Raman shifts and in situ TEM electrical degradation of electron-irradiated monolayer MoS$_2$.\(^1\) WILLIAM M. PARKIN, ADRIAN BALAN, Univ of Pennsylvania, LIANGBO LIANG, Rensselaer Polytechnic Institute, PAUL MASH DAS, Univ of Pennsylvania, MICHAEL LAMPARSKI, Rensselaer Polytechnic Institute, CARL NAYLOR, JULIO A. RODRIGUEZ-MANZO, ALAN T. JOHNSON, Univ of Pennsylvania, VINCENT MEUNIER, Rensselaer Polytechnic Institute, MARIJA DRNDIC, Univ of Pennsylvania — We report how the presence of electron-beam-induced vacancies affects first-order Raman modes and correlate this effect with the evolution of in situ TEM two-terminal conductivity of monolayer MoS$_2$ under electron irradiation. We observe a redshift in the E$'$ Raman peak and a less pronounced blueshift in the A$'$_1 peak with increasing electron dose. Using energy-dispersive X-ray spectroscopy, we show that irradiation causes partial removal of sulfur and correlate the dependence of the Raman peak shifts with S vacancy density (a few percent), which is confirmed by first-principles density functional theory calculations. In situ device current measurements show exponential decrease in channel current upon irradiation. Our analysis demonstrates that the observed frequency shifts are intrinsic properties of the defective systems and that Raman spectroscopy can be used as a quantitative diagnostic tool to accurately characterize MoS$_2$-based transport channels.

\(^1\)This work was supported by the NIH Grant R21HG004767 and NIH Grant R21HG007856. Theoretical work at RPI was supported the NYSTAR program C080117 and the Office of Naval Research. C.H.N. and A.T.C.J. acknowledge support from UES/Air Force Research Lab.

William Parkin
Univ of Pennsylvania

Date submitted: 06 Nov 2015

Electronic form version 1.4