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Effects of structural disorder on phonon spectra of $2H$-$TaSe_{2-x}S_x$ $(0 \leq x \leq 2)$ single crystals

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Transition metal dichalcogenides, as a well studied family of quasi-2D materials, have attracted considerable attention in recent years due to rich phase diagrams, thickness-dependent transport, unique optical properties and collective electron phenomena which occur at experimentally accessible temperatures. Additionally, it was recently shown that in the metallic single crystal alloys of $2H$-$TaSe_{2-x}S_x$ the crystalline disorder promotes superconductivity, while suppressing charge density wave (CDW) order. In this work, the lattice dynamics of $TaSe_{2-x}S_x$ $(0 \leq x \leq 2)$ alloys was probed using Raman spectroscopy and results were compared to density functional theory (DFT) calculations. In order to investigate whether crystallographic disorder affects the phonons, spectra of doped materials were compared to the ones belonging to the end alloys. The Raman spectra of the end compounds ($x = 0$ and $x = 2$) host two out of three symmetry-expected Raman active modes for backscattering configuration. Calculated phonon energies agree well with the experimental ones. In Raman spectra of the doped samples additional peaks, though of low intensity, can be easily identified. These additional peaks most likely arise from the crystalline disorder. Dependence of phonon energies and linewidths on sulfur content x also reveals a clear fingerprint of crystallographic disorder.

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