Cavity-enhanced photo-thermoelectric effect in Landau-quantized graphene

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We demonstrate enhancement of photo-thermoelectric effect (PTE) of graphene in infrared (IR) region by using TiO_2/Au optical cavity. As shown in Fig. 1a, *h*-BN/graphene (Gr)/*h*-BN device with a graphite local gate was fabricated on TiO_2/Au/SiO_2/Si substrate (optical micrograph is shown in Fig. 1b). The TiO_2 and Au layers work as a dielectric and a mirror, respectively. The incident and reflected IR light exhibits constructive interference at the location of Gr (✪) to enhance its optical absorption. Photovoltage (V_{ph}) due to the PTE versus carrier density (n_e) of Gr tuned by a gate voltage V_G is shown in Fig. 1c (measured under irradiation of $\lambda = 9.25$ μm at $T = 2$ K). Comparing with the V_{ph} from the reference Gr device w/o cavity (Fig. 1d), larger V_{ph} signal was obtained in the device w/ cavity around $n_e \sim 0$. The amplitude of V_{ph} defined by arrows in Figs. 1c and 1d is plotted for various λ in Fig. 1e. The cavity-enhanced V_{ph} appears around $\lambda = 9.25$ μm having 60 times larger V_{ph} signal than the device w/o cavity. Experiment showed good agreement with calculated light intensity ($|E|^2/|E_0|^2$) from FDTD method indicated by solid and dashed lines in Fig. 1e. In a presence of magnetic field B, series of V_{ph} peaks are observed at cavity resonance condition of $\lambda = 9.25$ μm (Fig. 1f). The dominant peaks are due to cyclotron resonance (CR) transitions in monolayer Gr as indicated by T_3 to T_7 in Figs. 1f and 1g. This is evidence of cavity-enhanced CR. Further, we observed additional V_{ph} signals depicted by ▼ in between CR signals (Fig. 1f), which is due to cavity-enhanced cyclotron anti-resonance. These results demonstrate a coupled optoelectronic system between IR cavity and Landau-quantized graphene.

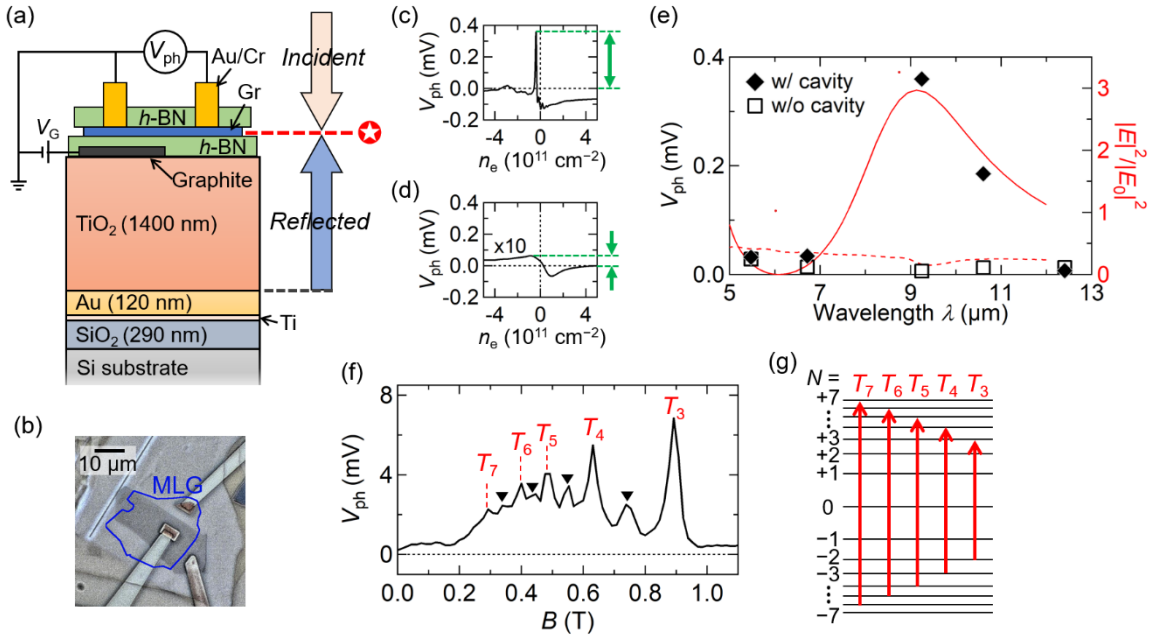

Fig. 1: (a) Device structure. (b) Optical micrograph. (c,d) V_{ph} data from the device (c) w/ cavity and (d) w/o cavity. (e) V_{ph} vs λ. (f) V_{ph} vs. B. (g) CR transitions in monolayer Gr.