Nitrogen-incorporated ultrananocrystalline diamond electrodes on single-crystal diamond anvils

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1. Background and development

Diamond anvil cells (DACs) [1] are fundamental tools for high pressure research, providing sample environment pressures that range from tens of kilobars to multiple megabars. DACs have been used in many fields of science for decades, most commonly on condensed matter physics, chemistry and material sciences, for example assisting on the search and development of new compounds or novel properties in materials. Most recently, some remarkable achievements in physics such as near-room-temperature superconductivity [2-4] were only possible due to DACs along with various technical developments [5-8]. One of the critical aspects in these experiments is to achieve high pressures while maintaining electrical access to DAC. In this work we present progress on the development of a unique type of designer diamond anvil cell for high pressure transport measurements [9]. Using a microwave plasma chemical vapor deposition (MPCVD) process, we fabricate conducting N-incorporated ultrananocrystalline diamond (N-UNCD) electrodes optimized for high pressure resistivity experiments. These electrodes are then covered with an UNCD insulating layer to prevent shorting with the metallic gasket that surrounds the sample. Our first tests were performed on a 300 µm-culet diamond anvil, but the procedures developed can be easily adapted for reaching higher pressures with diamonds of smaller culets.

2. Discussion and improvements

In previous work, B-doped diamond electrodes were deposited via MPCVD [10], showing superconductivity below ~5K. At room temperature, however, N-doping yields higher conductivity than B- or P-doping [11]. Although N-UNCD usually presents resistivity values of about 4 orders of magnitude higher than metals commonly employed in conventional designer anvils like Pt or Ti [12], diamond electrodes provide better robustness and performance under pressure, with deformations and failures occurring less frequently. Additionally, replacing metallic contacts with low Z, carbon-based probes makes *in-situ* X-ray diffraction or other experiments that use a transmission geometry more reliable [13], without issues arising from the interaction with electrodes. Furthermore, the four-point probing method for resistivity measurements tend to mitigate the overall effect of high-resistance electrodes, making all-diamond designer anvil cells an ideal instrument for reliable transport experiments, that can be combined with concomitant diffraction or spectroscopy techniques.

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