Surface-enhanced infrared spectroscopy with graphene plasmon

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Far-field mid-infrared spectroscopy has an increasingly important role for numerous applications (for example, chemical detection, food safety and biosensing) through directly probing vibrational characteristics of a broad range of molecular species and compounds. However, molecular fingerprinting at the nanoscale level still remains a significant challenge, due to weak light-matter interaction between micron-wavelengthed infrared light and nano-sized molecules.

Surface-enhanced infrared absorption (SEIRA) has been shown to significantly increase the detection sensitivity in the IR up to several orders of magnitude via enhanced light-matter interactions assisted by surface-plasmon polaritons [1]. Graphene plasmon is a promising candidate for SEIRA due to its ultrahigh field confinement and electrical tunability.

We have demonstrated molecular fingerprinting at the nanoscale level using our specially designed graphene plasmonic structure on CaF_2 nanofilm, as shown in Fig. 1a. This structure not only avoids the plasmon-phonon hybridization, but also provides in situ electrically-tunable graphene plasmon covering the entire molecular fingerprint region, which was previously unattainable [2]. The vibrational signatures of ~ 8 nm thick PEO film are enhanced more than 20-fold (Fig. 1b). In addition, undisturbed and highly confined graphene plasmon offers simultaneous detection of in-plane and out-of-plane vibrational modes with ultrahigh detection sensitivity down to the sub-monolayer level, significantly pushing the current detection limit of far-field mid-infrared spectroscopies.

Furthermore, by designing graphene plasmonic structures to introduce Fano resonance or metallic integrating structures, the sensitivity of SEIRA can be further improved [3,4]. Our results provide a platform for the fingerprint detection of nano-scale molecules.

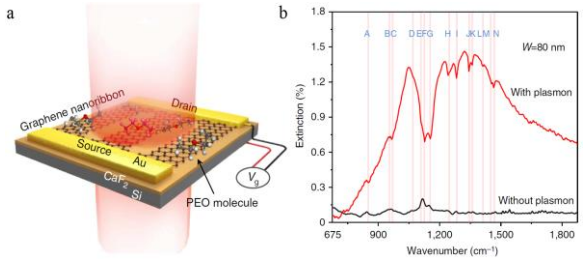

Fig.1 (a) Schematic of the graphene plasmon-based sensor. (b**)** A comparison of the sensing results for an 8-nm-thick PEO film with and without graphene plasmon.

References

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