Diamond for DAC

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Diamond Anvil Cells (DAC's) are widely used tools in high-pressure materials research in many fields of science. In the DAC the sample to be studied is squeezed between the tips of two diamond anvils, while being confined laterally, usually by a metal gasket. The intrinsic properties of diamond make this material ideally suited for use in this type of research: diamond is the hardest material known, is chemically inert, has a wide optical transparency window from the visible to the far-infrared, has only low impurity-induced fluorescence, is electrically insulating in its pure state, but can be made conducting by suitable doping, and has high X-ray transparency due to its low nuclear mass. Thus optical, electrical, magnetic and X-ray studies of a wide range of materials relevant to biology, physics, geophysics, chemistry and material science have been reported. Improvement in anvil design, of traditional polishing techniques, and of gasket technology has led to an ever-increasing range of pressures that can be achieved in DAC's. Pressures in excess of 100 GPa are now routinely obtained in many laboratories using diamond anvils that are polished to very tight tolerances.

In this lecture we will discuss some of the essential design features and requirements of modern anvils and show state-of-the-art examples of polishing quality. We will then focus on new developments relevant to the increasing use of DAC's as measurement tools in beamline facilities. In one new development the study of larger volume samples is made possible by applying a small tapered indentation in the diamond anvil culet. In finite element simulations it was found that the indentation does not affect the mechanical strength of the anvils. The increased sample volume and thickness allows better resolution in X-ray studies of light materials, especially biological systems. In another development micro-heater rings for in-situ laser heating of samples to temperatures in excess of 1000 ˚C were made from boron-doped polycrystalline diamond. These rings also provide for a uniform temperature environment for the sample to be studied. We will further discuss initial results of a study of high-pressure induced helium diffusion into diamond anvils, which can lead to early failure of anvils.