



Contribution ID: 205

Type: **Contributed Oral**

Using shear to lower transition pressures to new phases in Carbon, Si and Ge

Wednesday 3 December 2025 10:45 (30 minutes)

This study investigates the impact of shear strain on the phase transformation behavior of Si and Ge under high-pressure conditions. Si and Ge are known to undergo a series of pressure-induced phase transformations, resulting in new phases with technological potential [1,2]. Utilizing both traditional diamond anvil cells (DAC) and a new rotational diamond anvil cell we demonstrate that high-shear environments reduce the pressure threshold required for the semiconductor-to-metal phase transformation from diamond cubic (dc) to (β -Sn) structures in both materials. In situ Raman spectroscopy and X-ray diffraction experiments reveal that with rotational shear the metallic β -Sn phase can form in Ge at pressures well below the threshold required under hydrostatic conditions. In a rotational DAC, the transformation occurs at approximately 4 GPa, significantly below the conventional 10 GPa threshold. Furthermore, we observe unexpected decompression pathways that deviate from established behavior. When (β -Sn)-Ge forms below 10 GPa under high shear, it directly reverts to the original dc-Ge structure upon decompression, contrasting with the formation of the exotic metastable phases (r8-Ge, bc8-Ge, st12-Ge) typically observed after decompression from (β -Sn)-Ge. A similar behavior is seen for Si. Microstructural analysis of single crystal Si samples using transmission electron microscopy suggest that this pressure reduction phenomenon may be facilitated by shear-induced defects, particularly stacking faults along {111} planes, which serve as nucleation sites for the phase transition [3].

References

- [1] B. Haberl et al. Applied Physics Reviews 3, 040808 (2016)
- [2] C. Rödl, et al. Phys. Rev Materials 3, 034602 (2019)
- [3] S. Butler et al. Applied Physics Letters 123, 231903 (2023)

Authors: BRADBY, Jodie (The Australian National University); GLUCK, Taylor (The Australian National University); Mr HEIMES, Hendrik (The Australian National University); Prof. WILLIAMS, Jim (The Australian National University); Prof. MCCULLOCH, Dougal (RMIT); Dr BUTLER, Sean (RMIT); Dr HUSTON, Larissa (The Australian National University)

Presenter: BRADBY, Jodie (The Australian National University)

Session Classification: Condensed Matter & Materials

Track Classification: Topical Groups: Condensed Matter & Materials