# Modulating properties of solid carbon nanospheres via ion implantation with heteroatoms

**Boitumelo J. Matsoso[2,3] , Daniel Wamwangi [1, 4], Rudolph Erasmus[1,4], Neil J. Coville[1,2], Trevor Derry [1,4]**

[1] DSI-NRF Centre of Excellence in Strong Materials and [2]Molecular Science Institute, School of Chemistry, University of the Witwatersrand, Johannesburg, South Africa

[3] Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Prague, Czech Republic

[4]Material Physics research Institute (MPRI) and School of Physics, University of the Witwatersrand, Johannesburg, South Africa

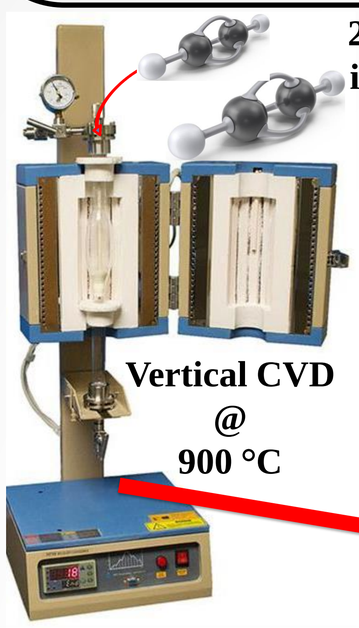
## I. Introduction

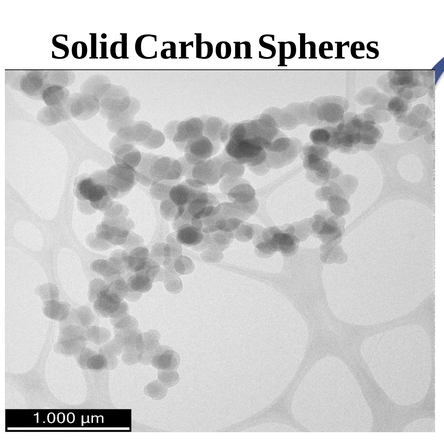
Carbon-based nanostructures have been the forefront materials of interest for a vast array of applications since the discovery of fullerenes in the mid-1980's. Among the carbonaceous material family, solid carbon nanospheres (SCSs) have gained interest in the renewable energy technology arena due to their spherical morphological framework which provides accessible surface for charge storage. Moreover, the surface properties can be modulated by introduction of the heteroatoms. Practically, modulation to desired depths via the ion-implantation technique is the preferred route as the core of the SCSs nanostructures is not compromised, whilst the tuned surface is available for either energy conversion and/or storage applications.

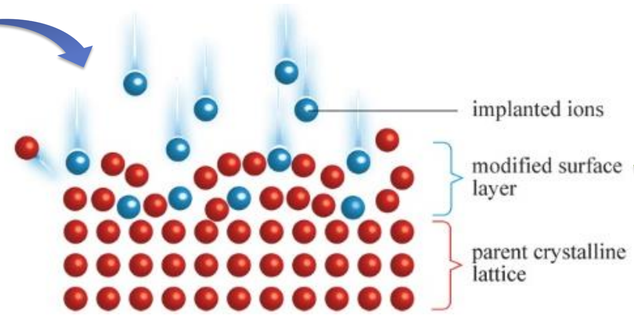
## II. Research Objectives

- Employ the vertical CVD technique for synthesis of SCSs.
- Post ion implantation using $Ne^+$, $B^+$, and $N^+$ ions.
- Investigate the influence of heteroatom ion on the physicochemical properties of SCSs .

