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Electronic Supplementary Material

Direct identification of monolayer rhenium diselenide by an individual electron diffraction pattern

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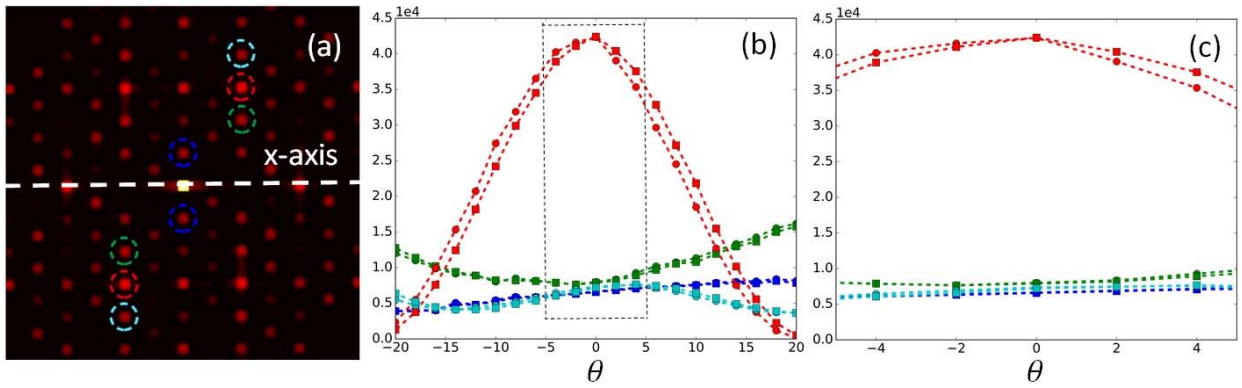

Figure S1 Large-angle tilt diffraction pattern series were simulated for monolayer $ReSe_2$ to explore its structure factors since monolayer $ReSe_2$ is a sandwiched structure with three layers closely packed, instead of an ideal monolayer. (a) one of the simulated diffraction patterns, and the tilt axis is x-axis, with selected spots coded with different colors, (b) intensities of selected diffraction spots in (a) vary with tilt-angle, up to $\pm 20°$, zoom-in area indicated by the dashed black box is displayed in (c). As compared to shape factors, structure factor variation is much slower for monolayer $ReSe_2$ and there is no intensity mismatch at zero tilt-angle.

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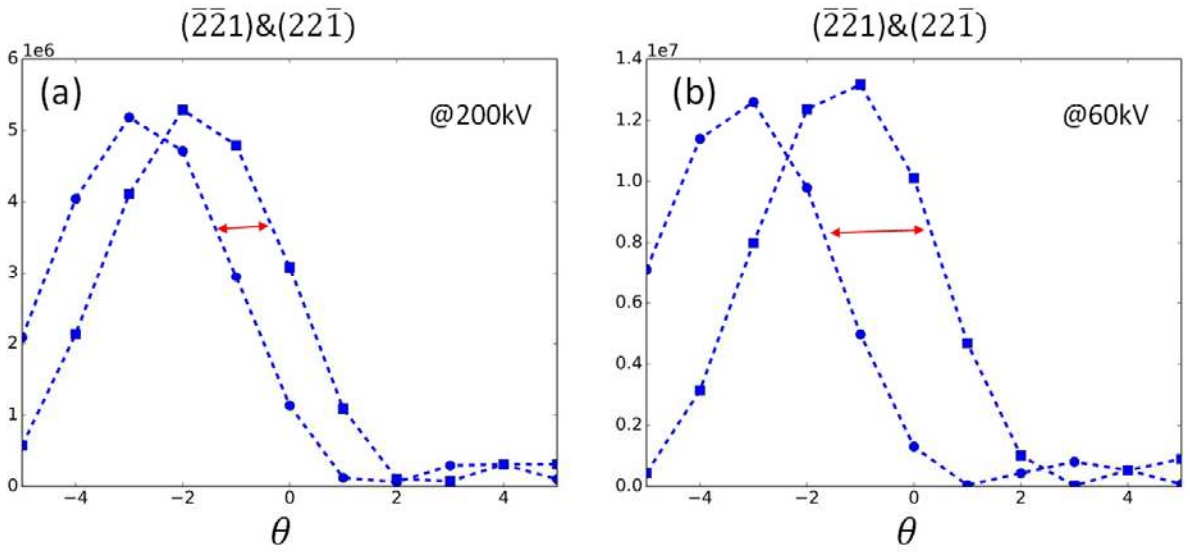

Figure S2 (a)&(b) Intensity variations, of the selected Friedel pair $(\bar{2}\bar{2}1)\&(22\bar{1})$ in 4L $ReSe_2$, with tilt-angle, which are from simulated diffraction patterns at accelerating voltages of 200 kV and 60 kV respectively. Intensity mismatch could be broadened by increasing the curvature of Ewald sphere, which is to decrease the accelerating voltage.

