Strain-guided Nano Perforation on 2D materials

Takumi Furutani1*, Tomoyasu Tanaka1, and Akio Yonezu1

1 Department of Precision Mechanics, Chuo University, 1-13-27 Kasuga, Bunkyo, Tokyo, Japan
*t-furutani@mater.mech.chuo-u.ac.jp

Introduction.

Graphene is a monolayer of carbon atoms which are arranged in a honeycomb network. It is reported that graphene possesses unique properties such as superior electrical property, large surface area, and high thermal, mechanical and chemical stability. Because nano porous graphene is potentially useful for DNA sequencing, water desalination, and supercapacitor, manufacturing of nano pores in a graphene has been strongly demanded (1)-(3). Thus, an efficient technique with highly controllable is needed for this purpose. Here, we propose a simple technique to manufacture porous graphene using local bending strain owing to nanoparticles (NPs). This may be useful for manufacturing porous graphene for wide surface area with lower cost compared with the previous technique (i.e. heavy ion irradiation, oxygen etching).

Method.

Figure 1 shows our manufacturing process of porous graphene. First, NPs were arranged on a flat glass substrate by using dip coating method. As shown in this illustration, NPs are descreately arranged on the flat surface. Next, CVD-grown graphene is transfered on the NPs-substrate. This results in that the graphene becomes tent shape due to the arragned NPs. This induces local bending strain near NPs. After that, oxygen plasma etching is carried out to nucleate nano perforation due to the local bending strain. It is suggested that local strain encourgaes nucleation of pore due to etching. Thus, this method is simple and cost effective way, and it may be applied for wide area of grapehen.

Results.

This study employed FESEM and AFM to observe nano pores on graphene. Figure 2 shows tent strcture of graphene surface. After oxygen plasma etching, it was found that nano pores were formed near the NPs. The number of pores varied depending on the etching time. In addition, Raman spectral analysis revealed that oxygen bonding and graphene edges are increased when the etching time is longer. Therefore, loacal strain encourgaes nuculeation of pore in grapehen.

Conclusions.

We successfully manufactured porous graphene due to bending strain of graphene and NPs. Bending strain encourages etching to nucleate nano pores, and then size of nano pores and its distribution can be controlled. It was clarified that the number of nano pores increases with longer etching time. In the future, we will elucidate the mechanism of nano pores nucleation of graphene by using molecular dynamics (MD) simulation.

The authors are grateful to Professor Xi Chen and Dr. Xiangbiao Liao at Columbia University for their significant contributions.

References.

(2) Homaeigohar, Elbahri Graphene membranes for water desalination (2017) NPG Asia Materials vol.9, page e427