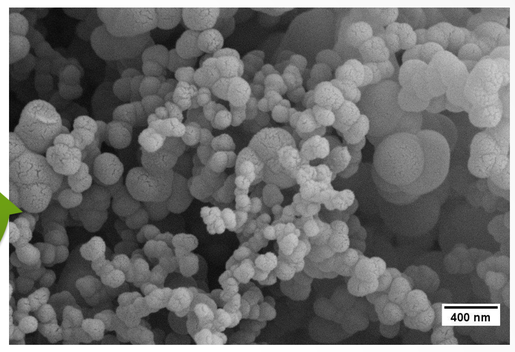
## III. Experimental Procedure



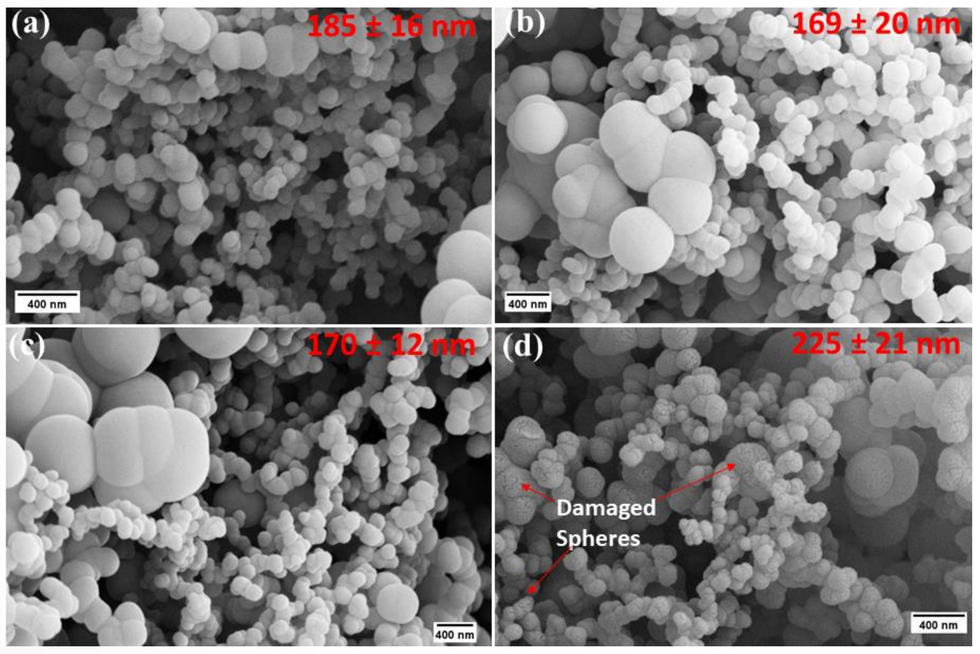

**Implantation using:**
**$Ne^+$, $B^+$ , $N^+$ at 100 keV for 7 h**



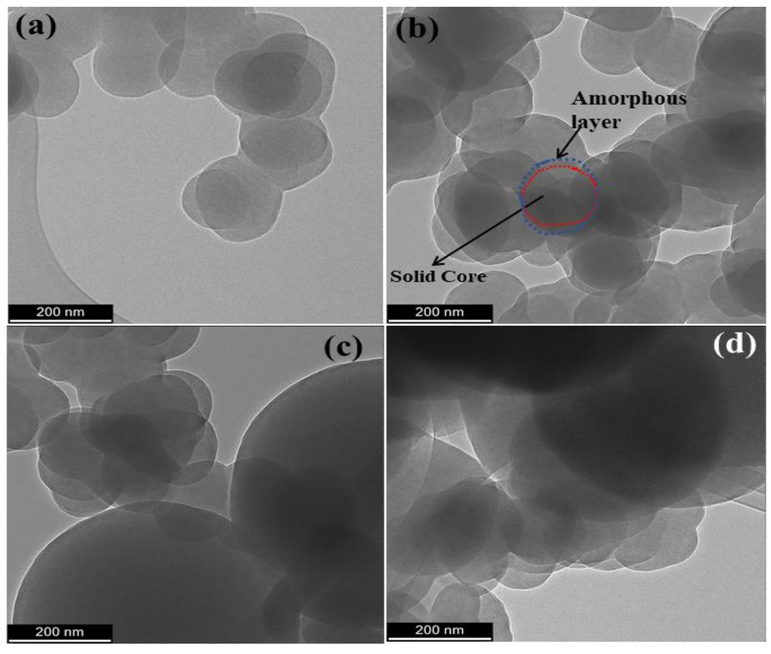

**Implanted Solid Carbon Spheres**

## IV. Results and Discussions

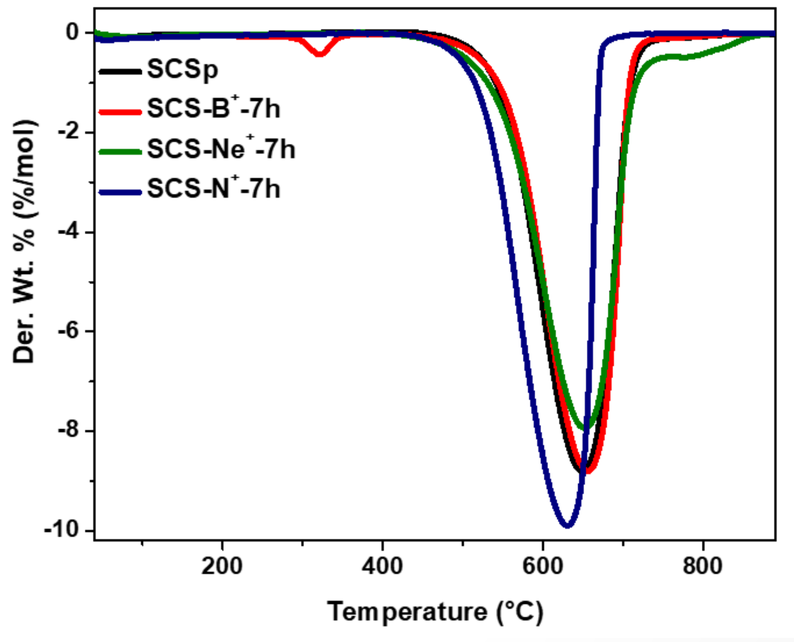
### (i) SEM micrographs




### (ii) TEM micrographs




### (iii) Thermal stability




(i) SEM and (ii) TEM images of (a) Pristine and doped (b) $Ne^+$ (c) $B^+$, and (d) $N^+$ SCSs. Depiction of agglomerated spheres as well as damaged spheres for N-implanted samples. Presence of varying thickness of amorphous layer around SCSs depending on heteroatom ion (**Table 1**). Thicker amorphous layer suggestive of depth of implantation.

Pristine SCSs are more thermally stable due to solid core. Narrow bandwidth for ion-implanted samples signifies generation of defects, thus enabling easy decomposition and compromised thermal stability.

