Terahertz Optical Modes of Supported Graphene Bilayer

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The peculiar and promising thermal properties of graphene are strongly influenced by interactions with the substrate, presence of defects and lattice distortions. At low temperature, thermal capacity and conduction are mainly related to the properties, i.e. dispersion and density of states, of the acustic modes. The ability to tune these modes can therefore open the way to a fine control on the thermal properties of graphene-based systems, through the so-called phonon engineering [1]. Moreover, ultra-low frequency vibrations could have interesting applications such as the design of novel electromechanical nanoresonators operating in the THz range [2].

In this work, we investigate by HREELS the vibrational properties of a graphene bilayer, grown on the Ru(1000) surface (BLG@Ru) [3], unraveling the details of phonon dispersions in the THz region.
As shown in the inset of Fig. 1 a typical HREEL spectrum is built by several peaks, observed in both loss and gain sides. Spectra are fitted with a sum of gain-loss Voigt doublets, thus allowing a precise determination of the peak energy.

In Fig.1 the dispersion curves are shown and compared with the theoretical dispersion of the freestanding bilayer of graphene (BLG)[4]. In the BLG case, the ZA branch splits, giving origin to the optical mode ZO', i.e. a breathing mode of the two layers [4,5]. Moreover, the TA and LA modes are expected to give origin to an optical ultra-low frequency shear mode [6,7]. Instead, in the case of BLG@Ru, we observe two such modes located at 12.5 and 8.2 meV due to the presence of the substrate. A possible role of the Moiré-derived corrugation is also envisaged. Indeed, also the higher-energy ZO mode is splitted (107 and 88 meV). Another non-dispersing mode is observed near the Γ point, at 4.7 meV. A similar one was also observed in the single layer graphene grown on Ru(0001) [8]. Its origin is still not clear, but we tentatively attributed to an interlayer shear mode, originated from TA/LA [5,6]. The possible origin of its localized nature will be discussed.

References

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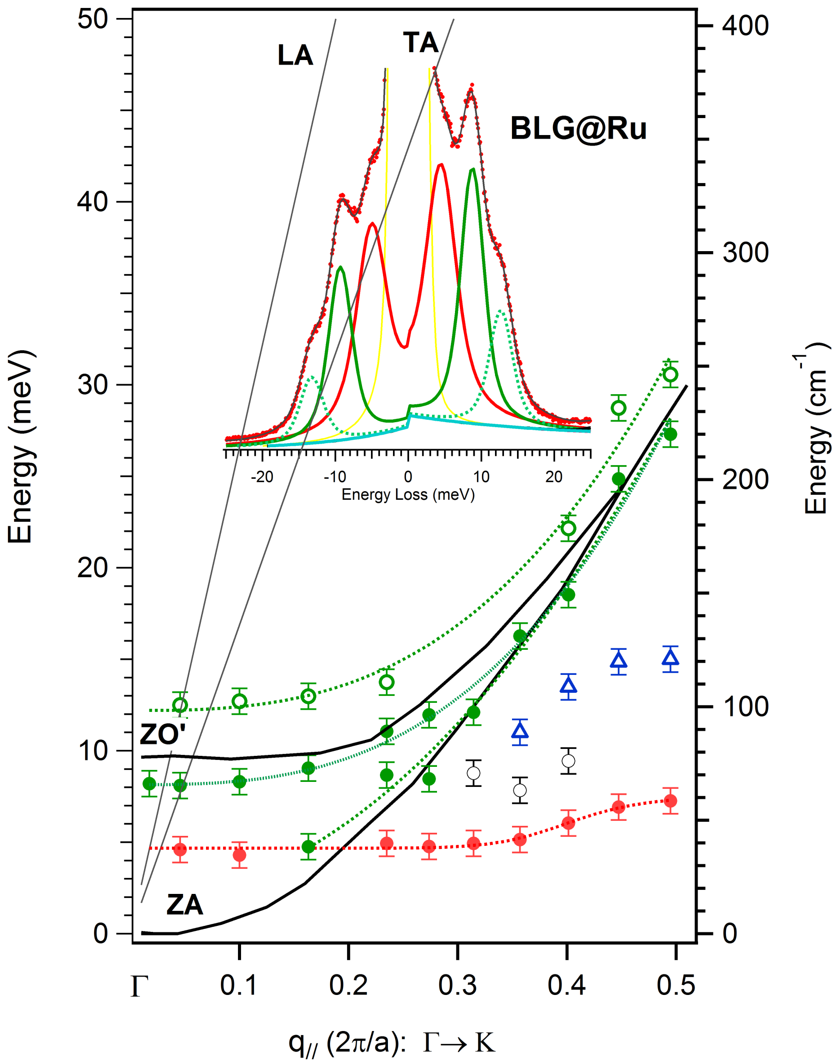

Figure 1: The measured dispersion curves of the BLG@Ru. The black solid lines represent the theoretical dispersion for the freestanding bilayer of graphene [4]. The inset shows a typical HREELS spectrum together with fitting curves.