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This Week's Citation Classic

Livingston J D. The density and distribution of dislocations in deformed copper crystals. *Acta Metallurgica* **10**:229-39, 1962. [General Electric Res. Lab., Schenectady, NY]

Etch-pit techniques were used to measure the density and distribution of dislocation lines in copper single crystals plastically deformed in tension. The dislocation density was found proportional to the square of the flow stress, in quantitative agreement with other experimental and theoretical results. [The *SCI*® indicates that this paper has been cited over 140 times since 1962.]

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"When I arrived at General Electric's Research Laboratory in 1956, I was very impressed with the beautiful work being done there by Johnston and Gilman on dislocations in lithium fluoride crystals using etch-pit techniques.[1] Since the 1930s, plastic deformation of crystals had been presumed to occur by the motion of linear crystal defects known as dislocations. However, it was not until the 1950s that various experimental techniques had been developed to observe individual dislocations. The simplest of these were the etch-pit techniques, which employed chemical etchants that preferentially attacked crystal surfaces at the points of emergence of dislocation lines, leaving etch pits. From my thesis work at Harvard, I was aware of the great interest in understanding the plastic deformation behavior of pure metals such as copper, and aware that this understanding was hampered by lack of data on the density and distribution of dislocations in deformed metal crystals. I recall wishing that a dislocation etchant like that being used for LiF was also available for copper.

"When I learned, in 1959, that Lovell and Wernick[2] had discovered an etchant that revealed dislocations in pure copper, I immediately decided to apply this technique to the study of plastic deformation of copper crystals. Although this decision turned out to be well-timed with respect to the external world of science, it was ill-timed with respect to trends within General Electric and many other industrial research laboratories. Basic studies such as these had little relevance to industrial products and problems, and management support of such work had begun to decline. My decision to study dislocations in pure copper crystals was therefore met with a notable lack of enthusiasm by my manager, who suggested several other projects that he considered more interesting. I nevertheless persisted, and my copper project was patiently tolerated for several years, a support for which I was and am grateful.

"Soon after starting, I learned that Lovell and Wernick's etchant was not immediately suitable for the study I had intended. It required several months of patient experimentation to develop specimen-preparation techniques and a modification of their etchant before I could satisfactorily reveal dislocations. I then proceeded to deform various copper single crystals, etch them, and photograph and count dislocations produced by the deformation. The data gathered and the various qualitative observations made supported many of the ideas that had been previously developed by dislocation theory. In particular, the data established a correlation between dislocation density and stress that is fundamental to understanding the work-hardening of metals. These various results were basic to many later studies of dislocations and plastic deformation in copper and other metals, presumably accounting for the frequent and continuing citations."

1. **Johnston W G & Gilman J J.** Dislocation Velocities. dislocation densities, and plastic flow in lithium fluoride crystals. *J. Appl Phys.* **30**:129-44. 1959.
[Citation Classics *Current Contents®/Physical. Chemical & Earth Sciences* (28):12, 9 July 1979.]
2. **Lovell L. C & Wernick J H.** Dislocation etch pits and polgonization in high purity copper. *J. Appl. phys* **30**:590-2, 1959.