**Table 1:** Textual and morphological parameters of the samples

| Sample | BET surface area ($m^2/g$) | Pore size (nm) | Amorphous layer (nm) | Decomp. Temp (°C) |
|---|---|---|---|---|
| **SCS** | 13.3 | 25.1 | 2.3 ± 0.5 | 650 |
| **$Ne^+$- SCSs** | 13.6 | 51.9 | 7.8 ± 1.8 | 652 |
| **$B^+$- SCSs** | 12.5 | 22.4 | 16.9 ± 2.2 | 321, 656 |
| **$N^+$- SCSs** | 10.1 | 21.6 | 13.6 ± 1.8 | 630 |

## V. Conclusions

- Successful growth of SCSs using vertical CVD technique and implantation with $Ne^+$, $B^+$, and $N^+$ ions.
- Physicochemical properties of ion-implanted samples was dependent on the type of heteroatom ion..
- $N^+$-7h implantation led to more defective and less thermally stable samples.
- Affinity of $B^+$ and $N^+$ ion to carbon lattice led to increased outer shell distortion; suggestive of a deeper ion implantation.

❖ **Demonstration of significance of choice of heteroatom ion for tuneable physicochemical properties of SCSs.**

## Acknowledgements

DSI-NRF Centre of Excellence in Strong Materials
School of Chemistry
University of the Witwatersrand, Johannesburg
MPRI