

Inorganic Synthesis and Crystal Chemistry at Multimegabar Pressures

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The impact of high-pressure studies on fundamental physics and chemistry, and especially on the Earth and planetary sciences, has been enormous. Modern science and technology rely on the fundamental knowledge of matter that is provided by crystallographic studies. The most reliable information about crystal structures and their response to changes in pressure and temperature is obtained from single-crystal diffraction experiments. Advances in diamond anvil cell (DAC) techniques and double-stage DACs, as well as in modern X-ray facilities have increased the accessible pressure range for structural research up to multimegabar range. We have developed a methodology to perform single-crystal X-ray diffraction experiments in double-side laser-heated DACs. Our results demonstrated that the solution of crystal structures, their refinement, and accurate determination of thermal equations of state of elemental materials, oxides, carbides, borides, carbonates, and silicates from single-crystal diffraction data are possible above 200 GPa at temperatures of thousands of degrees. These resulted in findings of novel compounds with unusual compositions, crystal chemistry, and physical properties. We illustrate application of new methodology for simultaneous high-pressure and high-temperature single crystal diffraction studies using examples of investigations of chemical and phase relations in the Fe-O system, transition metals carbonates, silicates, and nitrides.

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