Electronic Supporting Information for

Robust Room Temperature Valley Polarization in Monolayer and Bilayer WS_2

Pramoda K. Nayak [1,3‡], Fang-Cheng Lin[2‡], Chao-Hui Yeh[1], Jer-Shing Huang[2*], Po-Wen Chiu[1*]

[1]Department of Electrical Engineering, National Tsing Hua University, Hsinchu 30013, Taiwan

[2]Department of Chemistry, National Tsing Hua University, Hsinchu 30013, Taiwan

[3]Interdisciplinary School of Green Energy and Low Dimensional Carbon Materials Center, Ulsan National Institute of Science and Technology (UNIST), Ulsan 689-798, Republic of Korea

*E-mail; jshuang@mx.nthu.edu.tw or pwchiu@ee.nthu.edu.tw

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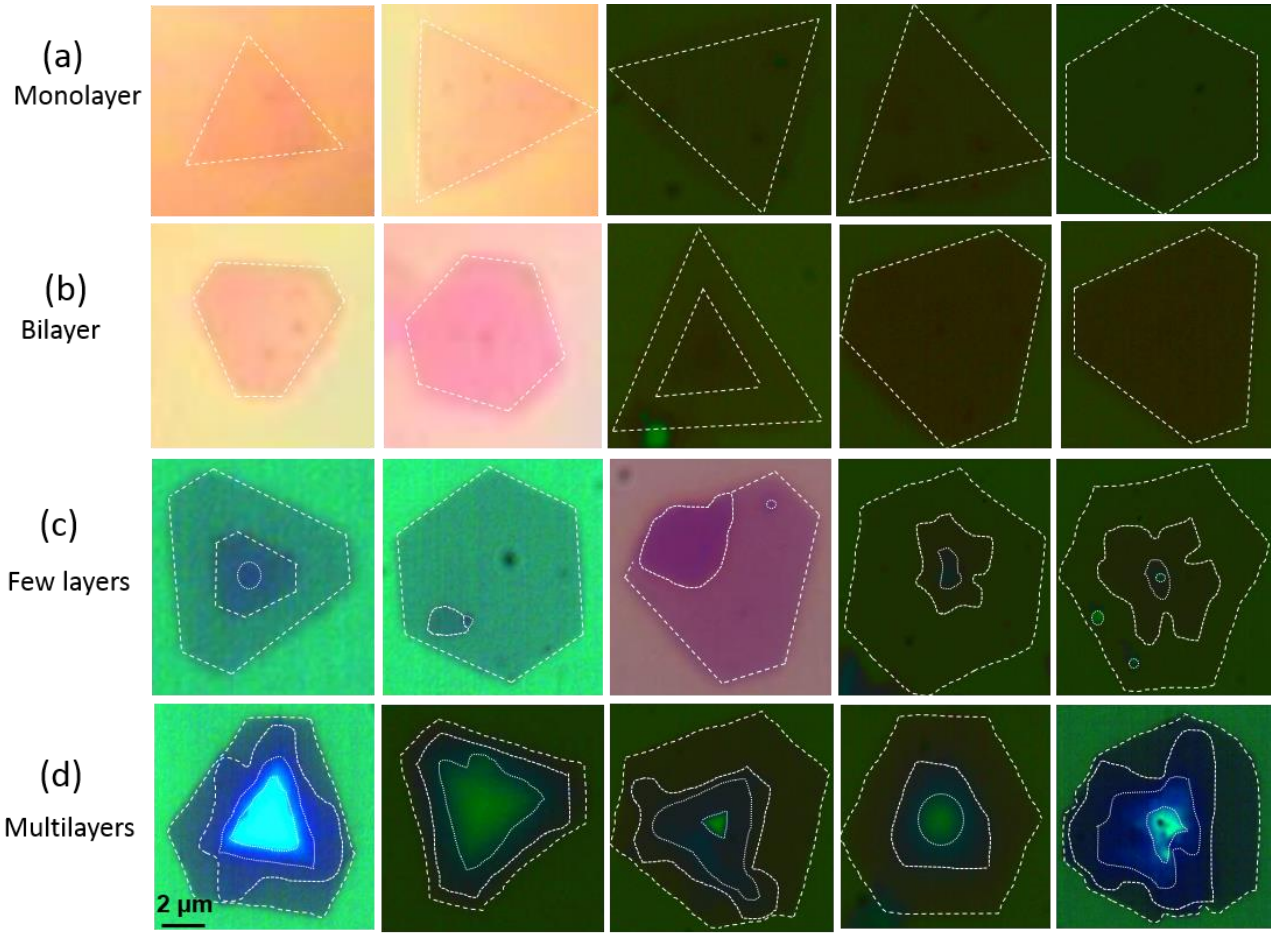

