Inteferometric investigation of suspended monolayer TMDCs enabled by e-beam lithography

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The discovery of graphene has spearheaded research in two dimensional materials to unveil their unique electromechanical, chemical and optical properties. Beyond graphene, transition metal dichalcogenides (TMDCs) is another family of 2D materials that gained tremendous attention in recent years. TMDCs such as MoS_2, WS_2, and $MoSe_2$ have been studied and demonstrated interesting properties in their monolayer form such as possessing intrinsic sizable band gap and piezoelectricity. Nanofabrication techniques that became more and more accessible is the key to realizing experimental studies of low dimensional materials such as TMDCs. Techniques such as e-beam lithography, photolithography and focused ion beam have enabled design and implementation of devices down to the nanoscale for investigations of 2D materials. Here, we are reporting the methods adopted to study suspended monolayer TMDCs. In the first design, utilizing e-beam lithography, a PMMA/HSQ 2-layer lithography process was selected to allow construction of electrodes and support, which enables fabrication of devices with suspended TMDCs between electrodes. The separation between suspended flake and the bottom substrate serves as the Fabry-Perot cavity used by the custom-built interferometer. Furthermore, with e-beam lithography and photolithography, chips with a second design of interdigitated electrodes are fabricated. With the help of a PMMA based 2D material transfer method, large number of suspended TMDC resonators can be assembled on such chips to scale up research on suspended TMDCs. Devices outlined here have vast implications in the field of NEMS, material science and electronics as they enable exotic experiments to study TMDCs' fundamental properties such as piezoelectricity and resonator behaviors, all in a contact-less manner.