Supporting information for:

Local Conduction in Mo$_x$W$_{1-x}$Se$_2$: The Role of Stacking Faults, Defects and Alloying

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Experimental Configuration

The schematic of Figure S1 shows the experimental geometry of the contacts. A thick piece of TMDC is placed on top of a muscovite mica for structural support and mechanical stability. The electrical contact of the TMDC is done by the combined use of graphite flakes and silver paint. A graphite flake is placed on top of one of the ends of the TMDC flake. Silver paint is used to complete the electrical connection with the wiring of the AFM setup. The conductive AFM experiments were done with the use of a highly p-doped diamond tip and in contact mode. In this setup the tip is grounded, a bias voltage is then applied to the sample. The current is measured though the tip. The same scheme is commonly used in STM measurements, since this gives lower noise levels than using a biased I-V converter.

![Figure S1: Schematic configuration of the sample connections.](image)

XPS spectrum

In order to confirm the composition of the obtained samples (from HQ graphene, the Netherlands) we have done X-ray Photoelectron Spectroscopy (XPS) measurements with an Quantera SXM (Physical Electronics). The X-rays were Al Kα, monochromatic at 1486.6 eV with a beam size of 200 µm. XPS measurements were done at several different locations on the samples. A small deviation of a few percentage has been observed between different locations (possible due to segregation). However on average the samples follow the composition given on the text and indicated by the provider. An example is given in figure S2 for the
Mo0.7W0.3Se2 sample, where in the region of the XPS measurement the areal percentages are: 27% for Mo, 8% for W and 63.3% for Se, thus the sample is really close to the expected composition.

![Full range XPS spectrum of the Mo0.7W0.3Se2 alloy with x being on average 0.7.](image)

**Figure S2:** Full range XPS spectrum of the Mo0.7W0.3Se2 alloy with x being on average 0.7. The table provides the obtained concentration at one particular location of the sample. The spectrum was done from -1345 eV to -5 eV with a pass energy of 224 eV and δE 0.4 eV.

| Area       | Comment | O1s (a.u.) | Se3d (a.u.) | Mo3d (a.u.) | W4f (a.u.) | RSF       | CorrectedRSF |
|------------|---------|------------|-------------|-------------|------------|-----------|--------------|
| Mo0.7W0.3Se2 x=0.7-1 |         | 1.64       | 63.28       | 27.09       | 7.99       |           |              |
|            |         | 0.733      | 0.821       | 3.544       | 3.863      | RSF       | CorrectedRSF |

The table provides the obtained concentration at one particular location of the sample.

**2H and 3R phases**

Figure S3 shows another location of stacking faults as measured by C-AFM. The pattern looks different than the one shown in the main text. Characteristic of stacking faults since the exact pattern should depend on the preparation procedure and local strain variations.

We have also managed to visualize by the use of scanning tunneling microscopy (STM) the atomic structure of the 2H (AA') and 3R (AB) phases. The STM images are shown in Figure S4. The experiments were performed with an RHK AFM/STM (BeetleTM, RHK...
Figure S3: A large repetitive pattern observed on the surface of WSe$_2$ and attributed to stacking faults. The pattern is a result of alternation of the 2H and 3R phases.

Technology) system in N$_2$ environment. In the images the lattice periodicity and the structural differences of the two phases are clearly visible.

**Atomic periodicity**

In the main text we show that C-AFM is able to capture current variations down to the atomic level. In these images a trigonal lattice is often observed. This is also shown in the images of Figure S5 for both Mo$_{0.3}$W$_{0.7}$Se$_2$ and Mo$_{0.7}$W$_{0.3}$Se$_2$ alloys. Atomic periodicity was also captured in the corresponding topography and LFM images. The periodicity in all these images is approximately 0.31 nm. In addition, the topography and LFM images for both samples are flat. This is clearly not the case for the current images. Mo and W are very similar, mixing the two should not give any measurable structural variations. It however, gives a strong electrical difference. A Fast Fourier Transform (FFT) on such an image clearly displays a periodic pattern with a hexagonal symmetry. The measured lattice constant is 0.31 nm, in close agreement with the lattice of Mo$_x$W$_{1-x}$Se$_2$. The recorded FFT is shown in Figure S6.

The reproducibility of our results has been tested by repeating the experiments with two different AFM instruments. Figure S7 provides additional conductive AFM images of the
Figure S4: STM images of (left) the 2H (AA’ stacking order) and (right) 3R (AB stacking order) phases recorded at -2 V, 1.4 nA and 0.5V, 0.3 nA, respectively. The ball and stick model serves as a guide to the eye for the atom position. The size of the images is 1.2 nm by 1.8 nm.

studied alloys recorded with an Agilent 5100 and a Keysight 9500 AFMs. The quality of the images varies slightly and most probably depends on the state of the tip. Typically, as the tip gets older and normally after extended usage, it loses its sharpness and the imaging quality drops. In all the recorded images both the atomic periodicity of the surface as well as W-rich and Mo-rich regions are clearly visible.
Figure S5: (a) Topography, (b) LFM, (c) and Current images of the Mo$_{0.3}$W$_{0.7}$Se$_2$ sample. The atomic periodicity is resolved in both the LFM (due to stick and slip motion of the tip) and the Current image. Larger current variations are also clearly observed induced by the presence of Mo in the crystal. The corresponding topography and LFM are flat. (c) Topography, (b) LFM and (c) current images of the Mo$_{0.7}$W$_{0.3}$Se$_2$, showing again atomic periodicity and larger current variations due to the presence of Mo and W.

Figure S6: The FFT spectra of the current image of Figure S5c. The FFT clearly reveals a hexagonal symmetry, noted with the red circles, with a periodicity of $\sim$0.31 nm.
Figure S7: Additional C-AFM images with atomic periodicity and material contrast on the (a,b) Mo$_{0.7}$W$_{0.3}$Se$_2$ and (c) the Mo$_{0.3}$W$_{0.7}$Se$_2$ samples. The images were recorded with the use of two AFM systems; (a, c) the Agilent 5100 and (b) the Keysight 9500.