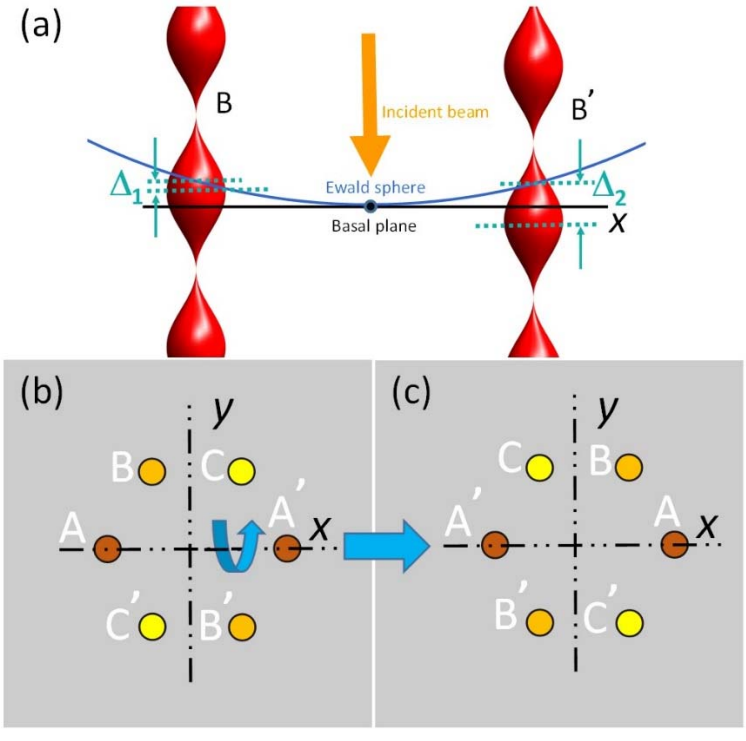

Figure S3 Illustration of how the intensity of electron diffraction pattern in multilayer $ReSe_2$ change when crystal was flipped upside down. When the Friedel pair in (a) was flipped around x-axis in (b), not only their positions flipped over to the opposite side of x-axis, but their intensities exchanged with each other, which was shown in (c), the diffraction pattern seemed to have flipped around y-axis (perpendicular to x-axis) if we have only considered the intensity of each spot.

