# Supplementary Information

## PMMA-Etching-Free Transfer of Wafer-scale Chemical Vapor Deposition Two-dimensional Atomic Crystal by a Water Soluble Polyvinyl Alcohol Polymer Method

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### 1. Electrochemical bubbling method for transfer of h-BN.

The front side of the h-BN film on the Pt foil was covered with PMMA. The Pt foil was immersed in an aqueous solution of 1 M NaOH for electrochemical delamination. The PMMA/PAV/h-BN/Pt foil and a bare Pt foil were employed as cathode and anode, respectively. The bubbling transfer was performed under a constant current of 1 A (corresponding electrolytic voltage of 5 - 12 V) for 1 - 5 min. After peeling the PMMA/PAV/h-BN film off from the Pt foil, it was rinsed with deionized water three times to remove residual NaOH. Finally, it was transferred onto a $SiO_2$(100 nm)/Si substrate.

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## 2. AFM images of transferred graphene after annealing

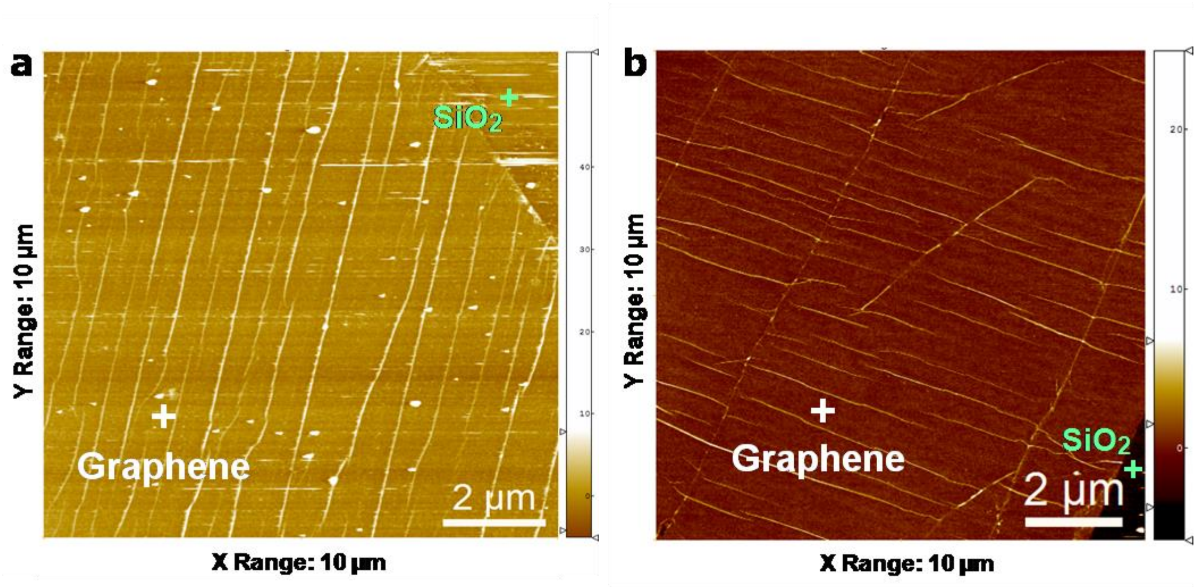

**Figure S1**. AFM images of graphene on $SiO_2$/Si substrate transferred using PMMA and PMMMA/PVA, respectively, after annealing.

