Electronic Supplementary Material (ESI) for Nanoscale.

Supporting information

Polyolefin support layers enhance graphene mobility

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Origin of scattering in carrier mobility

A large scattering of the mobility values for Parafilm samples of 50% was observed while PMMA-supported samples only exhibited variations of 20%. To understand this behaviour we re-measured the same graphene/Parafilm sample after several days. We find that the mobility varies between 4500 and 6800cm^2/Vs and shows no apparent trend with exposure time. All values fall on the same curve of $\mu n_s = const.$ which indicates that the difference in mobility is caused by changes in the concentration of charged impurities. The concentration of scatterers was found to be proportional to the environmental humidity suggesting that adsorbed water on the graphene film is the source of the scatterers.

We observe that the variability in carrier concentration is similar for both Parafilm and PMMA-supported graphene ($\Delta n_s \approx 10^{12} cm^{-2}$) demonstrating that water has the same impact on both supports. The larger effect of adsorbates on Parafilm-supported graphene is due to its lower intrinsic carrier concentration compared to PMMA-supported graphene.

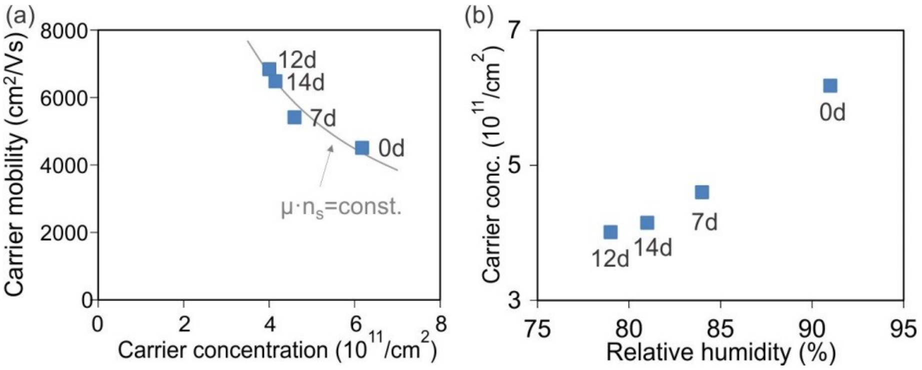
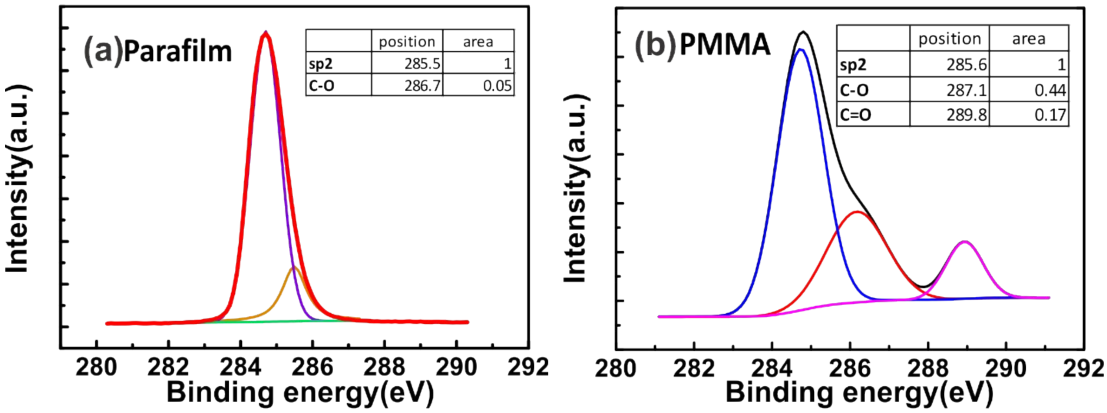


Figure S1 Performance of a single device over time: (a) mobility vs. carrier concentration, (b) impact of humidity on carrier concentration

Fit of x-ray photoelectron spectra

The C1s peak of transferred graphene was decomposed into 3 peaks following previous reports[1] : One peak at 285.5 which was associated with sp2-hybridized carbon, a $1.4eV \pm 0.1eV$ shifted peak that originates from C-O bonds, and a $4.2eV \pm 0.1eV$ shifted peak that corresponds to C=O bonds.

