Three-Dimensional Periodic Graphene Nanostructures

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Poster #

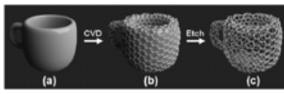
Motivation

- ❖ Fabricating complex 3D graphene nanostructures by growing graphene on pre-synthesized nanostructured metal templates by chemical vapor deposition (CVD) and then etching away the metal. Increase the mechanical stability as well as thermal stability of nanostructures by coating with carbon

- ➢ High specific surface area
- ➢ High electrochemical stability
- ➢ High electronic conductivity
- ➢ High thermal stability
- ➢ High connectivity

Experimental setup

Synthetic scheme of graphene nanostructures using chemical vapor depositiom (CVD)

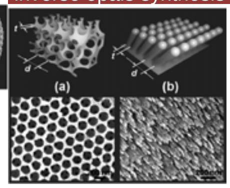


General scheme of growing arbitrarily shaped graphene nanostructures: graphene is grown on a metal nanostructure (a) by CVD to form a graphene-coated metal nanostructure (b) followed by the subsequent etching of the metal leaving a free-standing graphene nanostructure (c).

Metal nanostructures used in this work to grow graphene by CVD

Technique for nickel inverse opals synthesis

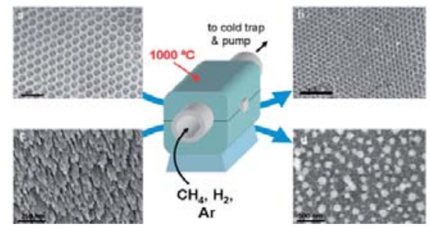
Technique for nickel nanopillars synthesis



- Polystyrene spheres were used to synthesized the opal template followed by electrochemical deposition of nickel to engineered the nickel inverse opals nanostructure subsequently graphene synthesis
- Nickel nanopillars were deposited using thermal deposition technique followed by graphene synthesis

(A) inverse opals and (b) slanted nanopillars. Top row panels show 3D schemes of these nanostructures; bottom row SEM images of nickel inverse opals and slanted nanopillars, respectively, An average periodicity (d) and size (t).

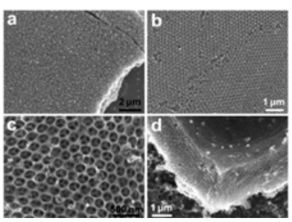
Chemical vapor deposition of graphene



Growth of graphene on nickel inverse opals (a and b) and SCTFs (c and d) from methane at 1000 C. Panels (a) and (c) show SEM images of pristine nickel nanostructures; panels (b) and (d) show the same nanostructures after graphene growth.

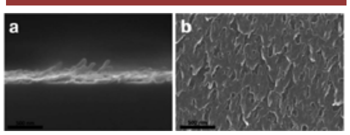
Processing of material

Free standing graphene inverse opal nanostructures



SEM images depicting different orientation of free-standing graphene inverse opals(a-c) top-view images and (d) side-view image after etching in iron III chloride solution

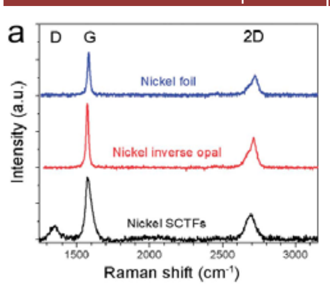
Slanted graphene nanostructures



SEM images of etched graphene SCTFs: (a) side view image (b) top-view image

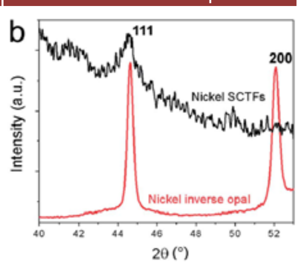
- ❑ Connectivity is very important in free-standing graphene
- ❑ Quality and quantity of free-standing is a measure of the template quality
- ❑ Temperature at which the graphene is very important to the quality
- ❑ Carbon precursor used is also important since this is directly related to temperature

Raman Analysis of graphene on the different nickel templates



Raman analysis of the graphene grown on different nanostructures. (red) nickel inverse opals, (blue) nickel foil and (black) nickel slanted nanopillars

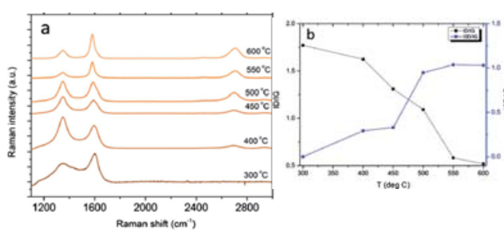
X-ray diffraction paten of the different nickel templates



X-ray diffraction of the nanostructures. (red) nickel inverse opal and (black) nickel nanopillars

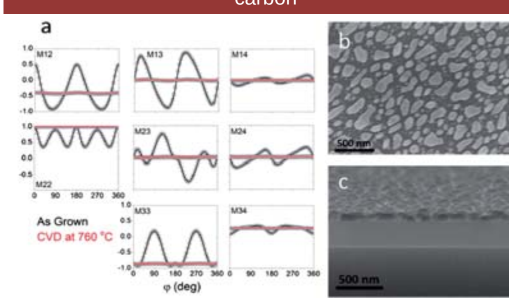
Results

A study of the effect of temperature on the quality of graphene nanostructures



(a)Raman spectra of graphene products grown at different temperatures by CVD on nickel foils with acetylene as a carbon source.
(b) I_D/I_G (BLACK) and I_{2D}/I_G (blue) intensity ratios versus growth temperature

Ellipsometry analysis of nickel nanopillar coated with carbon



Rotation scan ellipsometry of as-grown deposited nickel and graphene coated nickel SCTFs analyzed as a function of the in-plane azimuth of the SCTFs at 601 nm wavelength and 45° angle of incidence (a) and CVD graphene on nickel SCTFs at 500°C (b &c)

Future work

- ➢ Optimize the technique to synthesize bulk graphene inverse opal nanostructures
- ➢ Application of this material in energy storage sector such as supercapacitors as well as in sensor sector such as gas sensors
- ➢ Optimize the synthesis to engineer high quality-quantity in terms of domain size

Acknowledgments

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