MS27-2-14 High-pressure polymerisation of CS_2 : 'Bridgman's black' revisited
#MS27-2-14

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Abstract
It is known since decades that carbon disulfide (CS2) transforms under pressure of a few GPa and under moderate high temperatures irreversibly into a polymeric 3-dimensional solid ("Bridgman black") with complex structure containing multiple-types of C-C, C-S and S-S bonds [1-5]. Here we show that by compression at 300 K to ~7 GPa using large-volume Paris-Edinburgh devices, an instantaneous reaction leads to a mixture of pure sulfur and a well-defined compound with stoichiometry close to C2S (Fig. 1). The availability of macroscopic sample quantities enables an in-depth characterisation of the reaction product by applying a variety of techniques, in particular X-ray and neutron diffraction, Raman scattering, infrared absorption, density and resistivity measurements [6]. We find that this material is fundamentally different to Bridgman black and consists of sulfur bonded to sp2 graphite layers of nanometric dimension, with some similarity to graphene oxide (Fig. 2). The compound is a semiconductor with a gap of 45 meV and a conductivity 13 orders of magnitude higher than found in the 3D C-S polymer known so far. The material can be easily produced in cm3 quantity and may have technological applications.

References
[1] P.W. Bridgman, Proc. Amer. Acad. Arts Sci. 74, 399-424 (1942).
[2] B. Ochiai, & T. Endo, Prog. Polym. Sci. 30, 183-215 (2005).
[3] E. Whalley, Can. J. Chem. 38, 2105 (1960).
[4] E.G. Butcher, M. Alsop, J.A. Weston & H.A. Gebbie, Nature 199, 756 (1963).
[5] W.S. Chan & A.K. Jonscher, Phys. stat. sol. 32, 749 (1969).
[6] S. Klotz, B. Baptiste, T. Hattori, S.M. Feng, Ch. Jin, K. Béneut, J.M. Guigner, I. Estève, Carbon 185, 194 (2021)

Fig 1: Sample of CS2 (black sphere in the centre)

Fig. 2 Structural model of CxS