# Quantum Dot Formation in Locally Doped Graphene Nano Ribbons

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Transport gap opens in graphene nanoribbons (GNRs) due to quantum confinement. Due to the unavoidable fabrication residue and edge roughness, the transport gap is not uniform [1]. By controlling the local chemical potential of the GNR, transport gap at specific positions may serve as tunnel barriers thus quantum dots are formed [2]. So far, controlling the tunnel barriers has been achieved by applying electrical field from local gates. Alternatively, it can be achieved through precisely doping GNRs. In this work, various doping features are introduced to different areas of GNRs from HSQ capping layer by changing the HSQ e-beam exposure conditions. Figure 1 (a) is the exposure profile to control the doping from HSQ mask. The large contact leads are weakly n-doped due to an exposure dose of 900 μC/cm$^2$, while the middle ribbon is exposed to a dose of 1800 μC/cm$^2$, leading to a heavy p-doping in graphene [3]. Importantly, a space of 8 nm is kept between leads and ribbon. Due to the proximity effect, the ends of GNR are not doped as strongly as the center. As a result, transport gaps at the ends of nanoribbon serve as tunnel barriers to form a hole dot. Figure 1 (b) is the SEM image of HSQ capped GNR, ribbon connects to leads despite the space in the design. Figure 1 (c) displays the back gate modulation of source-drain conductance ($G_{sd}$ - $V_{bg}$) measured at 300 K and 5 K in a 20 nm-wide, 75 nm-long GNR. At room temperature, two isolated charge neutrality points (CNPs) are found at $V_{bg}$ = 3 V and $V_{bg}$ = 19 V, indicating a weak p-doping feature in the leads and a heavy p-doping feature in the nano ribbon. At 5 K, $G_{sd}$ in the regime between CNPs is strongly suppressed, known as the transport gap, where carrier tunneling dominates the transport. Interestingly, the boundaries of transport gap at $V_{bg}$ = 2 V and $V_{bg}$ = 19 V are close to the CNPs found at room temperature, suggesting the transport gap is dominated by the doping but not the disordered fluctuation. Subsequently, pronounced single dot-like Coulomb diamonds are observed in devices with a width of 30 nm and a length of 75 nm. More detailed analysis will be presented at the conference.

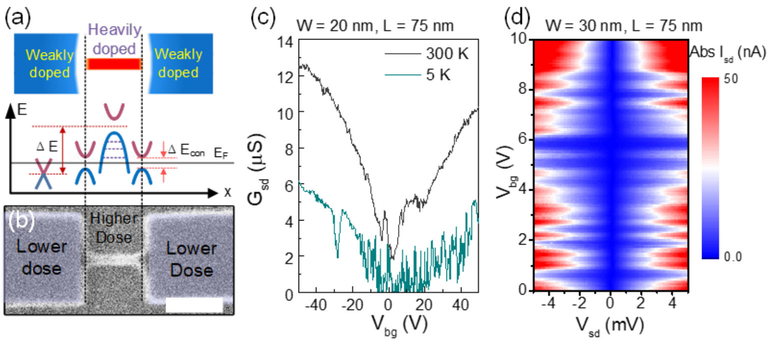


Fig 1. (a) Exposure profile of HSQ capping mask. Bottom is the potential landscape of locally doped GNR. (b) SEM image of a HSQ capped GNR. Scale bar is 100 nm (c) Back gate modulation of source-drain conductance ($G_{sd}$ - $V_{bg}$) at 300 K and 5 K measured in a 20 nm-wide 75 nm-long device. (d) Coulomb diamonds measured from a 30 nm-wide, 75 nm long locally doped GNR.

Reference:

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