Fig. S1 Representative optical images of CVD grown WS_2 flakes with variable thickness on 300nm SiO_2/Si substrates. (a) monolayer WS_2 marked inside the triangle and hexagon region shows single contrast throughout the whole surface. (b) bilayer WS_2 flakes exit either in single contrast in hexagonal shape and dual contrast in triangular shape as shown inside the marked region. The single contrast region is a result of complete bilayer with twist angle (0°), where two individual layers are merged together and the intensity of the contrast is stronger than monolayer region (a). (c) few layer flakes are represented by different color contrast inside the marked regions. The first layer exists in hexagonal shape and the successive second layer, third layer and sometimes fourth layer grow epitaxially on the top of the base layer with arbitrary shape. (d) multilayer WS_2, in which more than 5-10 layers grow on the top of first base layer as shown inside the marked region. The top marked region containing an illuminated contrast contains several layers. The scale bar is same for all the panel.

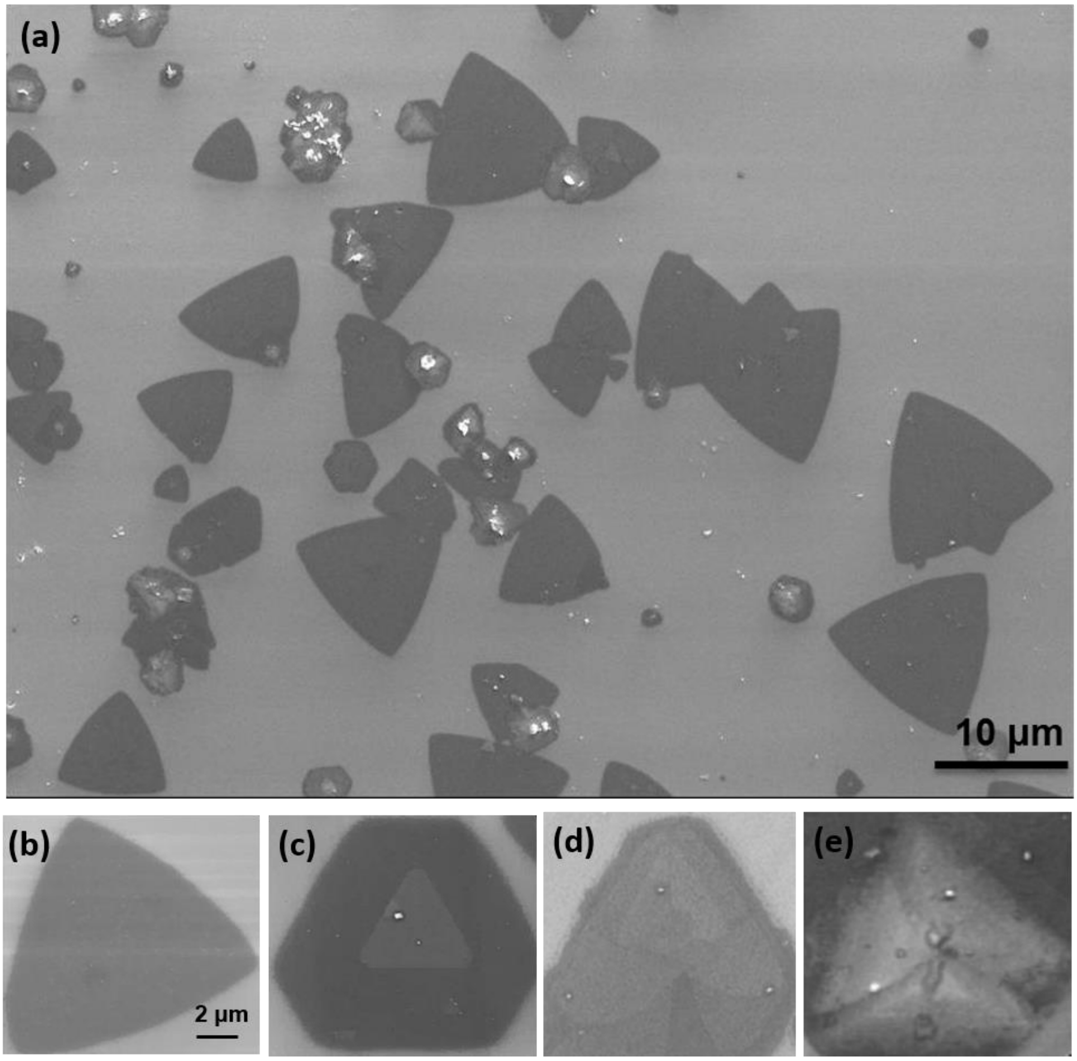

Fig. S2 SEM images of CVD grown WS_2 on 300nm SiO_2/Si substrate. (a) SEM image of selected region of the sample containing monolayer to bulk WS_2 flakes. (b-e) representative individual monolayer, bilayer, few layer and bulk WS_2 grains. Monolayer shows a single contrast throughout the whole surface. In the case of bilayer (b) the second layer nucleates from the center of the first layer and expands in all directions. The domain size of the second layer is either less than the first layer or same, regarded as complete bilayer (panel b, Fig. S1). In both the cases, the twist angle between the top layer and bottom layer is 0°. (d) few layer contains 3-5 layers and (e) bulk contains more than 5 layers as observed from the optical contrasts. The Fig.s in b-e share the same scale bar.

