Fabrication and Characterization of Porous Carbon for Lithium Sulfur Batteries

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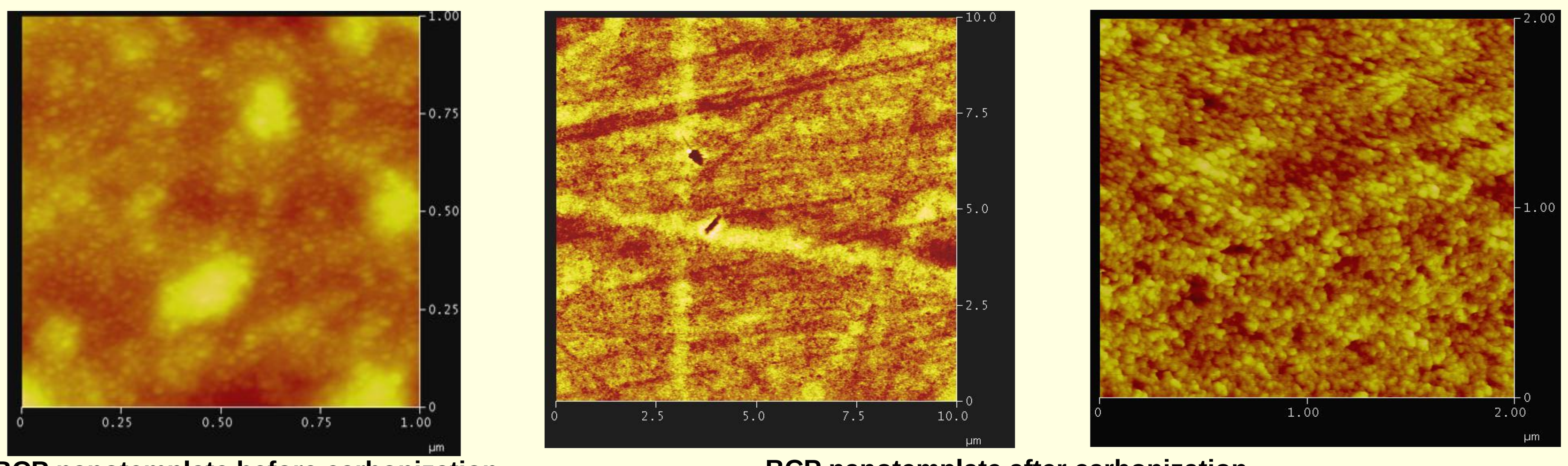
Introduction: Due to the continuous demand for alternative energy sources the need for an accumulator with high energy storage capacity, high reversibility of charging and discharging and longer cycle life Lithium Ion batteries come into the research [1]. That needs an electrode made of highly porous carbon infiltrated with sulfur. We are fabricating a highly porous carbon material with high surface area by taking different carbon precursors as polyacrylonitrile [2] based block copolymers and/or polymer resin and investigating by microscopic techniques e.g. AFM, SEM etc and by RAMAN spectroscopy.

