Simple measurement of the hardness of C_{60} samples recovered after compression to 75 GPa.

Jodie BRADBY (Research School of Physics, Australian National University, Australia)
Alexander MOZINA (Research School of Physics, Australian National University, Australia),
Hendrik HEIMES (Research School of Physics, Australian National University, Australia),

Abstract

Hardness, unlike elastic modulus, is not a fundamental material property [1]. Whereas elastic modulus is governed by interatomic bond stiffness and crystalline structure, hardness reflects how a material responds to localised stress, depending on a combination of yield strength, work hardening, and fracture behaviour. Because different indentation methods probe different combinations of these properties, a hardness value should be considered in the context of how it was measured.

For materials recovered after compression in a diamond anvil cell (DAC), conventional macro-scale methods such as Vickers indentation are impractical as this requires optical imaging of the residual indent which typically demands loads incompatible with the small DAC samples. Nanoindentation, as the name suggests, is more suited to such small samples and measures hardness using a combination of a well-characterized indenter tip with continuous in situ load and displacement measurements. Previous attempts to use nanoindentation to measure the hardness of materials created via DAC experiments have required extracting, mounting, and polishing the recovered sample, a process that is time-consuming and risks introducing artefacts including epoxy contamination and compliant substrate effects [2-3]. Here we describe a simpler alternative using direct nanoindentation on the sample still attached to the diamond culet itself, with no additional sample preparation.

In this technique the top anvil of a plate cell is carefully removed, and the sample and gasket are left in place on the bottom anvil. This is placed directly in a Hysitron nanoindentation system and indented using a Berkovich tip to loads up to 10 mN. Samples of compressed C_{60} fullerene to pressures up to 75 GPa were studied. A range of different hardnesses for the recovered samples was found, broadly consistent with our previous transmission electron microscopy studies [4].

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