Figure S2 shows the deconvolution of Parafilm and PMMA-transferred graphene.



	position	area
sp2	285.5	1
C-O	286.7	0.05

	position	area
sp2	285.6	1
C-O	287.1	0.44
C=O	289.8	0.17

Figure S2 Fitting of XPS spectra after Parafilm-transfer (a) and PMMA-transfer (b), (insets) table of peak position and normalized areas

Raman characterization after transfer

Figure S3(a) shows representative Raman spectra of graphene transferred by Parafilm and PMMA. A red-shift of the Parafilm-transferred graphene and an increase in the 2D/G ratio indicates a lower doping concentration in agreement with Hall-effect measurements.[2] The Raman D-Band region (Figure S1(b)) is of similar magnitude for both samples, which suggests comparable and low defectiveness of both basal planes.

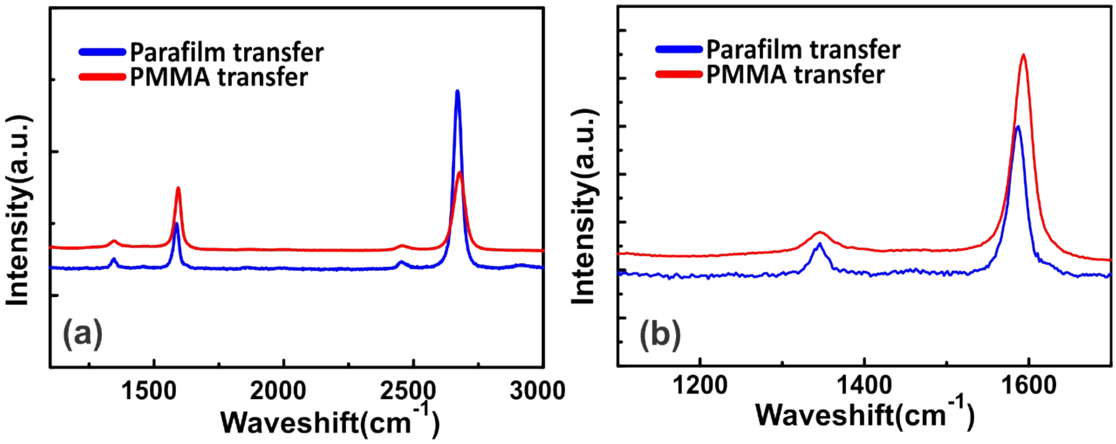


Figure S3 (a)Raman spectra of graphene samples after PMMA and Parafilm transfer, (b) magnified view of D-Band and G-Band region

Field-effect mobility measurements

FET measurements were carried out to confirm the Hall-effect measurements. Graphene transistors were fabricated after transfer to 300nm SiO_2 substrates in back-gate configuration using optical lithography. Figure S4(a) shows representative gate-sweeps for PMMA and Parafilm transferred graphene. The Dirac-Point could not be resolved for PMMA-transferred graphene due to the large amount of doping in agreement with Hall-concentration measurements. The position of the Dirac-point of Parafilm-transferred graphene corresponds to a doping level of $5 \times 10^{12} cm^{-2}$ which is within the range of expected doping levels from Hall-measurements. The somewhat higher doping level could originate from fabrication-induced residue. This residue could also explain the relatively lower carrier mobilities measured in both device types. Figure S2(b) shows a comparison of the field effect mobilities that were extracted by fitting the transconductance plots according to.[3] We find average mobilities of PMMA-transferred are around $454 cm^2/Vs$ while Parafilm-transferred graphene devices exhibit an average mobility of $2180\ cm^2/Vs$.

