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Tunable Optoelectronic Properties of WS_2 by Local Strain Engineering and Folding

Authors : Ahmed Raza Khan

Abstract : Local-strain engineering is an exciting approach to tune the optoelectronic properties of materials and enhance the performance of devices. Two dimensional (2D) materials such as 2D transition metal dichalcogenides (TMDCs) are particularly well-suited for this purpose because they have high flexibility and can withstand high deformations before rupture. Wrinkles on thick TMDC layers have been reported to show the interesting photoluminescence enhancement due to bandgap modulation and funneling effect. However, the wrinkles in ultrathin TMDCs have not been investigated, because the wrinkles can easily fall down to form folds in these ultrathin layers of TMDCs. Here, we have achieved both wrinkle and fold nano-structures simultaneously on 1-3L WS_2 using a new fabrication technique. The comparable layer dependent reduction in surface potential is observed for both folded layers and corresponding perfect pack layers due to the dominant interlayer screening effect. The strains produced from the wrinkle nanostructures considerably vary semi conductive junction properties. Thermo-ionic modelling suggests that the strained (1.6%) wrinkles can lower the Schottky barrier height (SBH) by 20%. The photo-generated carriers would further significantly lower the SBH. These results present an important advance towards controlling the optoelectronic properties of atomically thin WS_2 using strain engineering, with important implications for practical device applications.

Keywords : strain engineering, folding, WS_2, Kelvin probe force microscopy, KPFM, surface potential, photo current, layer dependence
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