A PLASTIC STRESS ANALYSIS OF CYLINDRICAL WAFERS UNDER ELASTICALLY DEFORMABLE COMPRESSION PLATES

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ABSTRACT

The use of an opposed-anvil apparatus as a mechanism for generating high-pressures in radially confined, circular specimens, has attracted the interest of many competent experimenters, and they have utilized the facility to explore the behavior of many materials in an environment of high pressure and temperature. The increased utility of the opposed-anvil device has demanded that a pressure calibration be made to determine the actual pressure gradient existing within the compressed specimen (pressure cell). It has long since been the general concensus of experimenters, that the pressure is not uniformly distributed across the cell, but agreement has not been achieved as to the location and magnitude of its maximum.

This report represents a combined analytical-experimental analysis of the pressure distribution occurring in a model, similar in structure and characteristics to the opposed-anvil or Bridgman-type pressure cell. From a mathematical necessity, the model has been constructed, and assumed to perform, in a manner consistent with the applicable laws presented in the theory of plasticity (von Mises yield criteria, St. Venant's flow laws, etc.). Such quantities as material compressibility, and pressure dependent properties, have been shelved in favor of examining the influence of radial constraints, material strain hardening, wafer diameter-to-height ratio, etc.

This report presents a method of solution that is traced from the results of a rigid-anvil analysis, to the establishment of two-dimensional stress and pressure distributions in compressed, low-shear, constrained and unconstrained wafers. A discussion is presented on the continuance of the solution for higher shear stress levels, and more general displacement patterns. The integrated axial normal stress distribution across the specimen surface has been verified with several materials, with and without radial constraints. Pressure levels in excess of the first bismuth transition have been recorded, and a possible high-volume, high-pressure generating device has been described. The future work that can, and will be attempted, is discussed briefly.