

Supporting Information

Interfacial State and Fano-Feshbach Resonance in Graphene-Silicon Vertical Junction

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Hall bar structure for magneto-resistance and Hall measurement

In order to study the possibility of spontaneously magnetization due to interface effect, e.g. hydrogen adsorption, a Hall bar structure was fabricated in following steps. An intrinsic (100) silicon was treated with buffered hydrogen fluoride solution to remove the oxidation layer and form hydrogen passivation. Then a layer of graphene was quickly transferred to the hydrogen-passivated silicon surface and dried under inter gas environment. After that, a layer of Al₂O₃ was deposited onto the graphene top surface for protection followed by photo-lithography and etching processes to generate the Hall bar structure.

The metal electrodes are fabricated through conventional photolithography and metal deposition process. It is worth to mention that there is no Al₂O₃ left between graphene layer and metal electrodes, because a base solution (FM319, MicroChem Inc.) was applied for the pattern developing process, which removes the Al₂O₃ protection layer as well.

We assume that the tunneling rates to each of the energy levels of the interfacial trap state are the same ($\tau_i = A$), and the tunneling rate to the graphene is proportional to the density-of-states which linearly depends on the tunneling bias ($\tau_g = B\varepsilon$), the Equation (6) can be expressed as

$$q \approx \alpha \frac{A}{B\varepsilon} = \frac{\beta}{\varepsilon} \quad (\text{S1})$$

where A is a constant with a unit of time representing the tunneling rate through the discrete interfacial states, B is the coefficient for graphene tunneling rate linear dependence, and $\beta \equiv \frac{\alpha A}{B}$.

Combining Equation S1 and Equation 4, we get Equation (S2)

$$\sigma_n(\varepsilon) = \frac{\frac{\beta + \varepsilon - E_n}{\varepsilon} \frac{\Gamma}{\Gamma}}{1 + \left(\frac{\varepsilon - E_n}{\Gamma}\right)^2} \quad (\text{S2})$$

Combining all the resonant peaks corresponding to the discrete energy levels of the interfacial states and the linear baseline due to the direct tunneling to graphene, the entire spectrum can be described as

$$\sigma(\varepsilon) = \sum_n \frac{\frac{\beta + \varepsilon - E_n}{\varepsilon} \frac{\Gamma}{\Gamma}}{1 + \left(\frac{\varepsilon - E_n}{\Gamma}\right)^2} + \gamma\varepsilon \quad (\text{S3})$$

where β , Γ and γ can be determined by fitting the experimental spectrum, and the reciprocal of Γ is proportional to the lifetime of the interfacial state ($\Gamma = \left(\frac{1}{\tau}\right) \cdot \frac{h}{4\pi}$, where h is Planck constant).