Diamond-based microhollow cathode discharges

S. Mitea [1 (*)], M. Zeleznik [2], M. D. Bowden [1], P. W. May [2], N. A. Fox [2], C. Fowler [3] and R. Stevens [3,4]

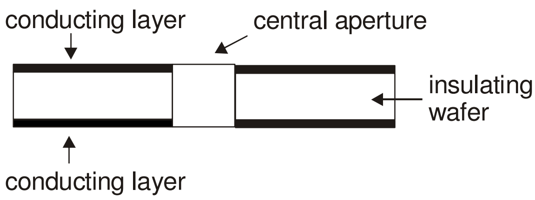
[1] *Department of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK*
[2] *School of Chemistry, University of Bristol, Bristol, BS8 1TS, UK*
[3] *Micro- and Nano-Technology Centre, STFC Rutherford Appleton Laboratory, Didcot, OX11 0QX, UK*
[4] *School of Science and Technology, Nottingham Trent University, Nottingham, NG1 4BU, UK*
s.mitea@open.ac.uk

We report the generation and characterisation of microdischarges in devices composed of microcrystalline diamond. Discharges were generated in device structures with microhollow cathode discharge geometries. One structure consisted of an insulating diamond wafer coated with boron-doped diamond layers on both sides. The second structure consisted of an insulating diamond wafer coated with metal layers on both sides. In each case, the discharge was generated in a sub-millimetre hole that had been machined through the conductor-insulator-conductor structure.

High-pressure microplasma research has strongly intensified over the past two decades [1]. Microhollow cathode discharges initially consisted of molybdenum electrodes separated by a mica insulator [2]. Other electrode materials have since included copper, gold, indium-tin-oxide (ITO), nickel and silicon [3]. Insulators have been made of alumina, glass, Kapton, mica and silicon dioxide [4]. Because of their high surface-to-volume ratio, studying the effect of the wall materials is critical for achieving a fundamental understanding. The aim of our research is to investigate the effects of wall and surface materials on discharge behaviour. Diamond is an ideal material for such studies, as its properties can be manipulated during fabrication, and its high thermal and mechanical stability should allow long-lived stable devices to be made and studied.

Microhollow cathode discharges were fabricated from microcrystalline diamond thin films obtained by chemical vapour deposition. The electrodes consisted either of p-type semiconducting diamond (~5µm thick) or metal (<1µm thick). The insulator was 250µm-thick undoped diamond.

Fig 1: Schematic diagram showing the geometry used for both devices.



Discharges were generated in a range of gases, and device operation was characterized by electrical and optical measurements. Breakdown voltages of 300-500 V and discharge currents of 0.1-2 mA were measured for different operating conditions. Preminary measurements of Paschen curves for these devices indicated a minimum breakdown voltage in the region of 2-5 Torr cm, as expected for glwo discharges. Device lifetimes appear to be in excess of many tens of hours.

The successful operation of diamond-based microdischarge devices represents a new technology for microdischarge fabrication. This demonstration of microdischarges in diamond-based devices offers the opportunity for detailed investigation of the role of material properties in the behaviour of microdischarges.

This research is supported by the UK Engineering and Physical Sciences Research Council (EPSRC), under grant EP/G057176/1.

References

[1] K. H. Becker *et al. J. Phys. D: Appl. Phys.*, 39:R55–R70 (2006).
[2] K. H. Schoenbach *et al. Appl. Phys. Lett.,* 68(1):13–15 (1996).
[3] F. Iza *et al. Plasma Processes Polym.*, 5:322–344 (2008).
[4] L. C. Pitchford, 6th International Workshop on Microplasmas, April 3-6 Paris, France (2011)