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This Week's Citation Classic

Johnston W G & Gilman J J. Dislocation velocities, dislocation densities, and plastic flow in lithium fluoride crystals. *J. Appl. Phys.* **30**:129-44, 1959. [General Electric Research Laboratory, Schenectady, NY]

The first measurements of velocities of individual dislocations in a crystal were reported. Data on dislocation velocities and numbers of dislocations were used to confirm the basic relation between microscopic dislocation properties and the macroscopic plastic deformation of crystals. [The *SCI*® indicates that this paper has been cited over 575 times since 1961.]

William G. Johnston
Corporate Research and Development
General Electric Company
Schenectady, NY 12301
and
John J. Gilman
Materials Research Center
Allied Chemical Corporation
Morristown, NJ 07960

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" 'Except for an accident, the present article could not have been written.' We used this opening sentence in a review of our work on 'Dislocations in lithium fluoride crystals.'[1] True, our techniques evolved from an accident, but the investigations that followed were no accident. They were part of a logjam of experiments that had been waiting for the proper techniques to come along.

"The plastic deformation of crystals had posed a dilemma in the physics of solids for decades. Observations indicated that deformation occurs by planes of atoms sliding one over another, but the stresses required are orders of magnitude less than those calculated from simple models. It was proposed in 1934 that an entire plane of atoms does not slip at one time.[2,3,4] Instead, a small portion slips by one atomic distance and the slipped region grows gradually. The boundary of the slipped region is a *dislocation* (discontinuity in displacement), and plastic deformation involves the generation and motion of dislocations.

"Dislocation theory was developed extensively by the early 1950s —before anyone had knowingly seen a dislocation! By the mid-1950s there were several methods for observing dislocations, and many theories and models had been confirmed qualitatively. There remained the need for a *quantitative* test of the relationship between the properties of dislocations and the plastic deformation of crystals.

"We developed the etchpit method into a versatile and reliable tool for observing the behavior of individual dislocations. We were able to introduce isolated single dislocations, move them controllably with an applied stress, measure their velocities, and observe their multiplication. We used measurements of dislocation velocities and numbers of dislocations, to confirm the equation for plastic flow of crystals: 'The strain rate equals the product of the dislocation density times the dislocation velocity times a crystal lattice spacing.' The main contribution of our paper was the confirmation of this basic equation of dislocation theory.

"Why the number of citations? The work was a necessary step in the development of the field; related work by others on metals broadened the applicability of our results. The subject was of interest to many materials scientists; and, because of its simplicity and relevance, the work became required reading for a generation of students."

1. **Gilman J J & Johnston W G**. *Solid State Physics 13* (Seitz F & Turnbull D., ed.) New York. NY: Academic Press. 1962. p. 148-222.
2. **Taylor G.** The mechanism of plastic deformation of crystals. Part I. Theoretical. *Proc. Roy. Soc. A* **145**:362-404. 1934.
3. **Orowan E.** Zur kristallplastizitat. I. II. III. *Zeitschrift Phys.* **89**:605-59: 1934.
4. **Polanyi M.** Uber eine Art Gutterstorung, die einen kristall plastich machen konnte. (On a type of lattice deformation that can make crystals plastic.) *Zeitschrift Phys.* **89**:660-4, 1934.