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Temperature Dependent Optical Spectroscopy of Defect States in Monolayer Molybdenum Disulphide Field Effect Transistors CHANGJIAN ZHANG, HAINING WANG, WEI MIN CHAN, SANDIP TIWARI, FARHAN RANA, Cornell University — Understanding the properties of defects is critical for improving 2D metal dichalcogenide materials and devices, yet little work in this field has been reported. We present optical spectroscopy (photoluminescence and absorption) studies of defects states in monolayer MoS2 field effect devices at different temperature. At low temperatures, a very large defect peak around $\sim$ 1.7 eV is seen in the PL spectra but not in the absorption spectra. The PL intensity decreases exponentially with temperature and vanishes when the temperature exceeds $\sim$ 150K. The PL quantum efficiency becomes extremely large when a negative gate bias is applied. Our data suggests the presence of both bright and dark defect states that contribute to recombination, and that the occupation of these defect states is accompanied by lattice distortions. The competition in the recombination process between these two kinds of defect states explains the temperature dependence as well as the gate bias dependence of our data. We find that, occupation of the dark defect states is thermally activated and their occupation quenches the PL from the bright defects. We attribute the defect states to originate from sulfur or molybdenum vacancies or to the presence of oxygen atoms.

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