Enhancing Graphene-metal Contact using Graphene Square Flake Array

Sandwich Structure

![Diagram of the sandwich structure process]

**Fig. S1.** Process of graphene transfer from copper foil to SiO$_2$/Si substrate

**Fig. S2.** I-V characterization of different lengths of graphene channels with GSF.

In Fig. S3, L was the length of graphene channel, W was the width of graphene channel, $R_s$ was sheet resistance, $R$ was resistance for the graphene length of L, $R_c$ was contact resistance, $d_T$ was the length of charge transfer region.
Before design of GSF contact structure, we have fabricated similar GSF contact structure in which the graphene channel we used is millimeter-size single-crystal CVD graphene island, and GSF is stack on single-crystal graphene of electrode area. On 100nm SiO2/Si substrate we fabricated two kinds of different three terminal devices of (a) without GSF, and (b) with GSF.

The back-gate Id-Vbg transfer curves on 100nm SiO2/Si of two kinds devices (W=5um, L=10um) are shown in Fig. S4 which was tested in air and room temperature. We use the equation (S1) to calculate carrier mobility $\mu$ and the calculated carrier mobility of two structures are listed in table S1, where $\frac{\Delta I_d}{\Delta V_{gs}}$ is the ratio of drain current and gate voltage, $\frac{L}{W}$ is the ratio of channel length and width, $C_{ox}$ is gate capacitance and $V_{ds}$ is the source-drain voltage. All the parameters can be extracted in the transfer characteristic.

$$
\mu = \frac{\Delta I_d}{\Delta V_{gs}} \cdot \frac{L}{W} \cdot \frac{1}{C_{ox} V_{ds}}
$$

(S1)
The decrease of contact resistance for with GSF contact graphene device would surely improve the performance of graphene device. The effect of GSF to the quality of graphene is only on the position of contacted area not the position of channel region. But the carrier mobility should be improved for GSF structure because of the smaller $R_c$ and larger $I_d$.

![Graph showing $I_d$ vs $V_{bg}$ for devices with and without GSF.](image)

Table S1. Carrier mobility of two structures

<table>
<thead>
<tr>
<th>Structure types</th>
<th>a-without GSF</th>
<th>b-with GSF</th>
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<td>Carrier mobility($\text{cm}^2/\text{Vs}$)</td>
<td>490.4</td>
<td>615.2</td>
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Fig. S5. Back-gate $I_d$-$V_{bg}$ transfer curve of devices without (a) and with (b) GSF.