Controlling friction energy dissipation by ultrafast interlayer electron-phonon coupling in WS_2/graphene heterostructures

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Abstract Electrons and phonons are regarded as the microscopic carriers of friction energy dissipation and their coupling is a typical dissipation mode. However, due to the lack of ultrafast detection technic, the friction mechanism about electron-phonon coupling remains unexplained. Here, using high resolution non-contact atomic force microscopy and femtosecond transient absorption spectroscopy, we find that interlayer electron-phonon coupling dissipation channel in WS_2/graphene heterostructures can be opened by defects. This is because defects provide a recoil-momentum which satisfies the requirement of momentum conservation between electrons in WS_2 and acoustic phonons in graphene and interlayer electron-phonon coupling occurs. Besides, the electron-phonon scattering time is accelerated from 2.4 ps to 1.1 ps. The enhanced electron-phonon coupling leads to significant energy dissipation. We further quantitatively model the friction Γ with dissipation rate τ^{-1} as $\Gamma = 2.75 \times 10^{-17}\,\tau^{-1}$ to control the friction energy dissipation by ultrafast interlayer electron-phonon coupling. This work provides a new way to understand the mechanism of electron-phonon coupling in friction.

Keywords

interlayer electron-phonon coupling; non-contact friction energy dissipation; ultrafast spectroscopy.