lation. Moreover, it seems more plausible that part of the flow stress has a bond-breaking component, than that the pressure dependence of the elastic constants is abnormally low, so the latter correlation is deemed to be the best.

Attempts to modify Equation 7 by adding a viscous term $\propto \mu$ to the flow stress equation makes the fit worse, so such an alternative can be excluded.

In summary, the SD effect alone and a comparison of SD results and flow stress results favour a model of dilatation normal to the glide plane, rather than one of hydrostatic pressure as a contribution to the flow resistance. This result is consistent with a dislocation-type flow mechanism in metallic glasses as suggested by Gilman [1, 2]. However, an exact fit to experimental results also requires a major contribution of a dissipative-type term to the flow resistance. An improved test of the suggested correlation could be achieved if independent measurements of the pressure dependence of the elastic constants were made available for metallic glasses.

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A new chemical polish and the study of dislocation movement in lithium fluoride crystals

The extent and nature of the dislocation movement produced in rocksalt-type crystals is well documented [1–3]. In particular, in magnesium oxide crystals the dislocation movement produced beneath localized regions of deformation caused by both indenters and sliders has been described recently [4]. The experimental technique used in that previous work involves repeated chemical polishing and etching of the deformed crystal in order to build up a cumulative picture of the dislocation pattern produced in the crystal bulk. In this way, the size and shape of the dislocated zone beneath a given indentation has been determined, and it has been established that the dimensions of this zone are largely defined by the magnitude and duration of the applied load, rather than by the shape of the indenter [4, 5]. A similar study on lithium fluoride crystals was initiated but, whilst a good dislocation etchant for this crystal is available, chemical polishing presented some problems. For the crystals used in this work, the polishing techniques and solutions used by Gilman and Johnston [3] and Borzhkovskaya *et al.* [6] produced surfaces which were too badly pitted to allow satisfactory application and interpretation of the subsequent dislocation etchant. As a result the following chemical polish was developed.

Single crystal specimens, (supplied by Rank Precision Industries, Margate and containing 50 ppm potassium, 20 ppm other elements) approximately 20 mm × 20 mm × 3 mm, were cleaved from large pieces of lithium fluoride; these were subsequently annealed in an argon atmosphere for six hours at 650° C and then slowly cooled to room temperature. Each crystal was washed in fresh water at 50° C and then vigorously agitated for 7 sec in fresh concentrated hydrochloric acid, also at 50° C, and then washed again

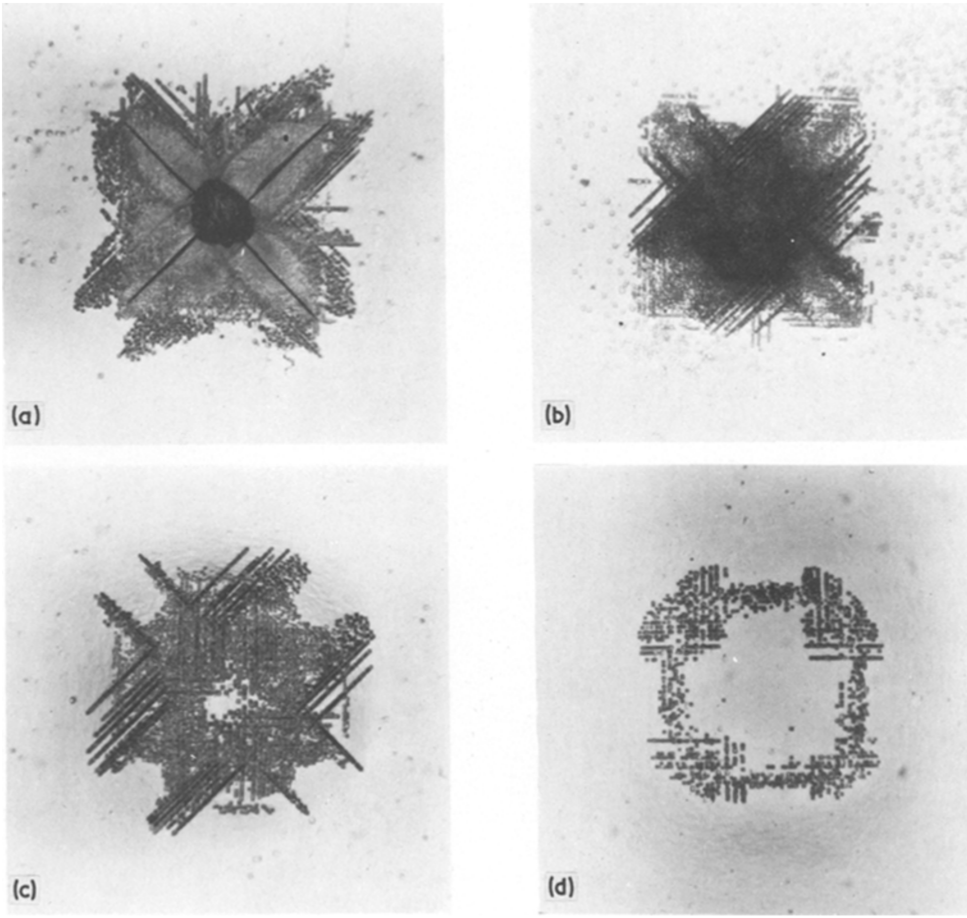

Figure 1 Dislocation patterns associated with a 60° cone indentation, revealed by successive removing of surface layers and re-etching.