## 3. Optical and Raman spectra of transferred graphene after annealing

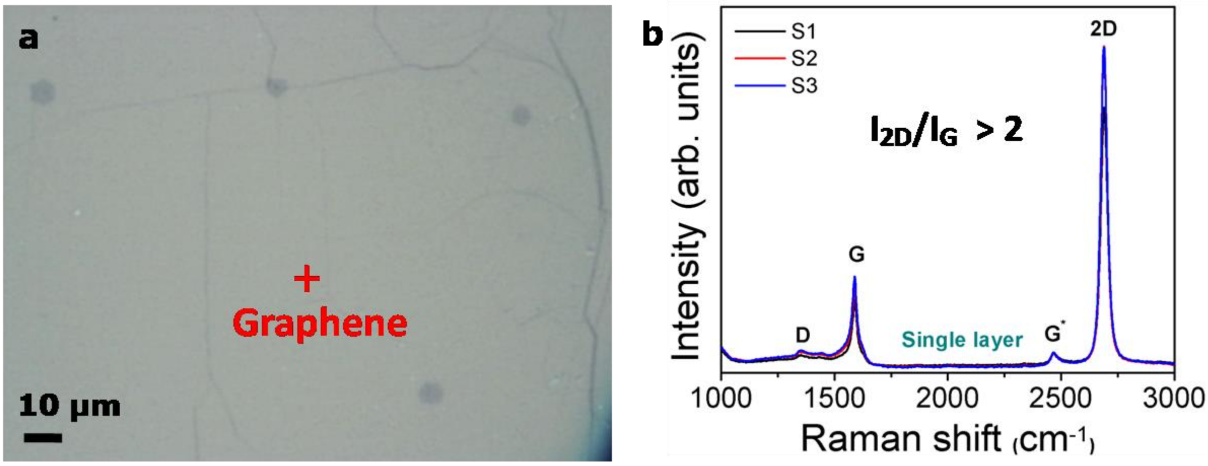

**Figure S2**. Transferred graphene on $SiO_2$/Si substrate after annealing using the PMMA/PVA transferring method: (a) Optical microscope image and (b) Raman spectrum

