High Pressure High Temperature Synthesis of Highly Boron Doped Diamond Microparticles for Electrochemical Applications

Georgia F. Wood,[a,b] Carmen Walters,[c] Mark Munday,[c] Viacheslav Shkirskiy,[a] Patrick R. Unwin[a] and Julie V. Macpherson[a]

[1] Department of Chemistry, University of Warwick, Coventry, UK

[2] Diamond Science and Technology Centre for Doctoral Training, University of Warwick, Coventry, UK

[3] Element Six, Global Innovation Centre, Didcot, UK

In recent years, boron doped diamond (BDD) has received significant investigation as an electrode material due to its superior properties when compared to traditional metallic and sp^2 carbon electrodes such as a wide solvent window, low background currents, biocompatibility, and resistance to both fouling and corrosion in harsh environments.[1–3] BDD thus offers many advantages over competing materials for electroanalysis.

The high levels of boron doping ($>10^{20}$ boron atoms cm^{-3}) reported in diamond grown by chemical vapour deposition (CVD) has yet to be achieved through growth by high pressure high temperature (HPHT) synthesis with metal catalysts. HPHT synthesis offers a lower cost alternative to CVD synthesis, which results in the production of BDD particles at the micro scale. Here, we introduce a HPHT synthetic route for the fabrication of highly doped BDD microparticles, sufficient for electrochemical applications, using a carbide forming Fe-Ni (catalyst) B-C system.[4] This catalyst system enables operation at a significantly lower temperature than previous work in this field, resulting in a lower cost and energy consumption of production. Aluminium diboride (AlB_2) is employed as both a boron source and a nitrogen getter to reduce boron-nitrogen aggregate formation, the latter which reduces the concentration of available boron charge carriers. Material and electrochemical characterisation is carried out on the BDD in both powder and powder-compacted (then polished) form. For higher resolution electrochemical studies both single microparticle studies are undertaken in conjunction with scanning electrochemical cell microscopy (SECCM).

References

1 N. Yang, S. Yu, J. V. MacPherson, Y. Einaga, H. Zhao, G. Zhao, G. M. Swain and X. Jiang, *Chem. Soc. Rev.*, 2019, 48, 157–204.

2 J. V Macpherson, *Phys. Chem. Chem. Phys.*, 2015, **17**, 2935–49.

3 S. J. Cobb, Z. J. Ayres and J. V. Macpherson, *Annu. Rev. Anal. Chem.*, 2018, **11**, 463–484.

4 G. F. Wood, C. Walters, M. Munday, V. Shkirsky, P. R. Unwin, J. V. Macpherson. submitted.

Activities Statement

I attend annually and have presented both poster and oral presentations at the Warwick Diamond Conference and the UK Midlands Electrochemistry Group Meeting. This year I also attended the Analytical Science Network Bright Spark Symposium in Brighton, UK, where I was awarded the prize for the best oral presentation.

Throughout my PhD I have enjoyed organising and attending outreach events and exhibits, to inspire people (most importantly the next generation of scientists!) to discover a passion for science. I was attracted by the world class speakers presenting at the Gordon 2020 conference and would relish the opportunity to listen to (and hopefully pick the brains of!) so many excellent scientists – particularly Linda Nazar and Richard Crooks who are both giving talks on areas which I have a strong research interest in myself. I feel I will be able to learn a lot to help in my own research and also potentially allow future collaborations. The Gordon conference is renowned for providing a varied and international network of students and academics, and as my first international conference, will be a great chance to experience and get involved in the global electrochemical community. I aspire to continue a career in electroanalytical chemistry post-PhD and think that this would be a great place to start! I also was so excited to see that the GRC Power Hour will focus on gender diversity and inclusion in science, which is a cause I feel passionately about and am always striving to educate myself further on what I can do within my career to help tackle the issues and barriers that women often face.

The Gordon conference is renowned for providing a varied and international network of students and academics, and as my first international conference, will be a great chance to experience and get involved in the global electrochemical community. I am particularly interested to speak to Linda Nazar and Richard Crooks who are both giving talks on areas which I have a strong research interest in myself and hope to get ideas for my own project and possibly instigate collaborative work.