Study of optical anisotropy property to rapidly characterize structural qualities of CVD prepared graphene films

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Graphene's sp^2-hydridized carbon atoms are packed in a honeycomb-like crystal lattice, forming a near-ideal flat two-dimensional nanostructure, with potentially attractive properties for device integration. We develop an angle-variable spectroscopic method to rapidly determine the optical anisotropy of graphene films. In this study, we employed optical anisotropy properties to characterize large-area, CVD-prepared single-layer graphene. Without the need for high-intensity laser irradiation or complicated optical setups, we readily measured and calculated the optical anisotropy rapidly to characterize the structural qualities of large-area graphene samples prepared under various conditions.

As displayed in Figure 1a, we could determine the optical anisotropy of these two-dimensional materials by measuring the transmission and reflection spectra for transverse electric (TE) and transverse magnetic (TM) polarized light at different incident angles. Here, we define the TE-polarized light as the direction of the electric field being perpendicular to the incident plane and parallels to the plane of the graphene surface at any incident angle. The TM-polarized light is defined as electric field parallel to the incident plane. Figures 1b displays the difference in absorption coefficients of one-layer CVD-prepared graphene film between the TE- and TM-polarized lights from 20 to 60°. Thus, the absorption coefficients of the graphene layer depended strongly on the direction of the polarized light, resulting in different absorption coefficients for different polarizations. To have a clear expression of the anisotropic absorption for a graphene layer, we define the ratio of absorption coefficients between the TE- and TM-polarized lights (α_{TE}/α_{TM}) as the optical anisotropy for CVD-prepared graphene films at different incident angles. As displayed in Figure 1c, the optical anisotropy (α_{TE}/α_{TM}) of the one-layer graphene film in the visible regime increased from approximately 1.2 to 2.5 when the incident angle increased from 20° to 60°. To investigate the correlation between the optical anisotropy and the structural quality of the graphene, we compared the D band-to-G band ratios from the Raman scattering spectra with the optical anisotropy in Figure 1d. Measurements of optical anisotropy also allow us to distinguish graphene samples with different extents of structural imperfections; the results are consistent with those obtained from using Raman spectroscopy.

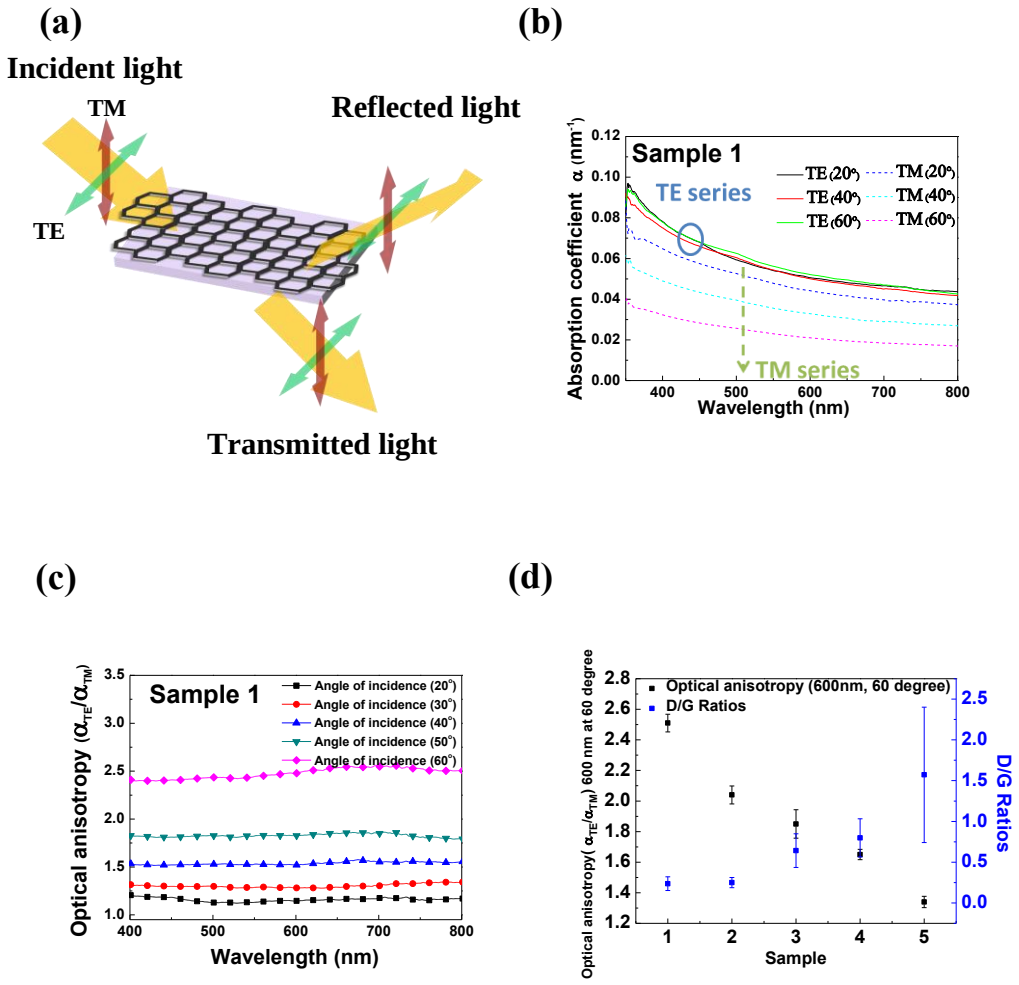

Figure 1: (a) Schematic representation of angle-variable reflectance and transmittance under different types of polarized light. (b) Absorption coefficients under different types of polarization at different incident angles. (c) Optical anisotropy of CVD-grown one-layer graphene film in the visible regime. (d) Correlation between the optical anisotropy (600nm for 60 degree) and the D band-to-G band ratios from Raman scattering spectra.