Sheet and edge plasmonic modes in shaped graphene nanoresonators

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Plasmons in graphene nanoresonators have large application potential in photonics and optoelectronics, including tunable photodetectors, sensors, reflect-arrays or modulators. Their future efficient design will critically depend on the precise knowledge and control of the plasmonic modes. Particularly, highly confined edge modes have been predicted, which could benefit enhanced light-matter interactions and the performance of graphene-plasmonic devices. Here, we apply near-field nanoscopy (Fig. 1a) to analyze in real space, for the first time, plasmon modes in tailored disk and rectangular graphene nanoresonators at mid-infrared frequencies. The near-field images exhibit intriguing patterns and features (Fig. 1c), indicating the interference of manifold plasmon excitations. A simple model well reproduces the two-dimensional experimental patterns (Fig. 1d), allowing us for identifying edge and sheet modes, as well as for separating them either spatially or in energy. We also find that puzzling negative plasmonic image contrasts are governed by a spatially varying Fano-like interference between the near field of the probing tip and the graphene plasmons. We anticipate that real-space analysis of GPs could be of great benefit for the development and quality control of emerging graphene plasmonic technologies, particularly when novel design concepts and 2D material heterostructures have to be tested and verified. Further, we believe that the developed understanding of graphene-plasmonic near-field contrasts is broadly applicable to other 2D materials [1].

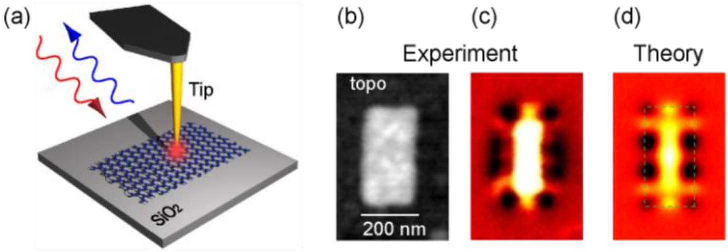

Figure 1: (a) The schematics of the concept of the experiment. A sharp metallic tip is illuminated by the external source. The strong near-field (hot spot) is created at the tip apex. The tip near-field apex excites the plasmons in the graphene rectangle. The tip is scanned above the rectangle and the scattered signal (proportional to the near-field of the plasmon) is recorded as a tip position. (b) Topography of the graphene rectangle. (c) Experimental near-field image of the graphene rectangle. (d) Simulation of the near-field image of the graphene rectangle.

References

[1] A. Y. Nikitin et al, Nat. Photon. 10 (2016), 239.