Strain tuning of Raman modes of ReS_2 monolayers

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The influence of mechanical strain on the optical properties of two-dimensional transition metal dichalcogenides (TMDCs) is currently a widely investigated topic. In recent years the majority of works has focused on semiconductors with a high in-plane symmetry like MX_2 with M= Mo, W and X= Se, S. It was found that strain shifts the exciton energies, manipulates the exciton-phonon interaction and changes the phonon modes [1,2]. In contrast to these intensively investigated TMDCs, ReS_2 crystals posses a reduced in-plane symmetry, leading to anisotropic optical properties.

Here, we report on the impact of strain on the Raman response of ReS_2 monolayers [3]. We apply uniaxial tensile strain of up to 0.74% along the Re-chain direction (x-axis) of the atomically thin crystal (Fig.1 (a,b)) and measure the Raman response with the scattered light polarized parallel and perpendicular to the strain direction along the x-axis of the crystal. In addition, we perform ab initio calculations to investigate the influence of strain on the phonon modes theoretically. We find consistent mode-dependent shifts to lower energies under tensile strain in experiment and theory. The obtained gauge factors for the Raman energy shift from different modes under strain in range from -0.1 cm^{-1}/% to -4.2 cm^{-1}/%. Fig.1 (c) shows exemplarily the shift of the third optically acessible mode (R3).

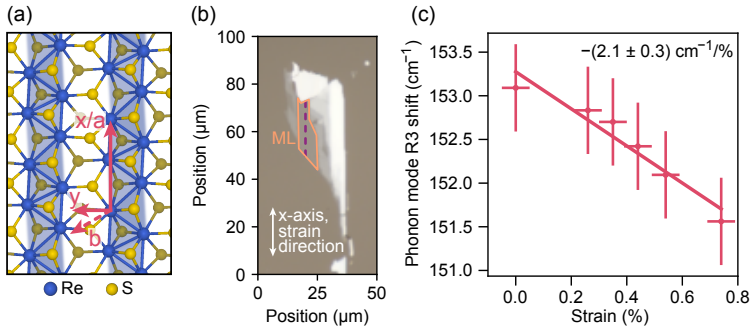

Figure 1: (a) Schematic drawing of the crystal structure. (b) White-light reflection image of the investigated monolayer (outlined in orange) on polycarbonate substrate. (c) Extracted energy values of the R3 mode as a function of strain

Our results promote that the unique opto-mechanical properties of ReS_2 can be continuously tuned by external strain.

[1] I. Niehues et al. Nano Lett. **18**,1751 (2018)

[2] I. Niehues et al. Nanoscale **12**, 20786 (2020)

[3] I. Niehues et al. submitted (2022).