Tunable electronic structure of few-layer graphene with pressure

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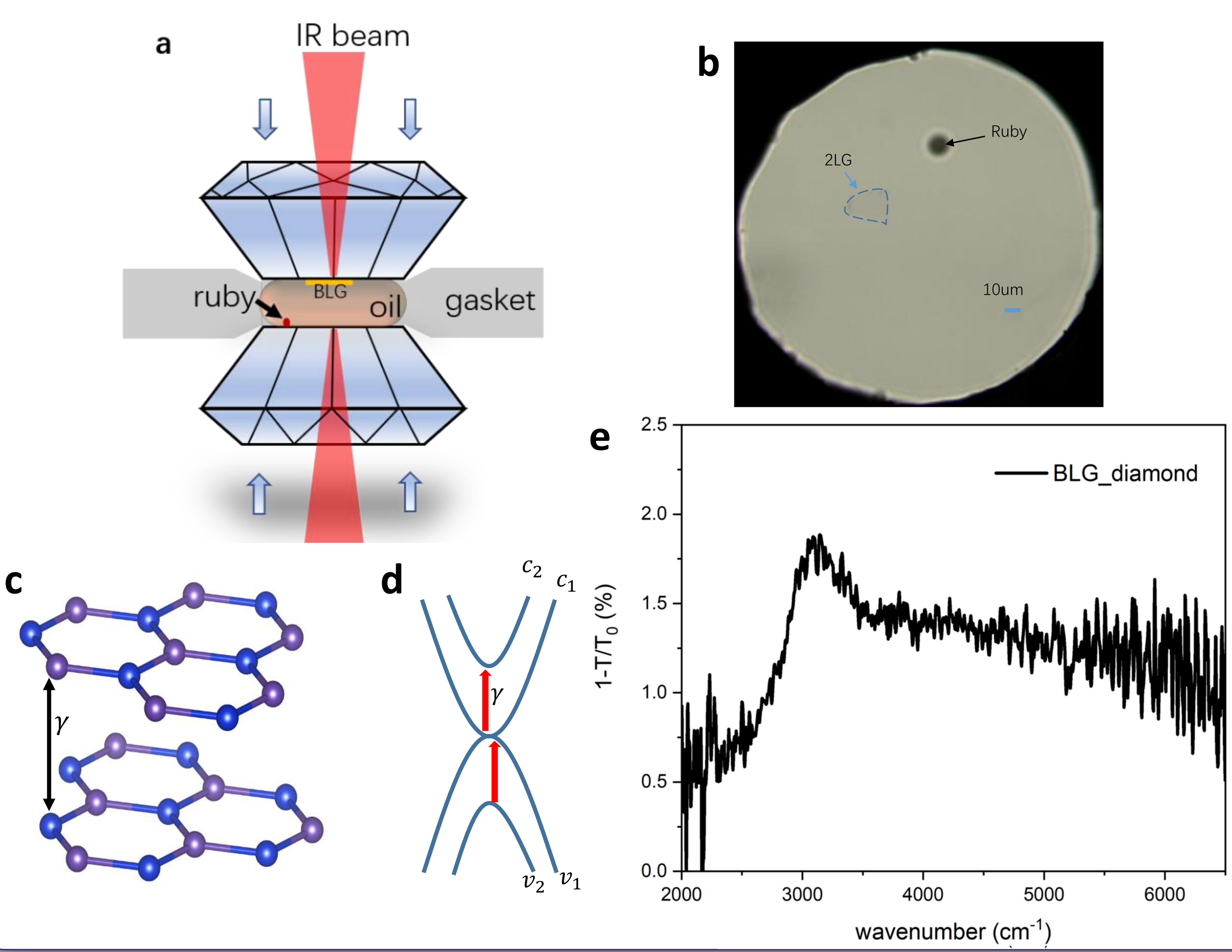
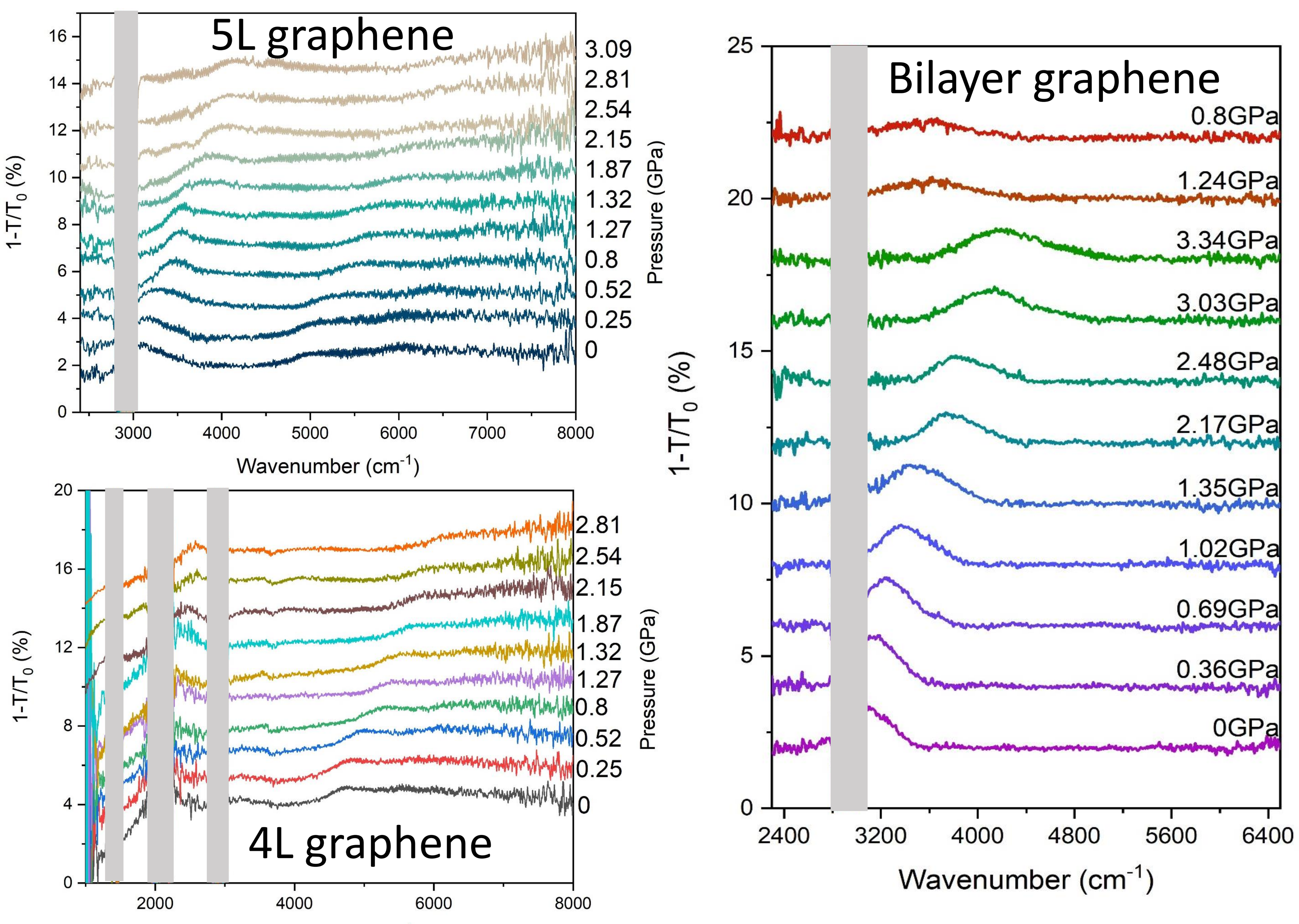
Introduction

