Apparatus for Mechanical Testing of Soft Crystals at High Pressure

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Introduction

In order to measure the initial flow stress of soft single crystals in a high hydrostatic pressure environment, it was necessary to develop apparatus for applying tensile loads to the sample and for measuring the load-extension relationship and thereby the resolved shear stress - shear strain relationship. Since only small changes were expected in the critical resolved shear stress with pressure, it was considered essential to make measurements at the highest possible pressure. The pressure limitation is due to the solidification of the pressure transmitting medium. It was felt that 50-50% mixture of n- and i- pentane (a common high pressure medium because of its high solidification pressure) could be used to approximately 30 kbars without encountering non-hydrostaticity effects[1,2] i.e., the presence of significant shear stresses in the fluid since these would lead to undesirable deformation of the samples. The zinc single crystals that were to be tested have critical resolved shear stresses at atmospheric pressure of as little as $20/gm/mm^2$

corresponding to an applied load of 280 gm on a crystal having an orientation, $\phi_o = 45^o$, $\lambda_o = 45^o$ and diameter of 3 mm. A load cell sensitivity of at least one tenth of that value or 28 gm is required.

Equipment similar to the present apparatus was first used by Bridgman[(3)] in the same pressure range (0-30 kbar) but differed mainly in the details of the tensile test fixture and in the load cell. Although Bridgman's load cell consisting of a slotted thin tube was the only one reported that could operate in this high pressure range, its inherent sensitivity is not sufficient for the accurate measurement of small loads. Other investigators[(4-7)] have developed load measuring equipment based on strain gages for use in a high hydrostatic pressure environment with inherent sensitivities greater than that used by Bridgman but it has yet to be shown that these can operate much above the 10 kbar range. The problem associated with strain gage load cells has been the parting of the strain gage from the substrate material due to the stresses arising from the differences in compressibility of the substrate and strain gage materials[(8)]. Apparatus making use of a load cell the active element of which is a capacitor gage is presently being developed in France[(9)].

With the possible exception of the equipment incorporating internal load cells based on the capacitance gage principal[(9)] or cells incorporating alumina coated strain gages[(6)], all of the thus far developed load measuring equip-