in fresh water. As a result of agitating the crystal in hydrochloric acid, chemical polishing of the lithium fluoride occurred with the rate of removal of material from the crystal surface being of the order of 1 μm sec^{-1}. This washing and polishing procedure was repeated until approximately 40 μm of material had been removed from the original crystal surface. At this stage, the crystal on drying developed a "frosted glass" appearance, caused by the presence of multitudinous etch pits covering the crystal surface. These pits were cleared by washing the crystal again in fresh water at 50° C and then vigorously agitating the crystal for 20 sec in a fresh saturated solution of ammonium chloride, also at 50° C, and then washing again. Generally, this sequence of water washes plus agitation in saturated ammonium chloride had to be repeated three times in order to remove all the etch pits produced by the hydrochloric acid treatment. Finally, the crystal was rinsed in acetone and then dried in warm air.

The effectiveness of this chemical polishing technique is illustrated in the micrograph shown in Fig. 1. After carrying out the chemical polish described, the crystal was indented with a 60° diamond cone and then etched. The dislocation etchant used was a modified version of that described by Newey and Davidge [7] i.e. 100 volume hydrogen peroxide solution was diluted with water in the ratio of 1:2. The indented crystal was then washed in fresh water at room temperature and then agitated in the dislocation etchant for 4 min. After a final washing the crystal was rinsed in acetone and then dried in warm air. The resulting dislocation pattern produced around the indentation is shown in Fig. 1a.

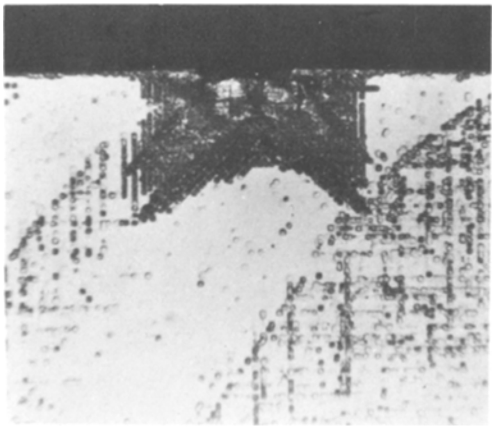

Figure 2 Section through a 60° cone indentation showing the dislocation pattern produced beneath the indentation.

The polishing and etching procedure was repeated in order to reveal the dislocation patterns produced at depths of approximately 40 μm (Fig. 1b) 80 μm (Fig. 1c) and 120 μm (Fig. 1d) below the original indented surface. Note that on the indented surface, a typical dislocation rosette is produced around the indentations due to the movement of dislocations on all of the six operative {1 1 0} slip planes. Also, it can be seen that at a depth of approximately 40 μm (Fig. 1b), the radial cracks on the {1 1 0} planes normal to the indented (0 0 1) surface, and presumably due to the Keh mechanism [2], have disappeared. It should be mentioned that the chemical polishing sequence was deliberately curtailed for this micrograph in order to demonstrate the nature of the pits remaining after the hydrochloric acid agitation treatment. At a depth of 80 μm (Fig. 1c), the dislocations are still present on all six slip planes. However, at this depth a dislocation-free region is developed at the centre of the dislocation pattern. Towards the bottom of the dislocated zone, at approximately 120 μm depth (Fig. 1d), dislocations are limited to the four {1 1 0} slip planes which are inclined at 45° to the indented (0 0 1) surface.

For comparison purposes, the dislocation pattern produced on a cross-sectional plane through a 60° cone indentation, and obtained by cleaving the crystal on a (1 0 0) plane normal to the indented (0 0 1) surface, is shown in Fig. 2.

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The decoration of surface flaws in glass

The uncertainty which still surrounds the nature and distribution of Griffith flaws in glass is a central problem in the characterization of glass surfaces; this is of technological importance in relation to the failure of optical components under arduous service conditions.

Attempts to observe Griffith flaws directly have been unsuccessful; this supports the view that if flaws exist in pristine glass surfaces they can only be described in terms of localized, atomic scale disruptions in surface structure. The exact nature of these perturbations in structure is yet unknown although it has been suggested that they may be identified with regions of weak bonding arising from an uneven temperature distribution during cooling. Alternatively they may result from local stresses associated with the presence of microstructures. Any such approach, however, must allow sufficient stress concentration and subsequent flaw growth to account for the rapid strength degradation which is observed when a pristine surface is subject to normal handling.