## 4. Optical images and Raman spectroscopy of single layer h-BN transferred using the PMMA and PMMA/PVA methods

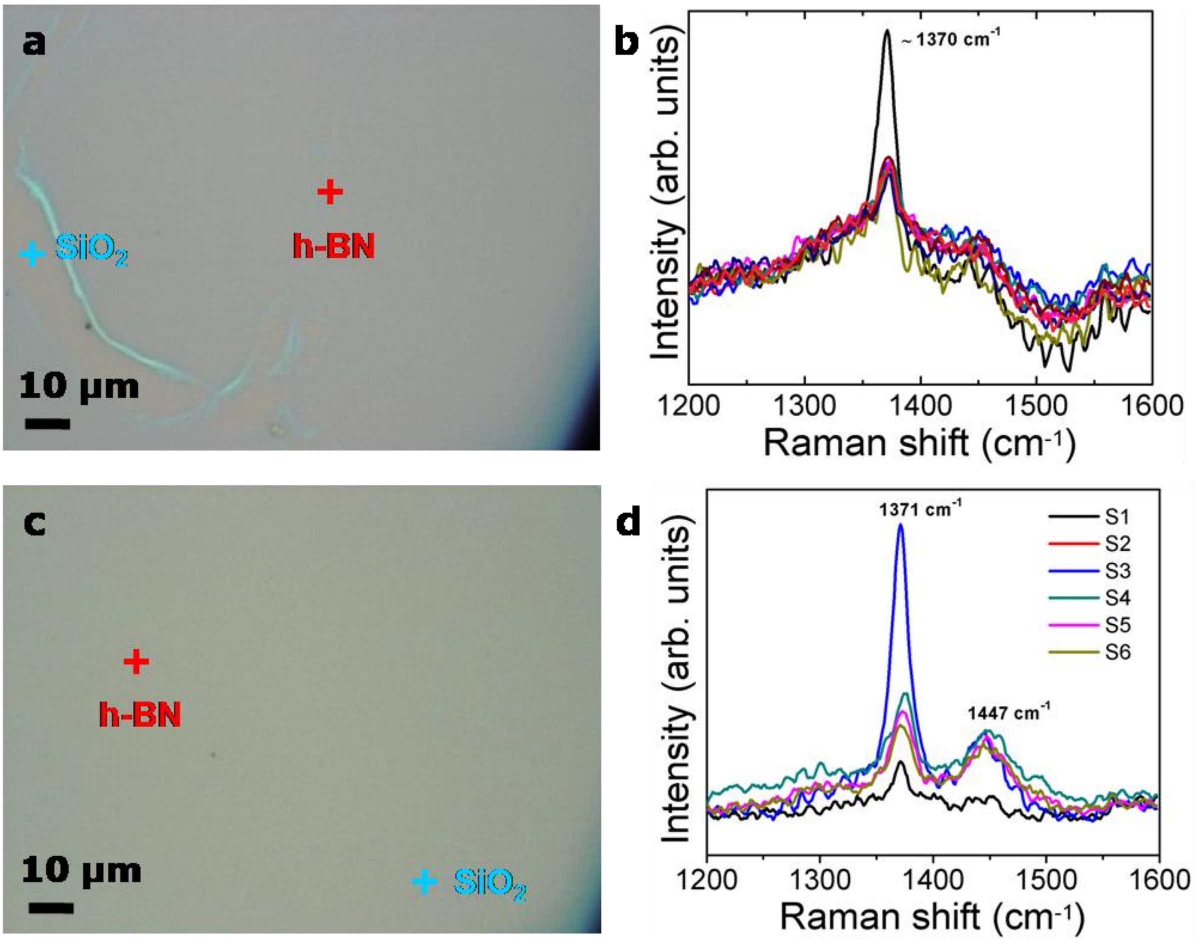

**Figure S3**. Transferred h-BN on SiO$_2$/Si substrate: (a, c) Optical microscope image and (b, d) Raman spectroscopy for the PMMA and PMMA/PVA methods of transfer, respectively.

## 5. Transferring $MoS_2$ to target substrates

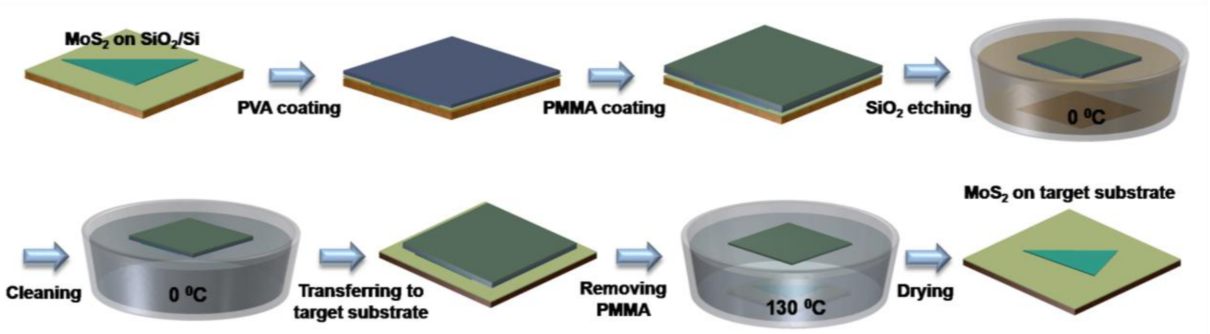

**Figure S4.** Schematic illustration of PMMA/PVA assisted transfer of CVD-grown $MoS_2$ onto a $SiO_2$/Si substrate by oxide layer etching method.

