New forms of carbon, silicon and germanium recovered from high pressure

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Polymorphism within the Group 14 elements is well known. Multiple allotropes of carbon, silicon and germanium can be formed under various pressure / temperature conditions, and some of these could remain metastable under standard conditions for time scales as long as the age of the universe. But the number of known allotropes pales in comparison with the number of hypothetical ones with energetic feasibility. For any given thermodynamic state, thousands of energetically competitive structures are plausible, a subset of which will exhibit mechanical stability. Further subsets of these structures offer enticing physical properties that differ from those of thermodynamic ground states. Here we discuss strategies for accessing these states experimentally.

We explore three strategies that enable the synthesis of metastable structures, all of which involve the application of pressure: 1) metastable backtransformations from thermodynamically stable states during decompression; 2) pressure-temperature induced transformations of metastable precursors; 3) ambient-pressure manipulation of metastable precursors recovered from high pressure. These methodologies have enabled the bulk synthesis of several allotropes for the first time, thus allowing for detailed measurements of physical properties. In particular, we discuss the formation of an open-framework allotrope of silicon [1] and new forms of carbon based upon interpenetrating graphene sheets [2-3].

Bibliography

[1] Kim et al., Nature Materials, **14**, 169 **(2015)**
[2] Hu et al., submitted **(2016)**
[3] Lin et al., submitted (**2016)**