Abstract
Understanding of electron–phonon coupling (EPC) in two-dimensional (2D) materials manifesting as phonon renormalization is essential to their possible applications in nanoelectronics. Here we report in situ Raman measurements of electrochemically top-gated 2, 3 and 7 layered 2H-MoTe$_2$ channel based field-effect transistors. While the E$_{2g}^1$ and B$_{2g}$ phonon modes exhibit frequency softening and linewidth broadening with hole doping concentration ($p$) up to $\sim 2.3 \times 10^{13}$/cm$^2$, A$_{1g}$ shows relatively small frequency hardening and linewidth sharpening. The dependence of frequency renormalization of the E$_{2g}^1$ mode on the number of layers in these 2D crystals confirms that hole doping occurs primarily in the top two layers, in agreement with recent predictions. We present first-principles density functional theory analysis of bilayer MoTe$_2$ that qualitatively captures our observations, and explain that a relatively stronger coupling of holes with E$_{2g}^1$ or B$_{2g}$ modes as compared with the A$_{1g}$ mode originates from the in-plane orbital character and symmetry of the states at valence band maximum. The contrast between the manifestation of EPC in monolayer MoS$_2$ and those observed here in a few-layered MoTe$_2$ demonstrates the role of the symmetry of phonons and electronic states in determining the EPC in these isostructural systems.