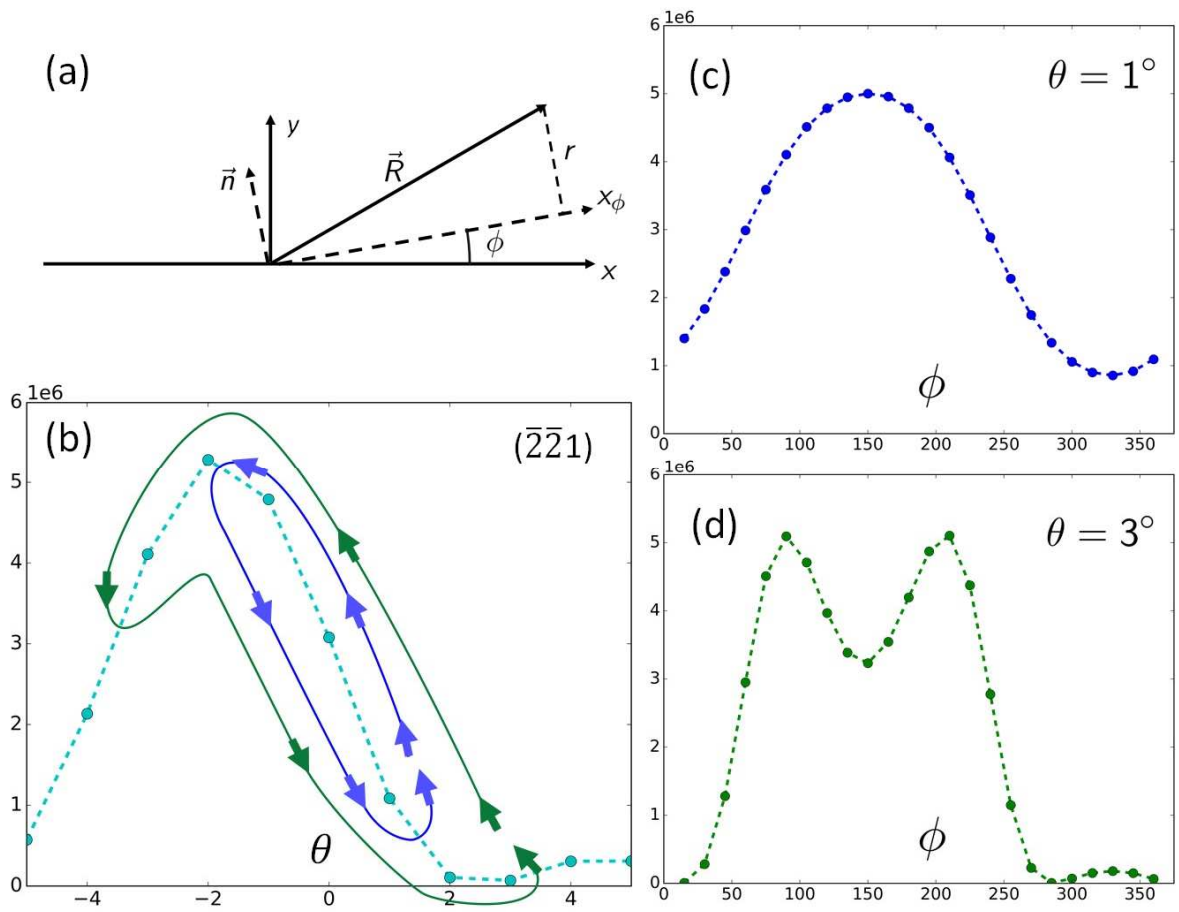

Figure S4 Discussion of the effects of rotating the tilt-axis around z-axis: (a) vector $\vec{R}$ denoted the position of the diffraction spot in consideration, as the tilt-axis x_φ rotated by the angle of ϕ, the corresponding tilt-arm length became $r = \vec{R} \cdot \vec{n}$, where $\vec{n}$ is the unit vector normal to tilt-axis, therefore, the effect of tilt-angle θ changed periodically with in-plane rotation-angle ϕ, (b) the relationship of simulated intensity of $(\bar{2}\bar{2}1)$ and tilt angle depicted variation of the corresponding reciprocal rel-rod in z direction, blue and green arrows indicated how the intersection, of Ewald sphere and the selected reciprocal rel-rod, moved with different $ReSe_2$ sample orientations in (c) and (d), which were acquired from simulations at fixed tilt-angle 1° and 3° with varying rotation-angle ϕ, ranging from 15° to 360°, at a step of 15°.

