On-demand single photon emission from TMD/μ-LED hybrid device

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Transition metal dichalcogenides are a particularly good host for naturally created or strain-engineered single-photon emission centers [1, 2]. Logically, this also provokes pertinent efforts to exploit the 2D semiconductors in designing and fabricating new opto-electronic devices of possible practical use. By extent, the operation of such devices requires direct electrical control. Controlled doping of TMD materials, though essential for the operation of conventional electroluminescent p-n diodes, remains a largely unresolved challenge [3]. Alternative methods are thus being developed that mostly rely on tunnelling mechanisms of carrier injection into the active areas of semiconductor layers. However, the complexity of manufacturing and the performance of such structures still remain not fully satisfying, especially in the context of potential industrial use. We propose a new concept of a compact pseudo-electroluminescent device by integrating the exfoliated WSe2 monolayer on top of the micro-(In,Ga)N-LEDs (μ-LEDs). We utilize the nanostructured surface of the μ-LEDs to deterministically create single-photon emitting centers. We show that μ-LEDs are a suitable excitation source for single-photon emitters based on atomically thin TMDs. The light emission from μ-LEDs is robust at liquid-helium temperatures which are preferential conditions for single-photon generation from TMD monolayers. Very low activation currents of the μ-LEDs facilitate broad-range tuning of the excitation intensity. We show that the ultrafast electric current modulation can be applied to the μ-LEDs, resulting in single nanosecond light pulses. With several times longer characteristic decay times of the WSe_2 single-photon emitters, our pseudo-electroluminescence hybrid device is capable of true on-demand single photon emission.

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