The superior physical properties of graphene make it a promising material. Recently, there is an alternative approach of tuning the interlayer interaction of few layer graphene with pressure to modulate the electronic structure. However, the pressure-induced infrared responses of few layer graphene have not been reported experimentally to date. Here, we investigate the pressure effect on the band structure of 2L-8L graphene with ABA-stacked in a diamond anvil cell(DAC) through Fourier transform infrared spectroscopy. The pressure effect on the electronic structure of few-layer graphene can be explained by the tight-binding model in conjunction with a Morse potential. Our study paves a way for van der Waals engineering of few-layer graphene.

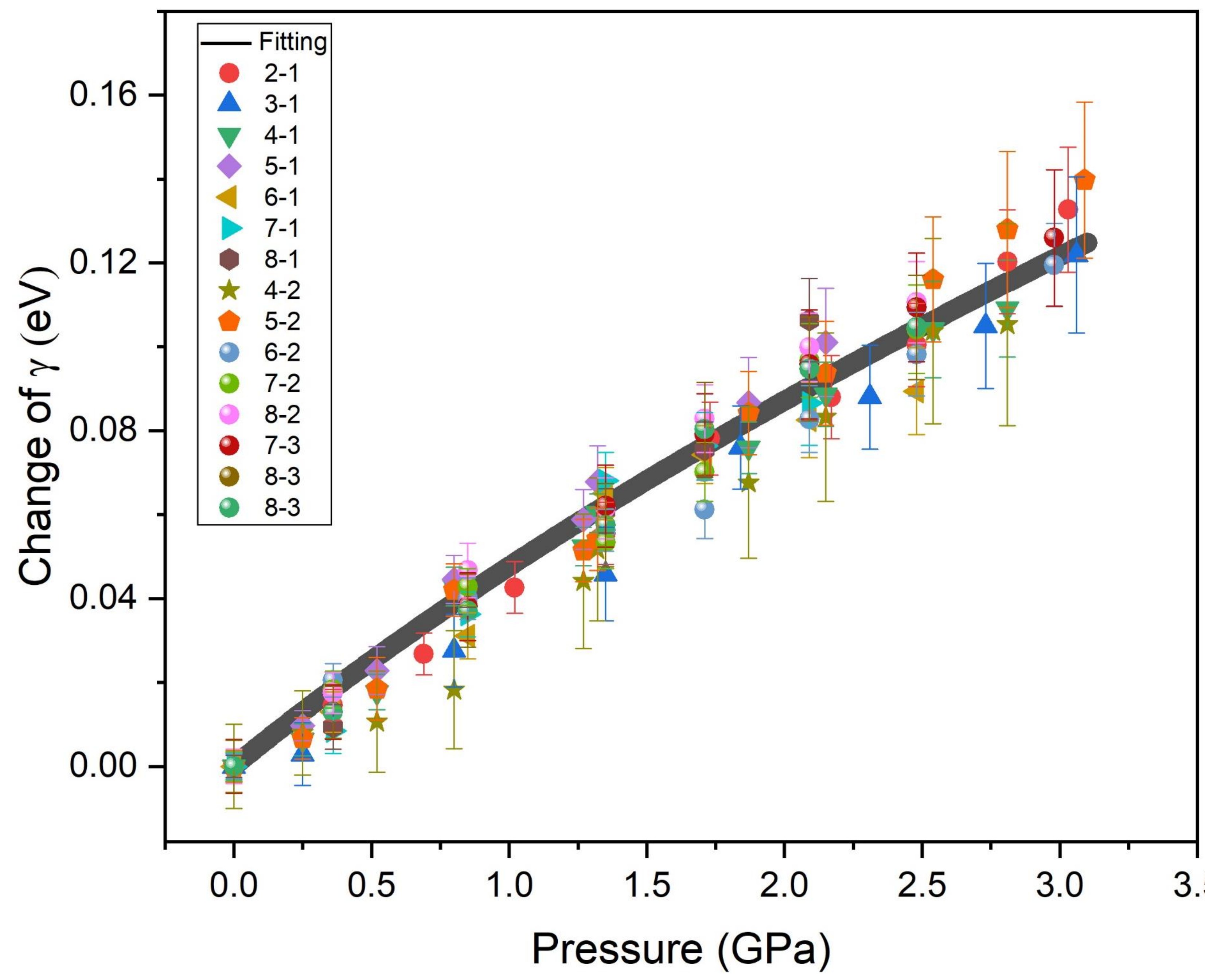
Optical characterization of bilayer graphene in DAC



Evolution of the band structure of graphene



Layer-dependent pressure effect on graphene



- Layer-dependent optical transition energy of graphene:

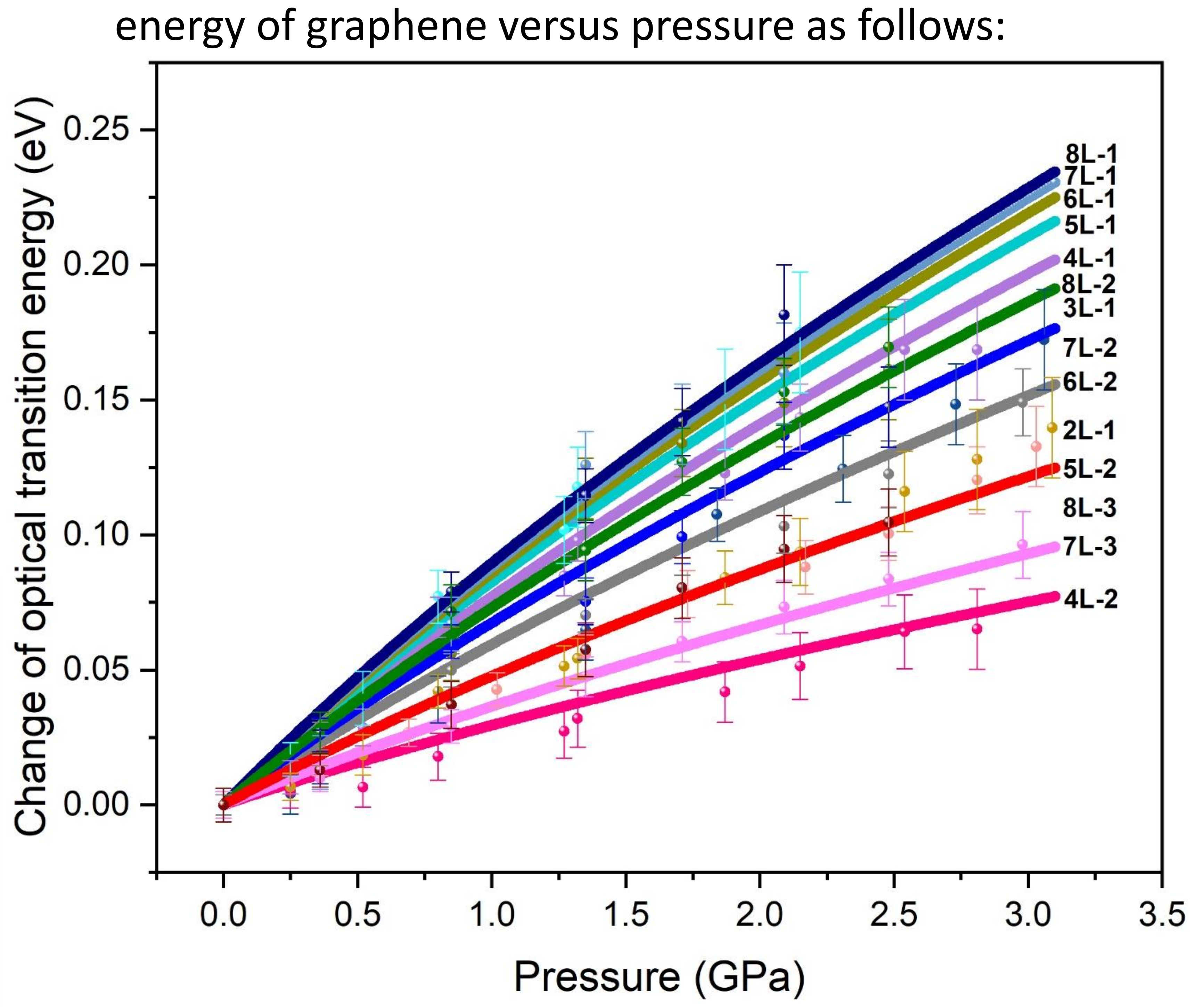
$$E(P) = 2\gamma(P)\cdot\cos\left(\frac{n\pi}{N+1}\right)$$

According to the Morse potential, the interlayer coupling strength $\gamma(P)$ can be given by

$$\gamma(P) = \frac{\gamma_0}{2}\left(1+\sqrt{1+P/P_{coh}}\right)$$

where γ_0 is interlayer coupling strength under 0GPa, P_{coh} is obtained as 1.74GPa through fitting datas.

- The relative changes of layer-dependent optical transition energy of graphene versus pressure as follows:



Conclusion

We investigated the evolution of pressure-induced electronic structures of 2L-8L graphene experimentally in detail. In order to quantify evolution of optical transition energy with pressure, the tight-binding model and the Morse potential are applied. Our study revealed that with increasing pressure, the interlayer coupling of graphene is enhanced, the correspond optical transition energy can increase ~22% up to 3GPa for 8LG.

Reference:
Lei Mu, Shenyang Huang, Qiaoxia Xing, Chong Wang, Yanlin Mou, Yuchen Lei, Yuangang Xie, Jiasheng Zhang, Junwei Ma, Yixuan Ma and Hugen Yan*, in publishing
Shenyang Huang, Yang Lu, Fanjie Wang, Yuchen Lei, Chaoyu Song, Jiasheng Zhang, Qiaoxia Xing, Chong Wang, Yuangang Xie, Lei Mu, Guowei Zhang, Hao Yan, Bin Chen and Hugen Yan*, Phys. Rev. Lett. 127, 186401(2021).