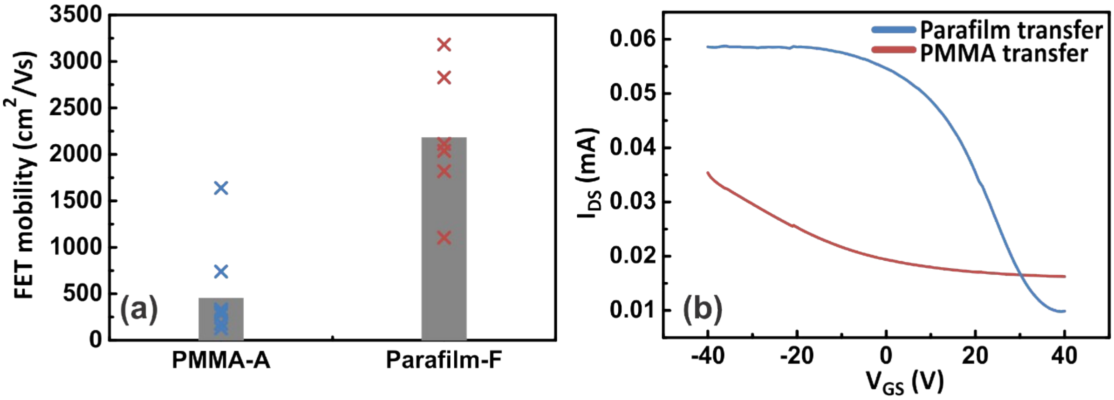


Figure S4 (a)Transconductance sweep of graphene field effect transistors after PMMA and Parafilm transfer, (b) comparison of extracted FET-mobilities

Morphology after transfer

Figure S5 shows representative AFM images of graphene after removal of the polymer support. Because of the historical role of PMMA in the transfer of graphene, optimization of the transfer process has been carried out that yields a ~3% coverage of residue. Prior to optimization, however, residue covers approximately 27% of the graphene, highlighting the value of an optimized recipe. Unoptimized Parafilm-transfer, on the other hand, results in a coverage of ~13% which suggests that future optimization could make Parafilm a suitable removable support for graphene transfer.

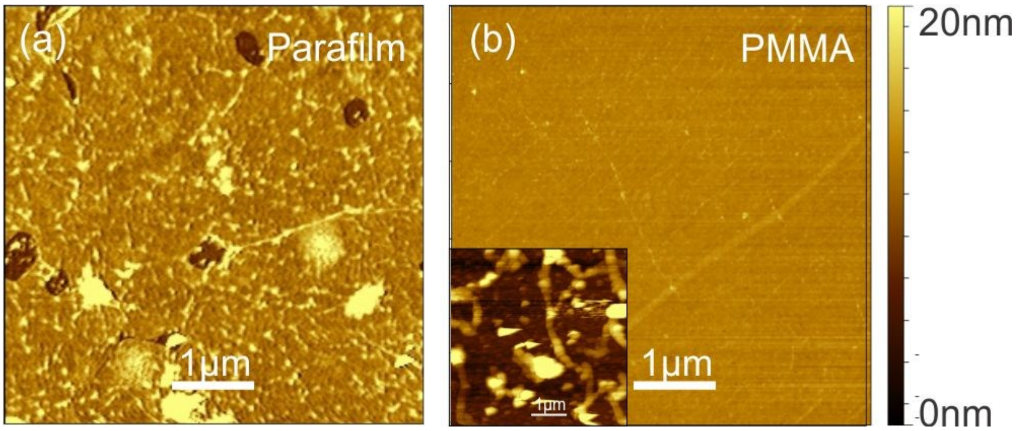


Figure S5 AFM images after transfer on same color scale (a)Parafilm, (b) PMMA

Reference

(1) Lin, Y. C.; Lu, C. C.; Yeh, C. H.; Jin, C.; Suenaga, K.; Chiu, P. W. *Nano letters* **2012**, *12*, (1), 414-9.

(2) Dresselhaus, M. S.; Jorio, A.; Hofmann, M.; Dresselhaus, G.; Saito, R. *Nano letters* **2010**, *10*, (3), 751-8.

(3) Nezich, D.; Reina, A.; Kong, J. *Nanotechnology* **2012**, *23*, (1), 015701.