Linearly polarized Raman spectroscopy of ReS_2 & $ReSe_2$

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In-plane anisotropy of rhenium dichalcogenides (ReX_2, X= S, Se), members of the group-VII transition metal dichalcogenides (TMDs), give additional degrees of freedom in manipulating device properties using anisotropic electronic and optoelectronic properties. The covalent bonding of the transition metal atoms (Re-Re) causes the anisotropic 1T' (distorted trigonal) structure and all axes are not normal to other axes of the crystal. Therefore, up- and- down faces of monolayer ReX_2 are not equivalent, and the physical properties are related to the crystallographic orientation [1][2].

In this study, we performed linearly polarized Raman measurements on 1- to 3-layer ReX_2 on both up- and down-sides. The thickness was determined by interlayer vibration modes in the low frequency region (< 40 cm^{-1}) [3]. We investigated the polarization dependence of the 18 Raman modes with the several excitation wavelengths (442, 514, 532, 633 nm). The polarization dependences of the Raman modes vary with the excitation wavelengths. From the relation of the polarization dependence of two Raman modes (ReS_2: 152, 212 cm^{-1} and $ReSe_2$: 125 cm^{-1} and 160 cm^{-1}), we classified the sides of the samples corresponding to the two vertical orientations. We also identified the Re-chain direction using the polarization direction of the Raman modes at 212 cm^{-1} (ReS_2) and 160cm^{-1} ($ReSe_2$) by comparing with scanning transmission electron microscopy (STEM) measurements.

References

[1] Y. Lin *et al.*, ACS Nano, 9 (2015) 363
[2] S. Sim *et al.*, Nature communication, 9 (2018) 351
[3] E. Lorchat *et al.*, ACS nano, 10 (2016) 27525

Figures

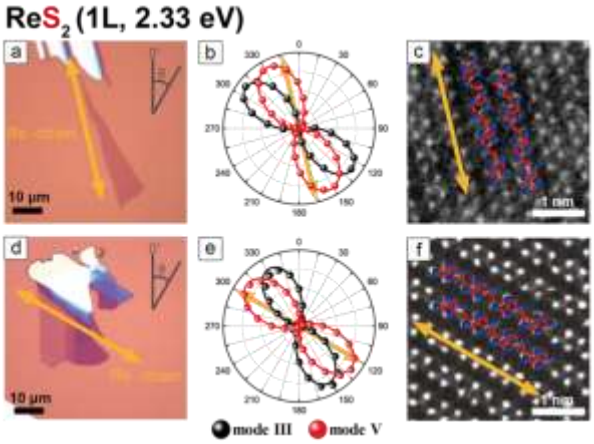

Figure 1: Optical images, Polarization dependences and STEM images of 1L ReS_2.

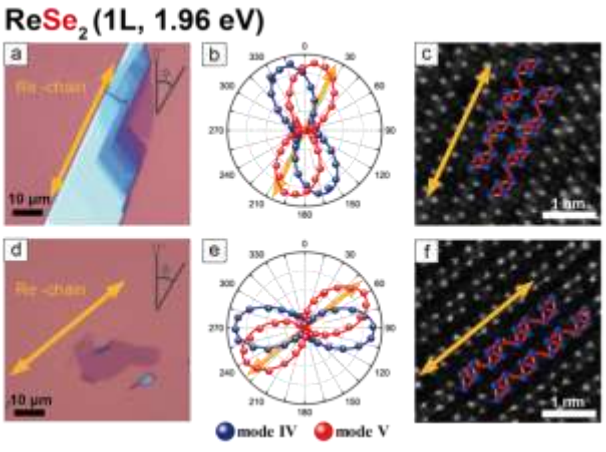

Figure 2: Optical images, Polarization dependences and STEM images of 1L $ReSe_2$.