Identification of non-uniform strain in WS_2 monolayers using P-SHG

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Strain in Transition Metal Dichalcogenide (TMD) monolayers (ML) changes the interatomic distances and the band structure, providing a new degree of freedom that allows manipulating their electronic properties, introducing the field of straintronics. Having an all-optical, minimally-invasive tool that rapidly probes strain in large areas of TMD MLs, would be of great importance in the research and development of novel 2D devices [1-3]. Here, we use polarization-resolved second harmonic generation (P-SHG) optical imaging to identify strain, induced in a single, spatially differentiated WS_2 ML placed on a pre-patterned Si/SiO_2 substrate with cylindrical wells. By fitting the P-SHG data pixel-by-pixel, we produce spatially resolved images of the crystal armchair direction. In the regions where the WS_2 monolayer is under non-uniform stain, we reveal a characteristic cross-shaped pattern in the armchair image. The presence of strain in these regions is independently confirmed using combination of atomic force microscopy and Raman mapping.

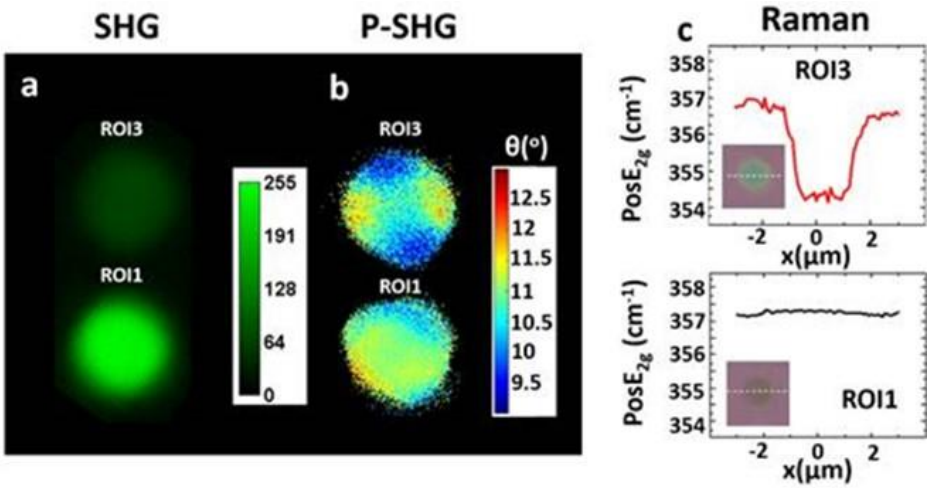

Figure 1: a) SHG intensity color map of strained (ROI3) and suspended (ROI1) ML WS_2, b) P-SHG color map of the corresponding crystal armchair orientation for the two ROIs, and c) Raman mapping for same ROIs: strained (ROI3) and suspended (ROI1)

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References

[1] L. Mennel et al., Nat Comm 9, 516 (2018)
[2] K. Beach et al., Phys Rev B 101, 155431 (2020)
[3] J. Liang et al., Nano Lett, 17, 7539 (2017)
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