## 6. Electrical transport properties of single layer $MoS_2$ FET devices

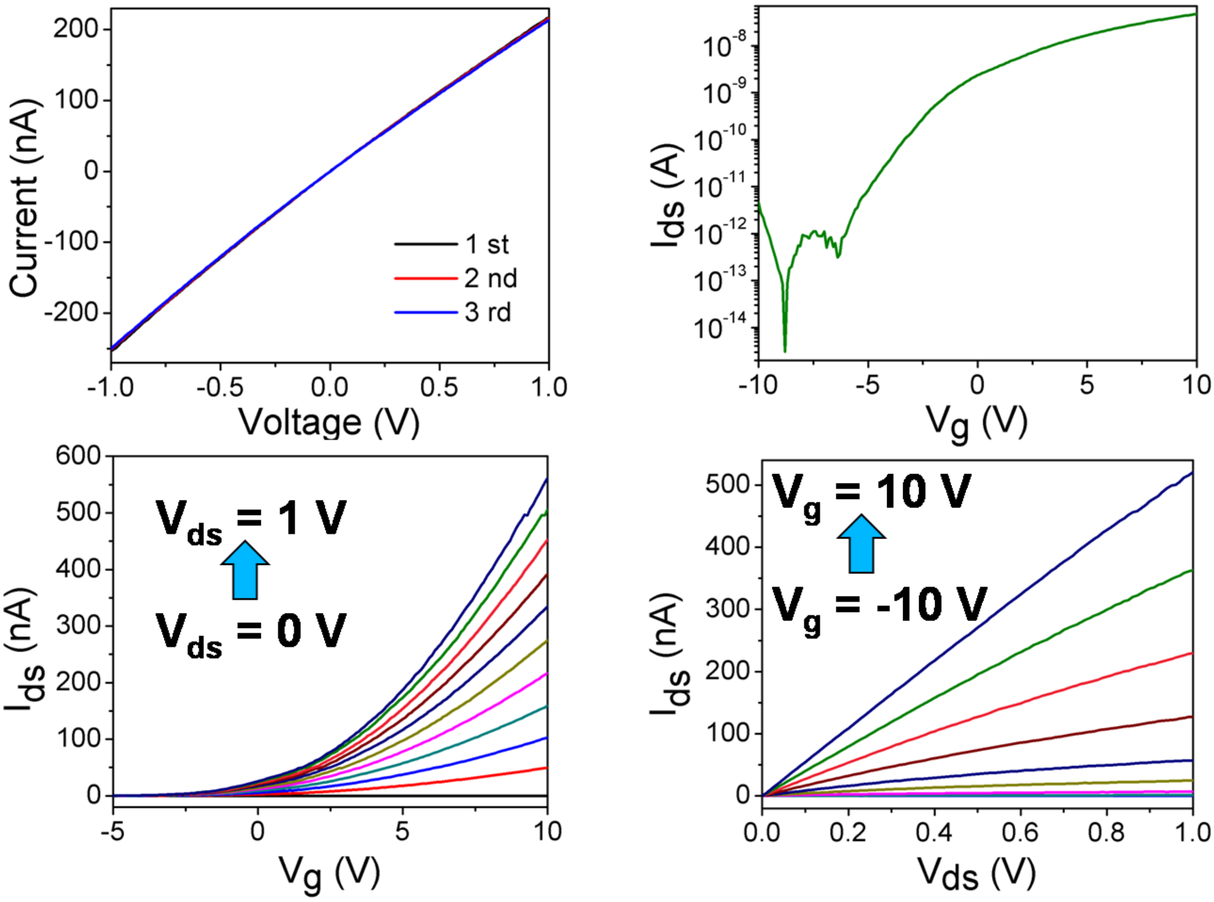

**Figure S5.** Electrical transport properties at ambient conditions of single layer $MoS_2$ FET devices based on PMMA/PVA transfer method. (a) Two probe measurements, (b) and (c) $I_{ds}$–$V_g$ transfer characteristics and (d) $I_{ds}$–$V_{ds}$ output characteristics.

To investigate the electrical properties of single layer $MoS_2$, we prepared typical $MoS_2$ FETs on a 100 nm thick $SiO_2$ layer on a heavily boron doped Si (p++ Si) substrate. The a-Si served as the back gate electrode. Figure S5d shows the drain current versus drain-source voltage ($I_{ds}$–$V_{ds}$) curves for a single layer $MoS_2$ FET. The conductance of $MoS_2$ increases monotonically as the gate potential increases from −10 V to +10 V, exhibiting a typical n-type $MoS_2$ FET behaviour. Figure S5c shows the drain current versus gate-source voltage ($I_{ds}$-$V_g$) curves obtained by sweeping the gate voltage continuously from −5 V to 10 V at drain voltages ranging from 0 to 1 V. The transconductance ($g_m$) and field effect electron mobility ($\mu_e$) of the back gate $MoS_2$ FETs were determined from the $I_{ds}$–$V_g$ curves using the following equations: $g_m = dI_{ds}/dV_g$ and $\mu_e = g_\mathrm{m}(L/W)(1/V_\mathrm{ds}C_\mathrm{ox})$. The gate oxide capacitance ($C_{ox}$) of a cylindrical wire on a planar substrate can be estimated by the relation $C_{ox} = \varepsilon_r\varepsilon_0 LW/t_{ux}$ using a relative dielectric constant value ($\varepsilon_r$) of 3.9, a $SiO_2$ gate dielectric layer thickness ($t_{ox}$) of 100 nm, a $MoS_2$ conducting channel length ($L$) of approximately 10 μm, and a width of approximately 20 μm. For n-type $MoS_2$ FETs on a $SiO_2$/Si substrate, a threshold voltage ($V_{th}$) of −6.5 V and a transconductance ($g_m$) of 83 nS were extrapolated from the linear region of the $I_{ds}$–$V_g$ curve at a value of 0.1 V for the $V_{Ds}$. The values of the field-effect electron mobility ($\mu_e$) and the resistivity ($\rho$) for $MoS_2$ were calculated from two-probe measurements and found to be 12 $cm^2\ V^{-1}\ s^{-1}$ and 0.21 Ω cm, respectively (Fig. S5a). Electron carrier concentration ($n_e$) was calculated to be $2.58 \times 10^{17}$ $e/cm^3$ using the equation, $n_e = C_{ox}V_{th}/e\pi r^2 L$. The sub-threshold swing given by $S.S = log\ [d\mathrm{V_g}/d\ (log\mathrm{I_{ds}})]$ was estimated to be 22 mV $dec^{-1}$.