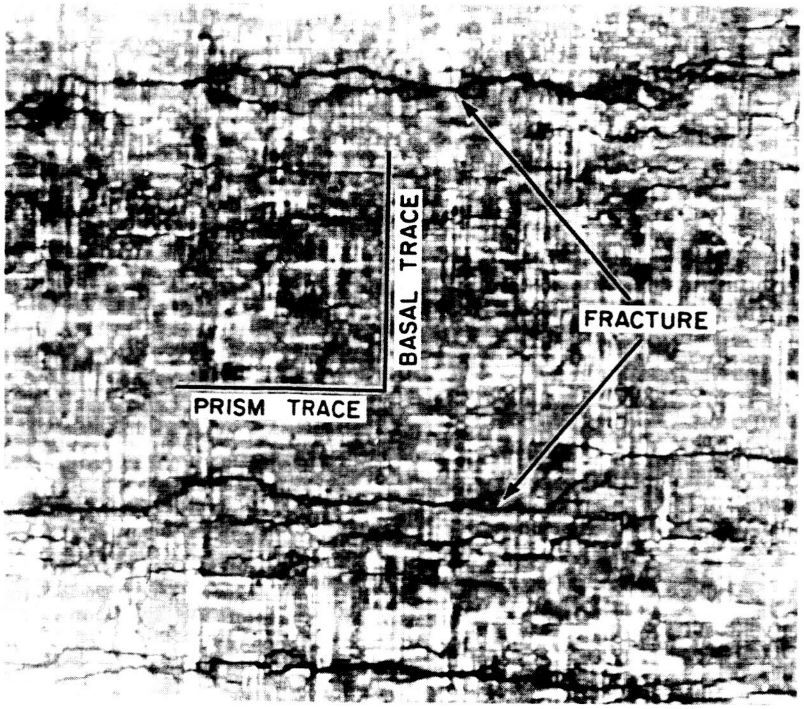

Fig. 1 - Bend Surface of Crystal Oriented for Prism Slip.

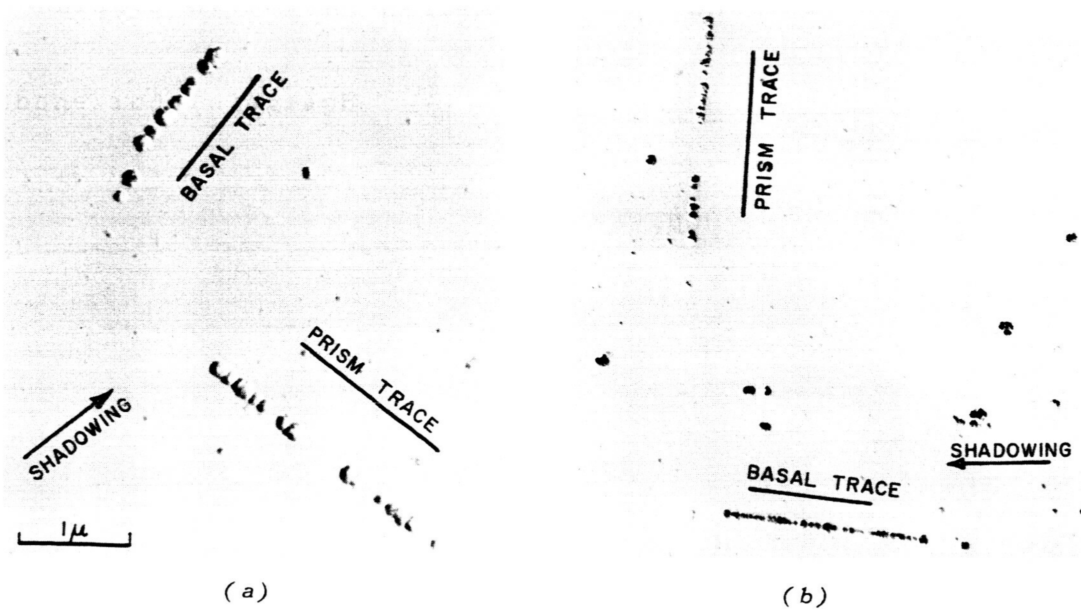

Fig. 2 - Replication of Bend Fatigue Prism Slip Crystal after Removal of ~5μ from Bend Surface. Note that the Rows of Pits Show Dark Contrast Towards the Direction of Shadowing.