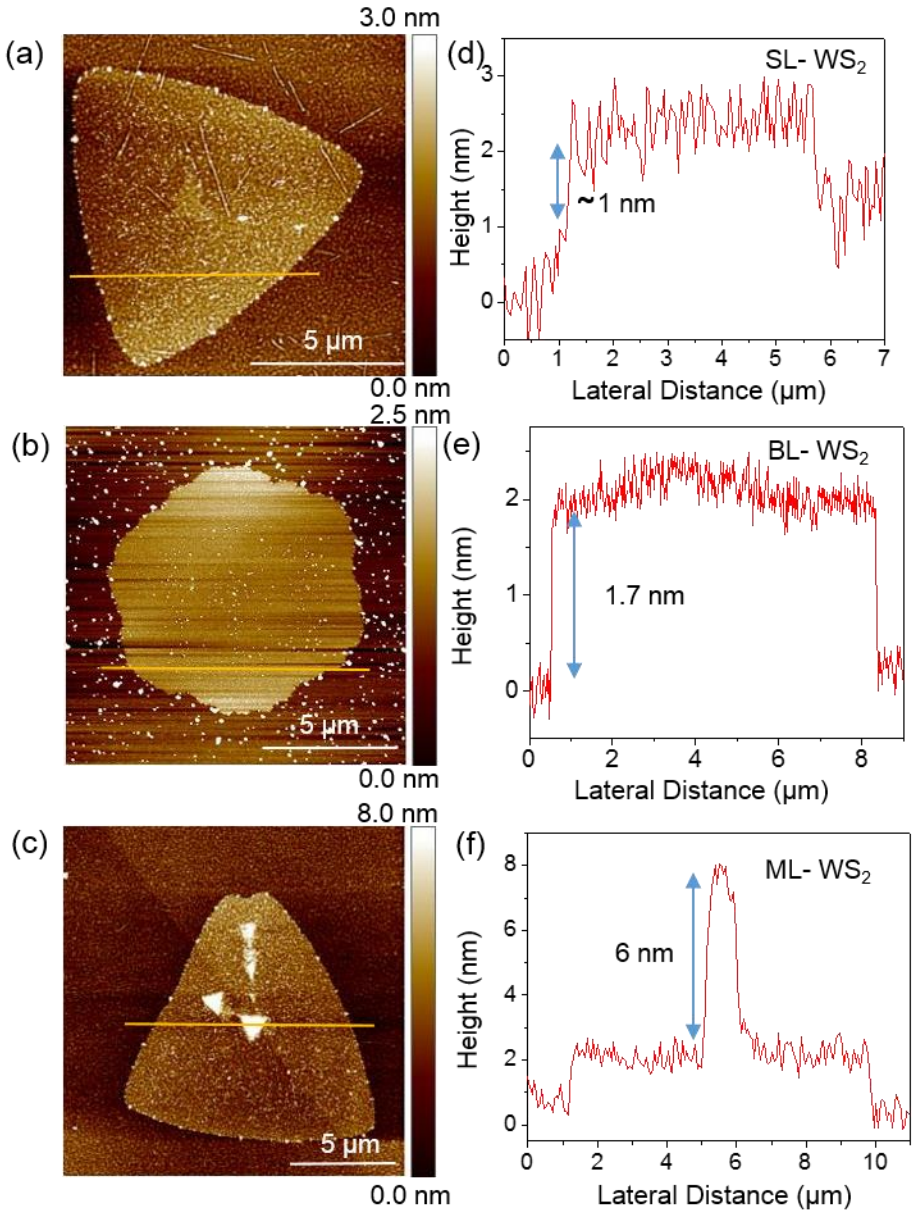

Fig. S3 AFM images and height profiles of WS_2 layers. A height of 1 nm, 1.7 nm and 6 nm in the marked region along y-axis revealing the positions of one layer, two layer and multilayer WS_2.

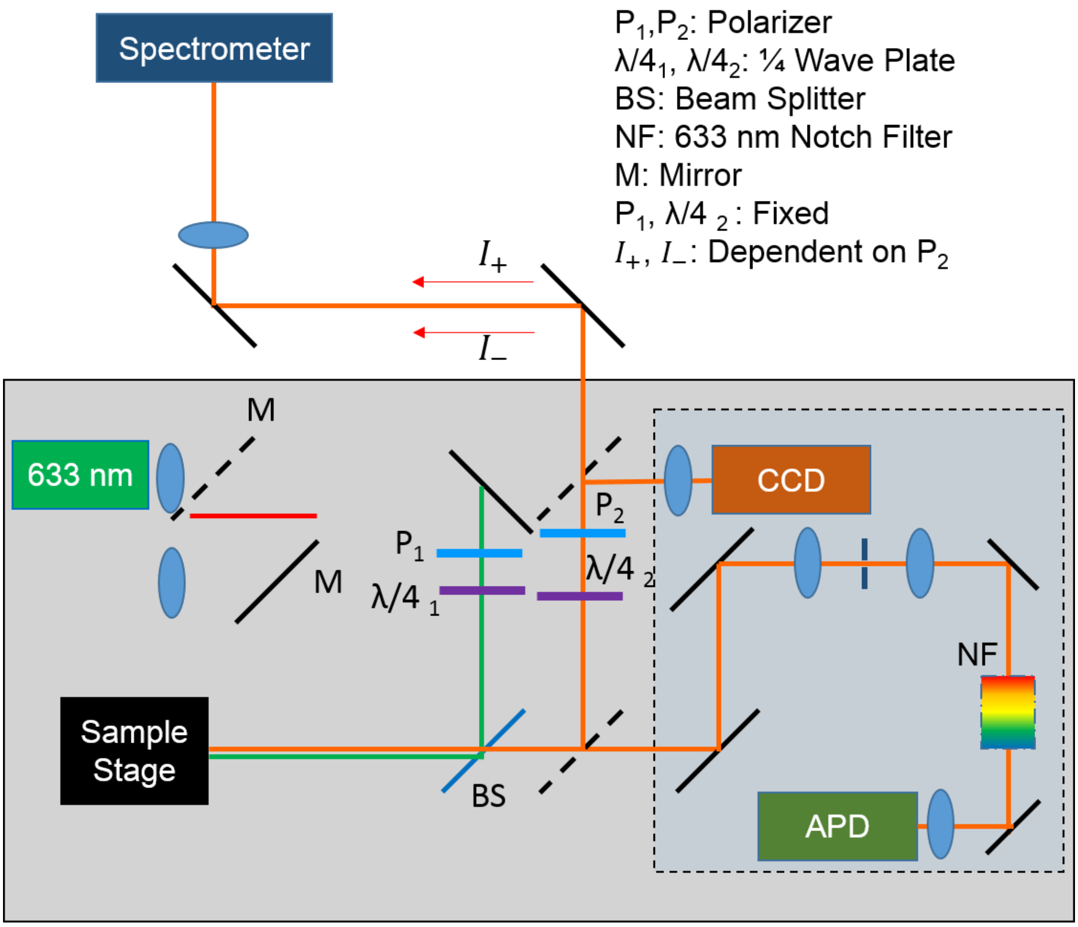

Fig. S4 Schematic of homemade confocal-like microscopic set-up used for room temperature polarization resolved photoluminescence measurement. I(+) and I(−) denote the intensity of the two orthogonally polarized beams casted in the CCD, for both right handed circular excited (σ+) and left handed circular excited (σ−) PL signal. The helicity of the circular polarization could be monitored by its attitude on the CCD image.

