This Week's Citation Classic

Petch N J. The cleavage strength of polycrystals. *J. Iron Steel Inst.* **174**:25-8, 1953.
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Cleavage strength is shown to be related to grain size. A theory is given in which yielding and cleavage depend on the stress concentration generated where a slip band across a grain is blocked by the grain boundary. [The *SCI*® indicates that this paper has been cited over 365 times since 1961.]

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"Although published in 1953, this work was carried out during 1946-1949 in the Cavendish Laboratory, Cambridge. Chance was in at the beginning. In 1946, after working at the Royal Aircraft Establishment during the war, I was wondering what to do next, and, happening to be in Cambridge, I went for coffee to Matthews (opposite Trinity College). There I chanced to meet Egon Orowan, known to me previously in the Cavendish, and High Ford, then of the British Iron and Steel Research Association. The outcome was I joined the latter to work in Orowan's metal physics group.

"Next came this particular problem. The war had highlighted a skeleton in the cupboard of structural steel. Normally with so many good properties, structural steel nevertheless can be brittle if there are notches and low temperatures, and brittle fractures, once started, can propagate at low stresses. The advent of continuous welded structures had shown the problems that could arise in this way, with fractures on Liberty ships then the classical example. Orowan was interested in this problem and had analysed the effect of notches. I decided to try to understand cleavage strength, since cleavage is the mechanism of these brittle fractures.

"My original idea was that Griffith cracks were produced by the fracture of brittle iron carbide particles in the steel and that the cleavage strength was determined by these cracks. This led me to vary the carbide size by various treatments. These also varied the size of the grains that make up the solid. After a while, I threw away the carbide idea and put responsibility on the grain size. We now know that was a bit too sweeping. On the changed idea, the slip bands that form across a grain by deformation became effectively the Griffith cracks. At the same time there was work going on in the group by Eric Hall, who had come from New Zealand, on the effect of grain size on the propagation of initial yielding in steel. His work was at room temperature. Yielding was also of great significance in my problem, since the yield stress had to get up to the cleavage strength before fracture could occur. This led me to study yield at low temperature.

"My paper is normally linked with the one by Hall,[1] and the reason for citation lies in the basis they gave for a quantitative approach to yield, flow, and cleavage of metals and other polycrystals using dislocation theory. By good luck, the relationships that emerged were simple and proved to have wide general application. They permit separation of the effects of lattice resistance, of stress fields due to precipitates or solute atoms, of dislocation locking, and of the size of grains or other structural dimensions. Particularly, there has been use as the framework for the development of high yield stress steels with low ductile-brittle transition temperatures (see Duckworth and Baird[2])."

1. **Hall E O.** The deformation and ageing of mild steel: III. Discussion of results. *Proc. Phys. Soc. B* **64**:747-53, 1951. [The *SCI* indicates that this paper has been cited over 220 times since 1961.]
2. **Duckworth E W & Baird J D.** Mild steels. *J. Iron Steel Inst.* **207**:854-71, 1969.