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Synchrotron Radiation and High Pressure: New Light on Materials Under Extreme Conditions[1]

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Current technological advances now make it possible to perform experiments on materials subjected to static or sustained conditions up to multimegabar pressures (>300 GPa) and from cryogenic temperatures to several thousand degrees ($\sim$0.5 eV range). With these techniques, densities of condensed matter can be increased over an order of magnitude, causing numerous transformations and new physical and chemical phenomena to occur. Growth in this area largely been made possible by accelerating developments in diamond-anvil cell methods coupled with new synchrotron radiation techniques. Significant advances have occurred in x-ray diffraction, spectroscopy, inelastic scattering, radiography, and infrared spectroscopy. With recent developments, structure refinements based on polycrystalline data up to multimegabar pressures have been possible. Single-crystal methods have been extended to megabar pressure, with the prospect of full crystallographic refinements. 'Three- dimensional' diffraction data can be collected for determining strength, deformation, and elastic tensors at high P-T conditions. Studies carried out during the past three years provide numerous breakthroughs in high-pressure x-ray spectroscopy and a broad range of inelastic scattering methods. Other experiments have exploited the use of x-ray radiography over a range of pressures. Finally, synchrotron infrared measurements have revealed a wealth of high-pressure phenomena, particularly for molecular systems. Examples to be discussed include investigations of dense hydrogen; transformations in molecular materials; novel ceramics; new types of superconductors, electronic, and magnetic materials; and liquids and amorphous materials.

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