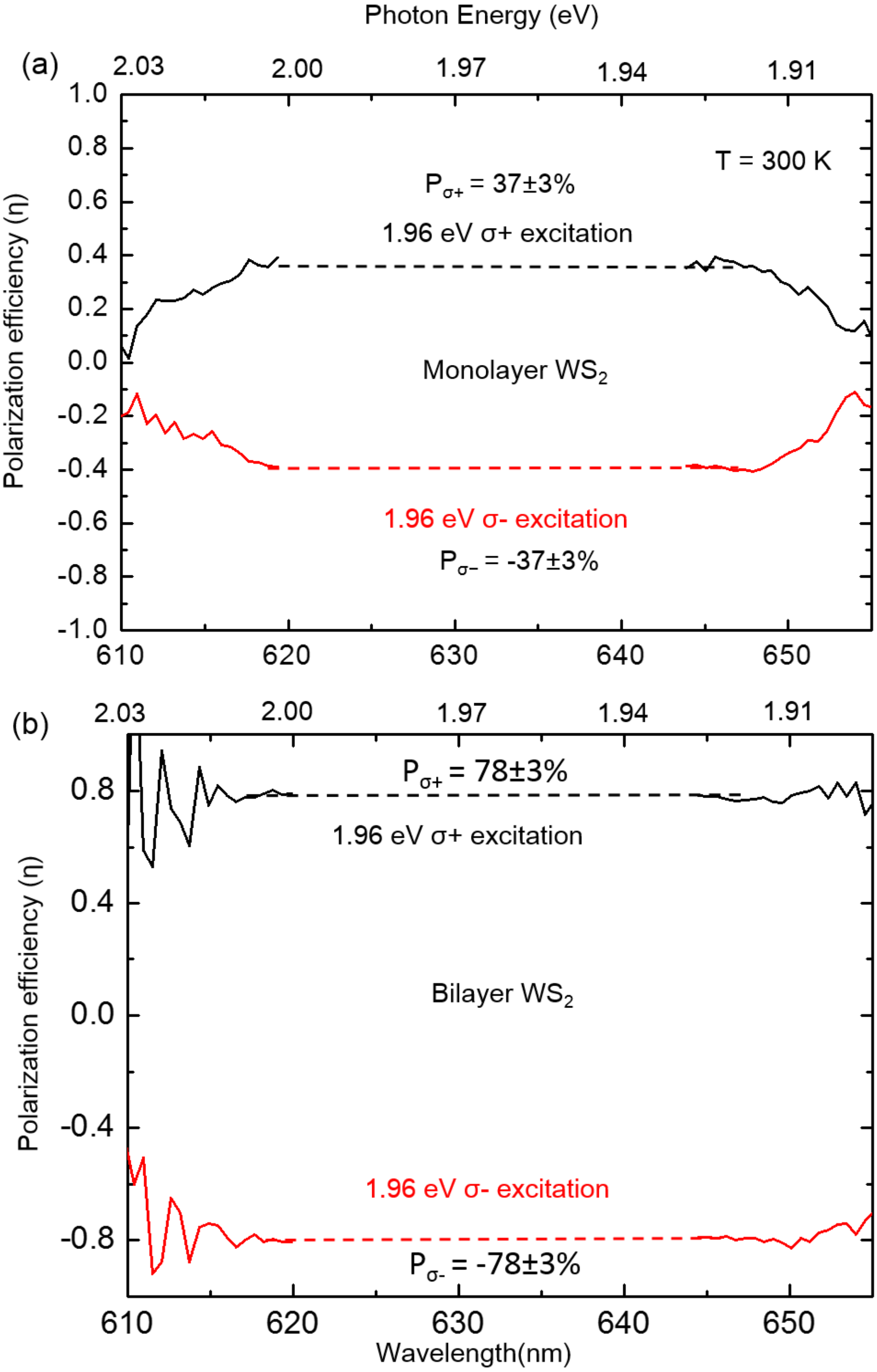

Fig. S5 Polarized luminescence spectra from other monolayer and bilayer WS_2 flakes. Polarization efficiency vs. photon energies for another (a) monolayer and (b) bilayer WS_2 flakes on the same sample. The polarization efficiency is found to be 37±3% for monolayer and 78±3% for bilayer.