Preparation of porous carbon from PAN based block copolymer

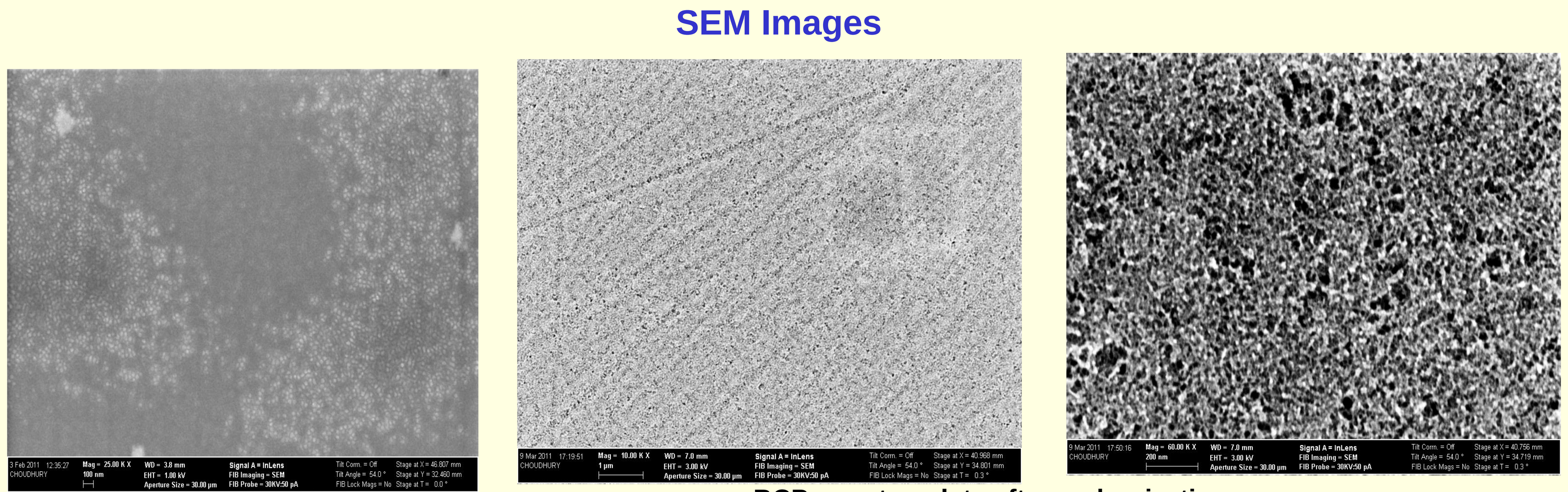
- ❖ Polyacrylonitrile containing block copoymers (BCP) was taken for nanostructure fabrication.
- ❖ Block copolymer solution was spin casted on substrates (Si wafers, Glassy Carbon).
- ❖ The nanotemplates were carbonized to get highly porous carbon materials suitable for electrode applications.

