Vertical Architecture for Black Phosphorus Mid-Infrared Light-Emitting Diodes.

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Black phosphorus (BP) is a 2D semiconductor demonstrating very interesting properties such as a tunable direct band gap down to the mid-infrared and excellent carrier mobility. Recently, bulk black phosphorus has been used as an active material for mid-infrared light-emitting diodes (MIR-LEDs). However, in most cases, contacts are directly fabricated on the semiconductor flakes using a combination of electron beam lithography (EBL) and metal deposition [1] [2]. On top of being time consuming and costly, this fabrication method imposes that the current flows horizontally through the device which seriously impedes its performance owing to the high sheet resistance of 2D semiconductors. The bias required for sufficient IR light emission from these LEDs results in extremely high current densities flowing laterally though the BP flakes which can seriously degrade the material, especially in the presence of water and oxygen. Here, we demonstrate a vertical MIR-LED architecture using a MoS2-BP PN junction. The BP flakes are mechanically transferred on a thick MoS2 flake sitting on top of a pre-patterned gold contact removing the need for EBL. The thick MoS2/gold structure acts as a weak microcavity enhancing the MIR light emission of BP. Finally, a thin graphite flake is used as a transparent top electrode. These vertical devices can support current in the order of milliamps while keeping the current density in BP relatively low and showing high MIR light emission. These structures are a promising step towards the fabrication of a BP electrically pumped VCSEL.

References

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