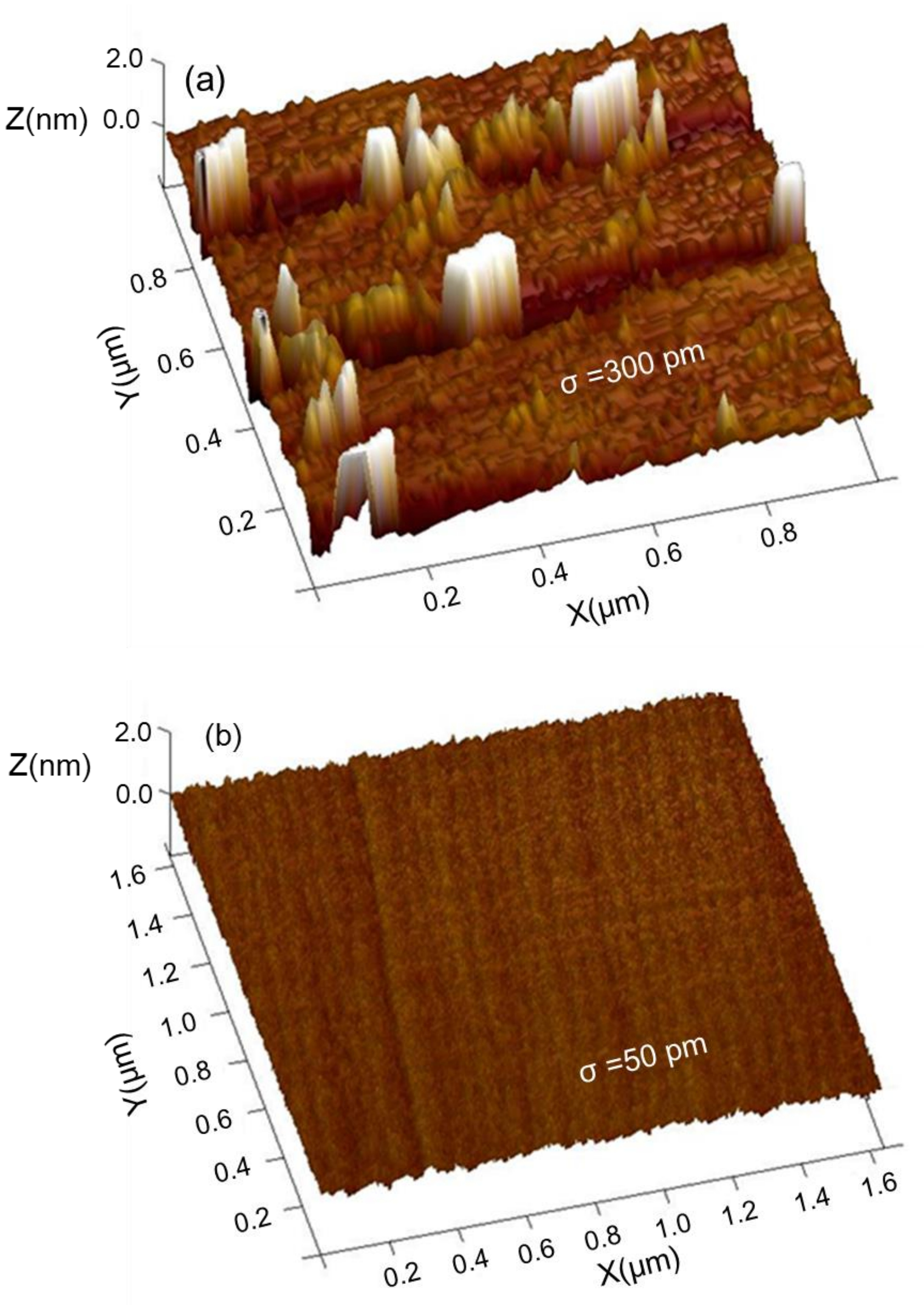

Fig. S6 Morphology of growth substrates. (a) AFM image of 300nm SiO_2/Si used here as the growth substrate. The surface roughness is around 300 pm excluding some add particles/scratches. (b) AFM image of c-plane sapphire substrate. The surface is relatively smooth with surface roughness of 50 pm.