AFM Images

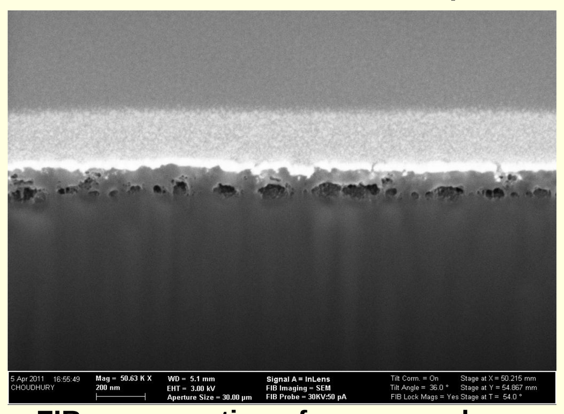


BCP nanotemplate before carbonization — BCP nanotemplate after carbonization

SEM Images



BCP nanotemplate before carbonization — BCP nanotemplate after carbonization

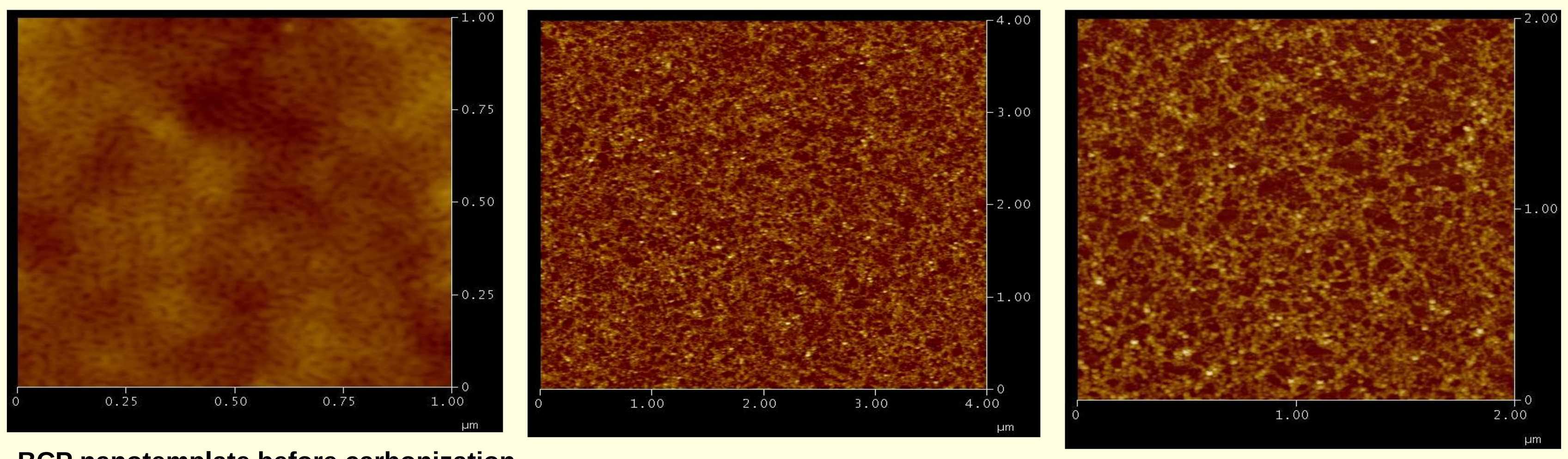


FIB cross section of porous carbon

Preparation of porous carbon from Polymer Resins

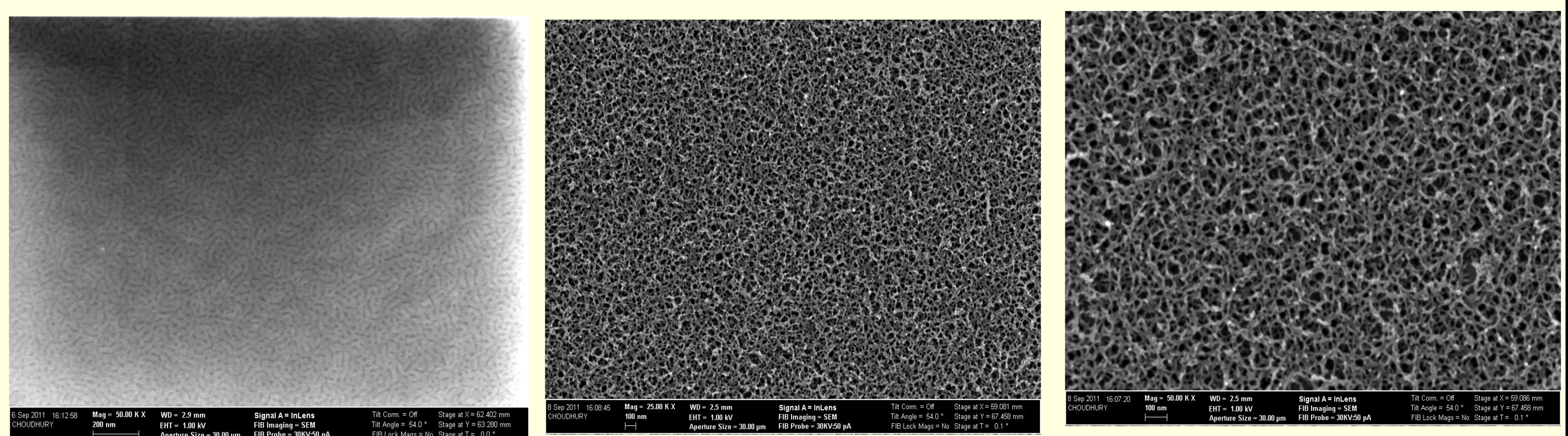
- ❖ Block Copolymer-Polymer resin mixture spin coated on silicon wafer and solvent annealed.
- ❖ Nanotemplates were crosslinked and carbonized at high temperature to fabricate porous carbon structure.

