

Supporting Information

Direct Growth of Graphene Nanopatches on Graphene Sheets for Highly Conductive Thin Film Applications

Wooseok Song,^{a,c} Ki Woong Kim,^{a,c} Sung-Jin Chang,^b Tae Jung Park,^b Sung Ho Kim,^a Min Wook Jung,^a Geonhee Lee,^a Sung Myung,^{a,*} Jongsun Lim,^a Sun Suk Lee,^a and Ki-Seok An^a

^a Thin Film Materials Research Group, Korea Research Institute of Chemical Technology (KRICT), Yuseong Post Office Box 107, Daejeon 305-600, Republic of Korea

^b Department of Chemistry, Chung-Ang University, 84 Heukseok-ro, Dongjak-gu, Seoul, 156-756, Republic of Korea

Synthesis and transfer of GN-assembled graphene films.

A conventional CVD system was used for the growth of graphene films. Initially, 25- μ m-thick Cu foil (Alfa Aesar, 99.8% purity) was prepared as a catalytic substrate for graphene growth. Cu foil was placed in the CVD reactor and heated to 1000 °C under a pressure of 5 Torr while H₂ (10 sccm) and Ar (1000 sccm) were introduced. Graphene was synthesized at 1000 °C by introducing CH₄ (30 sccm) with H₂ and Ar for 20 min. After turning off the flow of CH₄, the CVD reactor was cooled to room temperature with H₂/Ar. The graphene/Cu foil was immersed in NiCl₂ solution (0.2 M in ethanol) for 30 min. After assembly of the Ni NPs, the GNs were synthesized on the Ni-treated graphene under the same CVD conditions as graphene synthesis. The GN-assembled graphene film was then transferred to the desired substrates (300-nm-thick SiO₂/Si (001) or glass) by a PMMA-assisted wet-transfer method.^{S1} The PMMA dissolved in chlorobenzene was spin-coated onto the sample at 2000 rpm for 30 sec. The PMMA-coated sample was placed in Cu etchant (CE-100, Transene Company, Inc.) to remove the Cu foil. After the Cu foil was

completely etched away, the PMMA-coated sample was scooped out of the etchant using the desired substrates. The PMMA layer was then removed with acetone, and the surface was rinsed several times with DI water.

Preparation and measurement of electronic devices based on graphene with GNs.

For graphene device fabrication, an Al mask was initially patterned onto the graphene layer on a SiO₂ substrate, and subsequent oxygen plasma etching was conducted. After removing the Al mask patterns using Al etchant, the graphene channels were formed. Finally, electrochemically gated graphene-based FETs were fabricated by employing 1-butyl-3-methylimidazolium (BmimPF₆) as an ionic liquid and Cr/Au (10nm /70nm) through a shadow mask as source/drain electrodes. Here, the length and width of the graphene-based devices were 100 and 200 μm, respectively. A Keithley-4200 semiconductor parameter analyzer was used for measurement and data collection.

[Ref S1] X. Li, Y. Zhu, W. Cai, M. Borysiak, B. Han, D. Chen, R. D. Piner, L. Colombo and R. S. Ruoff, *Nano Lett.*, 2009, **9**, 4359.