Extreme Vertical Optical Confinement of Graphene Plasmons Using Metal Nanoribbon Arrays

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Graphene plasmons have been intensively studied thanks to their gate-tunability and extreme light confinement in applications such as molecular sensing[1]. Nevertheless, graphene plasmons have been observed in far-field experiments by nano-patterning it or using a dielectric grating[2].

Here we show a novel hybrid graphene - dielectric spacer - metal structure that allows for efficient coupling to Mid-infrared light while increasing graphene plasmons vertical confinement. Concept schematics of transmission measurement and FDTD simulation with efficient excitation of high order plasmon resonance are shown in Figure 1.

Reduction of the plasmon wavelength occurs under the metal due to screening of long-range Coulomb interactions as reported in recently near-field THz experiments in the form of acoustic Dirac plamons[3]. This effect gives rise to novel resonant modes with confined electric field between metal and graphene and extreme reduction of the plasmon volume close to the molecular level (see Figure 2).

This platform, due to the extreme field confinement, allows for enhanced light-matter interaction in the Mid-infrared range, paving the way for applications in sensing, photodetection and non-linear optics.

References

[1] D. Rodrigo et al, Science, 622 (2015), 165-168.
[2] W. Gao et al, Nano Lett., 13 (2013), 3698-3702.
[3] P. Alonso-González et al, Nature Nanotechnology, 12 (2017), 31-35.
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Figures

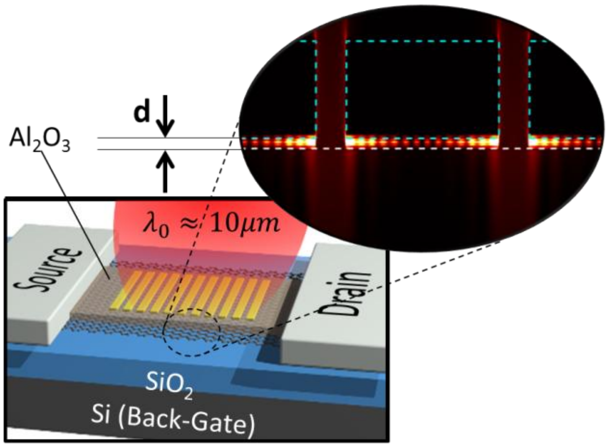

Figure 1: Device schematics including electrical and optical components. Bubble showing field amplitude of a high order resonance mainly confined between metal and graphene.

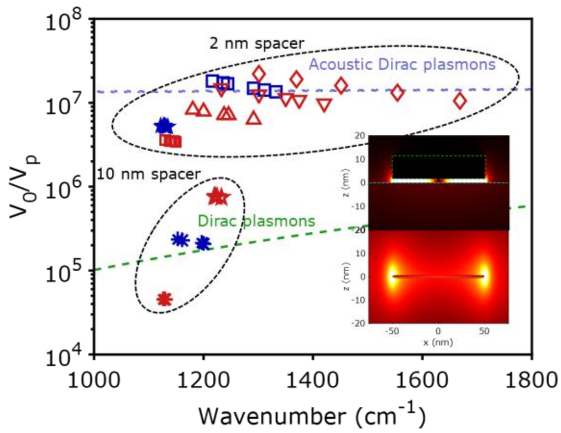

Figure 2: Experimental acoustic plasmon volume extracted from FTIR transmission compared to analytical Dirac plasmons (green dashed). Field amplitude for acoustic plasmon (top inset) and graphene nanoribbon (bottom inset) showing field confinement under the metal.