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TERS with in situ mechanical loading for nanoscale stress probing in suspended graphene

Tip-enhanced Raman spectroscopy (TERS) provides nanoscale chemical information,^[1] while tip–sample interaction can also generate highly localized mechanical forces. However, using a TERS tip to simultaneously apply force and monitor the resulting Raman response remains largely unexplored. Here, suspended monolayer graphene is used as a strain-sensitive model system under controlled tip loading. By varying the applied force up to 150 nN, we observe force-dependent redshifts of the G and 2D bands, consistent with strain-induced lattice deformation beneath the tip. Based on the established Raman response of graphene to strain,^[2] the local strain and stress are estimated, with tip-induced stress reaching the GPa regime. This demonstrates the feasibility of simultaneously inducing local stress and probing its vibrational response with TERS. Such GPa-level stresses are relevant to nanoconfined systems, where pressure can induce structural transformations such as clathrate hydrate formation.^[3] This work provides a basis for future TERS studies of pressure-driven processes in nanoporous systems.

References

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Figures

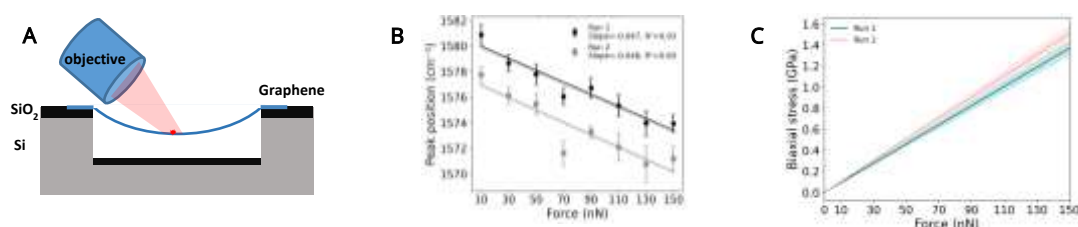


Figure 1: (A) Side-illumination TERS configuration for force-dependent measurements on suspended graphene. (B) Force-dependent G-band shift from two independent measurements. (C) Estimated biaxial stress versus applied force.