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High-pressure synthesis of new materials via formation of new bonding patterns and unusual stoichiometries[1]

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The search for new materials synthesized under extreme conditions of high pressure and high pressure is currently actively pursued. There are multiple theoretical predictions for superior material properties, such as ultra-hardness, superior transport properties such as electrical and thermal conductivity, high energy-density, high-temperature superconductivity, ability to storage hydrogen, etc. Synthesis of new materials at high pressures is based on changes in the equilibrium chemical bonding. Moreover, materials with "unusual" stoichiometries have been predicted to become thermodynamically stable at high pressures. Implications of this novel extreme chemistry for synthesis of new materials for practical applications remain challenging because high-pressure bonding patterns are often thermodynamically unstable at ambient pressure. Search for a recovery mechanisms or attempts of synthesis in nominally metastable conditions require detailed knowledge of the energy landscape; extensive collaborative efforts of experiment and theory are needed for its determination. Here, I emphasize the importance for this task of *in situ* fast diagnostic methods. I will present new results on synthesis of materials with new bonding patterns and unusual stoichiometries containing hydrogen, nitrogen, carbon, and halogens. This work has been performed in collaboration with M. Somayazulu, V. V. Struzhkin, V. Prakapenka, E. Stavrou, T. Muramatsu**,** A. Oganov, W. Zhang, Q. Zhu, S. E. Boulfelfel, A. O. Lyakhov, Z. Konopkova, H.-P. Liermann, D.-Y. Kim.

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