Wafer-Scale Epitaxy of Centrosymmetric GaSe

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Two-dimensional semiconductors based on metal chalcogenides (MCs) have versatile optical and electronic properties, and a unique inverted Mexican-hat shaped valence band dispersion in few-layer films. This unusually shaped band is expected to give rise to new forms of magnetic order, charge density waves and superconductivity driven by weakly screened electron correlations. [1] However, the observation of these new phenomena and their exploitation requires precise engineering of electronic properties. In particular, MCs possess many stable polymorphs and polytypes, which are difficult to control.[2]
Here, we report on the use of molecular beam epitaxy (MBE) to synthesise the recently discovered centrosymmetric polymorph of GaSe[3] with high quality and uniformity on a wafer-scale (fig. 1a). The polymorph is stabilised by in-plane tensile strain generated by the lattice mismatch between the GaSe and the sapphire substrate. We employ a range of techniques to characterise, for the first time, the optical, vibrational and electronic properties of the centrosymmetric polymorph of GaSe, including atomic force microscopy (fig. 1b) and cross-sectional high-angle annular dark-field imaging (HAADF) scanning transmission electron microscope (STEM) imaging (fig. 1c, d).

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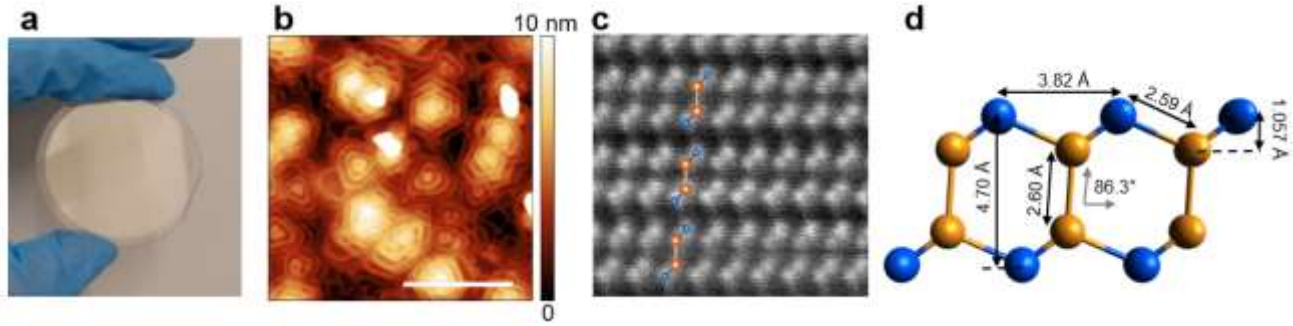

Figure 1a Image of 55 nm-thick GaSe grown on a 2-inch c-plane (0001) sapphire wafer. **b** Tapping mode atomic force microscope (AFM) image of 24-nm thick GaSe (scale = 300 nm). **c** Cross-sectional high-angle annular dark-field imaging (HAADF) scanning transmission electron microscope (STEM) image of 55 nm-thick GaSe with overlaid schematic of the centrosymmetric polymorph. **d** Schematic of centrosymmetric GaSe polymorph with lattice parameters derived by cross-sectional HAADF STEM image analysis.