AFM Images

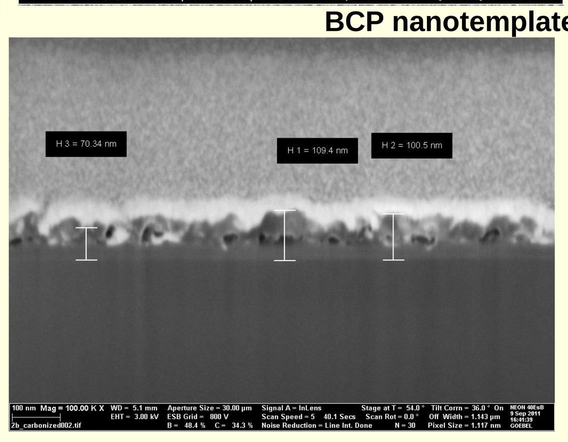


BCP nanotemplate before carbonization — BCP nanotemplate after carbonization

SEM Images

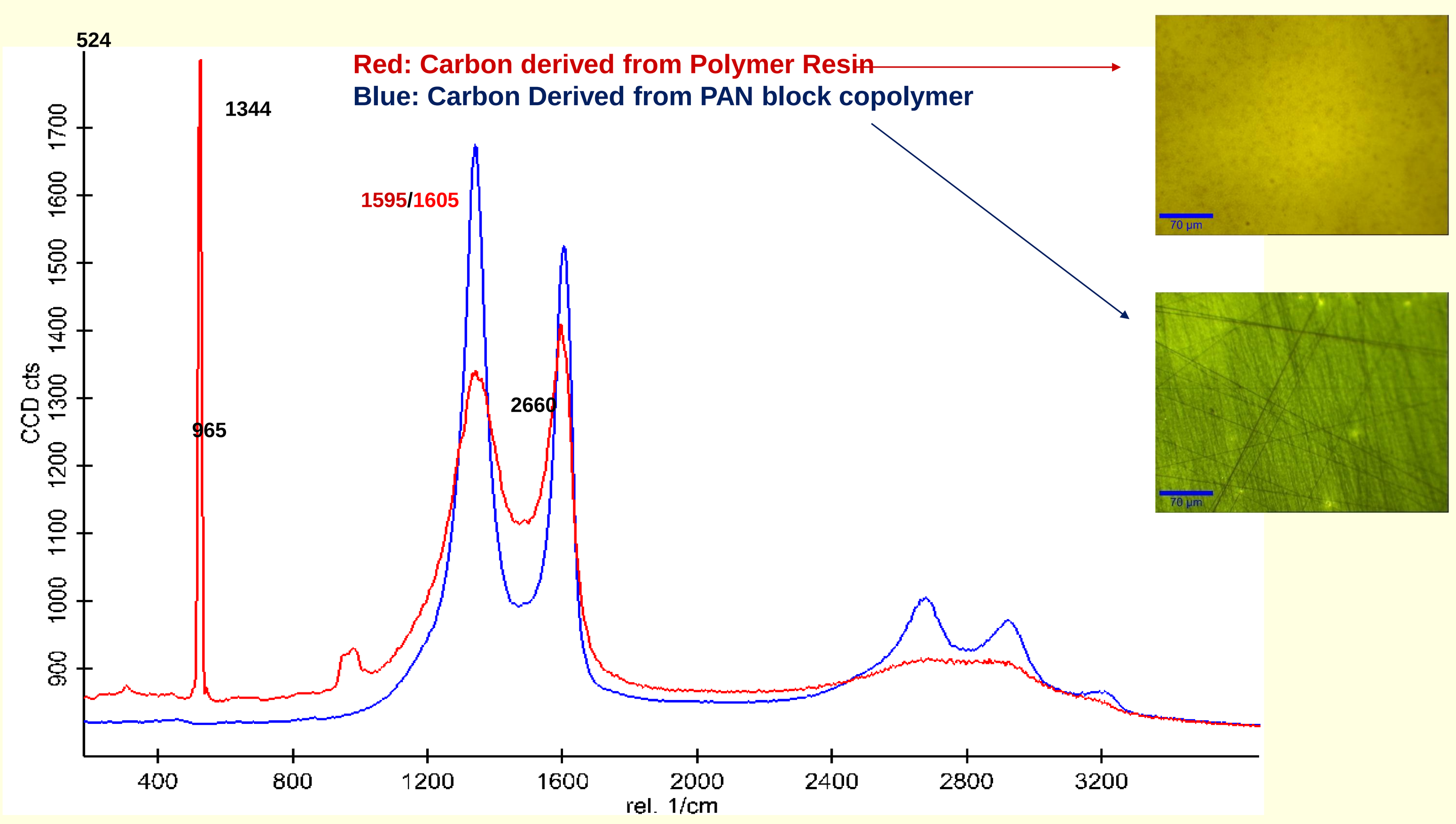


BCP nanotemplate before carbonization — BCP nanotemplate after carbonization



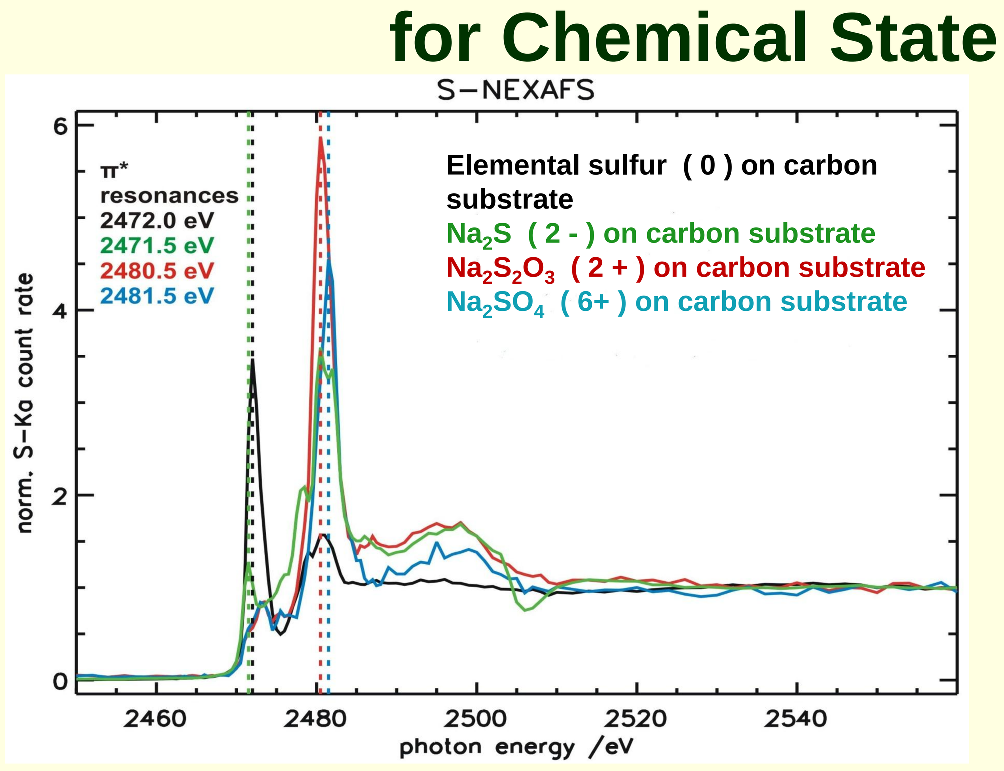
FIB cross section of porous carbon

RAMAN Spectroscopy Study



- ➢ For Both of the carbon materials the D band appear at 1344 cm^{-1} and G band appear at 1595 cm^{-1} for resin derived carbon and 1605 cm^{-1} for polyacrylonitrile derived carbon.
- ➢ Band appeared at 524 cm^{-1} for Si- Si coming from the substrate and band at 965 cm^{-1} from Si-0 also from the substrate.
- ➢The D/G ratio of resin derived carbon is lower (2.0) than that of polyacrylonitrile derived carbon (2.7) indicating more defect free structure of resin derived carbon.

Near Edge X-Ray Absorption Spectroscopy for Chemical State of Sulfur



- ➢ Sulfur with different oxidation states were studied.
- ➢ From the characteristic peak of sulfur compounds the species could be identified as different species appears at different photon energies.
- ➢ Little overlaps of peaks with -2 oxidation states of sulfur due to its chemical instability in air.

Future Outlook

- ➢To obtain the nanoscale ordered morphology of PAN containing block copolymer the casting, annealing and crosslinking conditions to be optimized.
- ➢ To the optimized nanoporous carbon filling of sulfur and the sulfur depth profile, speciation and quantification are under investigation.
- ➢The electrochemistry is to be studied with sulfur filled porous carbon as an electrode.

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References: [1] *Journal of Power Sources* 195, (2010) 2419-2430.
[2] *Chem. Mater.* 16 (2004) 100-103.