Gas identification with graphene plasmons

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In the present study, we identified gas molecules using graphene plasmons. The rotational-vibrational modes of gas molecules of NO_2, N_2O, NO, and SO_2, which are generally important in environmental and military monitoring applications, as well as in medical diagnostics are unambiguously detected and identified using the designed graphene nanostructures. We attribute this to the great adsorptive capacity to redistribute the gas molecules to the graphene surface (equivalent to amplifying the gas concentration), hence facilitating the interaction between ultra-confined graphene plasmons and gas molecules. Our theoretical analysis reveals that the adsorbed gas layer (about 800 zeptomole molecule per μm^2 for < 1 nm thickness) on the graphene structure, in conjunction with the strong field confinement, is critical to effectively detecting and identifying gas molecules. In addition, our graphene plasmonic sensors also successfully performed real-time monitoring of gas molecules during chemical reactions with a fast response time (< 1 min).

References

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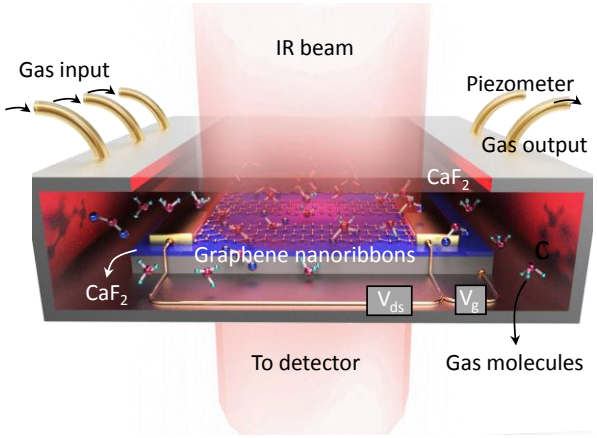

Figure 1: Experimental scheme of our device. A metal chamber with a piezometer was used for precise control of gas parameters. Plasmons in a graphene ribbon array were excited using an incident infrared beam and tuned in situ by electrostatic doping through a gate voltage (Vg). The plasmon resonances were coupled with molecular excitations, thus probing the rotational-vibrational spectral fingerprints of gas molecules.

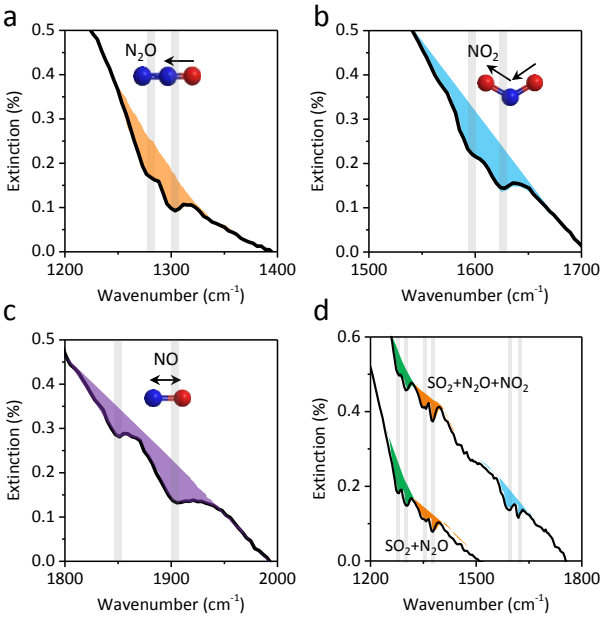

Figure 2: (a-c) Extinction spectra of graphene in the presence of N_2O, NO_2, and NO, respectively. The rotational-vibrational modes are marked with vertical lines. **(d)** Extinction spectra of graphene in the presence of two gas mixtures, one consisting of SO_2 and N_2O, and the other of SO_2, N_2O and NO_2. The graphene ribbon widths in a-c were 80, 60, and 40 nm, respectively, with a filling factor of 90%, δVCNP of 30 V, and concentration of N_2O of 8000 ppm, and NO_2 and NO of 4000 ppm at 1 atm.