Monolayer WS_2 nanopores for DNA translocation with light-adjustable diameters

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Abstract

Two-dimensional materials are promising for a range of novel applications, as well as attractive testbeds for probing the physics of low-dimensional systems. Tungsten disulfide (WS_2) monolayers exhibit a direct bandgap and strong photoluminescence (PL) in the visible range, opening possibilities for advanced optoelectronic applications. Here we report the realization of two-dimensional nanometer size pores in suspended monolayer WS_2 membranes, allowing for electrical and optical response in ionic current measurements. A focused electron beam was used to fabricate nanopores in WS_2 membranes suspended on silicon-based chips and characterized using PL spectroscopy and aberration-corrected high-resolution scanning transmission electron microscopy (AC-HRSTEM). It was observed that the PL intensity of suspended WS_2 monolayers is ~10-15 times stronger when compared to substrate-supported monolayers, and low dose scanning transmission electron microscope (STEM) viewing and drilling preserves the PL signal of WS_2 around the pore. We establish that such nanopores allow ionic conductance and DNA translocations. We also demonstrate that under low-power laser illumination in solution, WS_2 nanopores grow slowly in size at an effective rate of ~0.2-0.4 nm/s, thus providing new possibilities for atomically-controlled nanopore size using short light pulses.

Figures

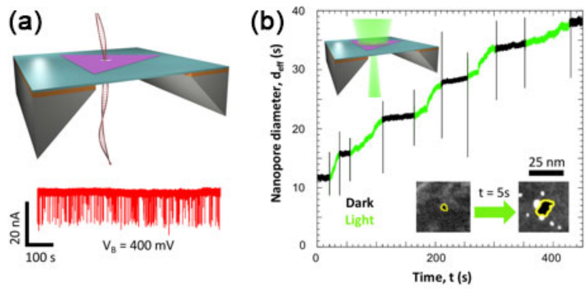

Figure 1. (a) WS_2 nanopore device illustrating translocation of DNA through the nanopore under a voltage bias across the membrane. (b) Ionic current signal at bias voltage of 400 mV showing DNA translocations as reductions in ionic current. (b-inset) Change in diameter of nanopore due to laser illumination.