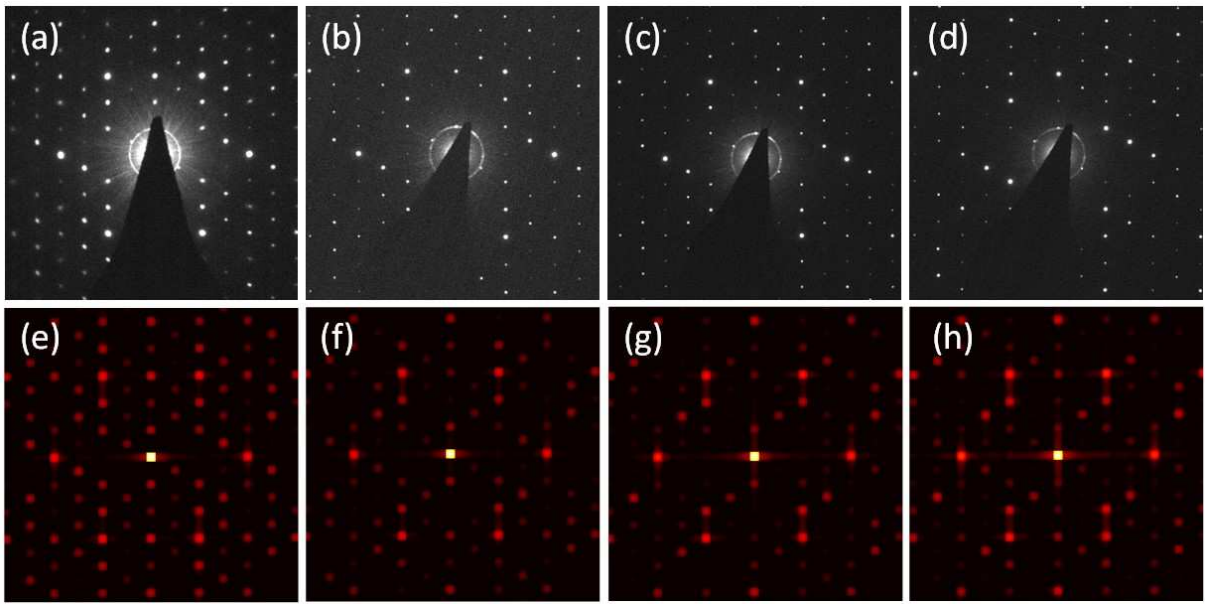

Figure S5 (a)-(d) experimental diffraction patterns for 1-4 L $ReSe_2$, (e)-(h) simulated diffraction patterns for 1-4 L downside-oriented $ReSe_2$ without tilting. As we can see, as layer number increased, the experimental diffraction patterns and the simulated ones became less consistent, which could be attributed to that shape factors are more sensitive to tilt-angle with increasing layer number.

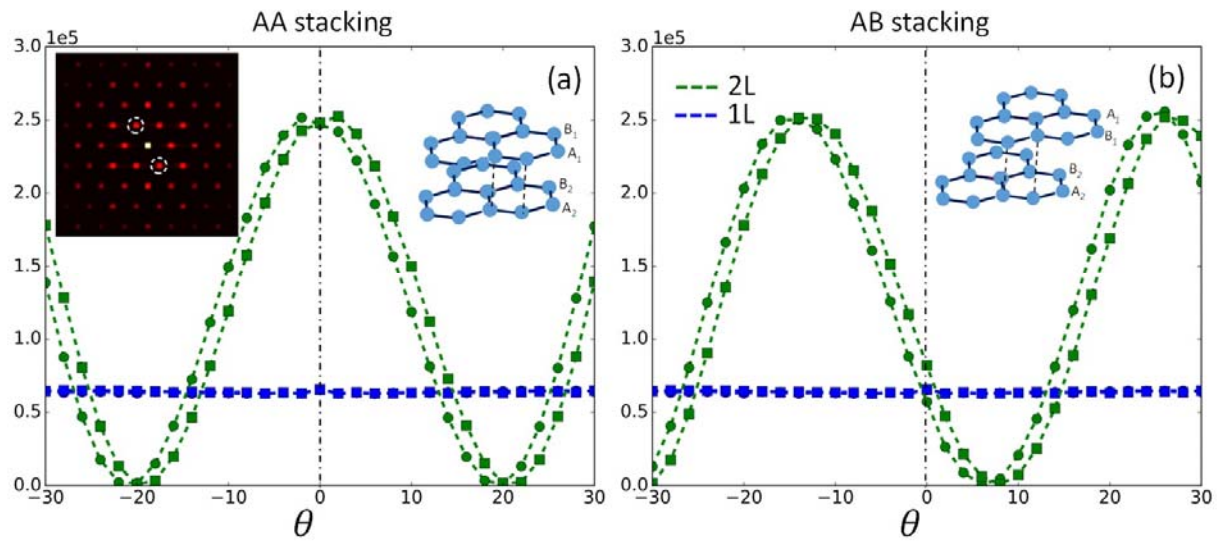

Figure S6 Generalization of our method to high symmetry 2D materials, e.g., graphene. (a)&(b) show how the simulated intensities of a Friedel pair (indicated by a pair of white dashed-circle in the inset of (a)) of mono- and bi- layer graphene vary with tilt-angle for AA stacking and AB stacking respectively. For both stacking configurations, there was a phase shift within the Friedel pair for bilayer graphene, furthermore, AB-stacking bilayer graphene was similar to triclinic crystal system, and there was a mismatch in intensity even without tilting, but in AA-stacking configuration, tilt-angle was required to distinguish monolayer from bilayer graphene by utilizing the corresponding intensity mismatch. Simulations were carried out under acceleration voltage of 60kV.