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Monolayer $MoSe_2/WSe_2$ heterojunctions at the atomic level

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While graphene is the most studied two-dimensional (2D) material, atomically thin layered transition metal dichalcogenides (TMDs) have recently emerged as a new class of 2D nanomaterials. Due to their band structure, monolayers of direct band gap semiconducting TMD have promise to complement the zero bandgap energy of graphene, offering an extensive range of applications in electronics and optics. The dichalcogenide heterojunctions were grown by physical vapor transport. Lateral heteroepitaxy was visible in an optical microscope and the structures showed enhanced photoluminescence. Atomically resolved transmission electron microscopy using a double-corrected ARM200F (80-200kV) revealed that the $MoSe_2/WSe_2$ heterojunction is an undistorted honeycomb lattice in which substitution of one transition metal by another occurs across the interface [1]. There were no dislocations or grain boundaries, i.e. an atomically seamless $MoSe_2/WSe_2$ semiconductor junction was achieved. Moreover, strain mapping of atomic resolution images demonstrates negligible distortion at the heterojunction, and the analysis of the different atomic species demonstrates that the interface has a finite width similar to 3D heterojunctions. Vertical stacking of $MoSe_2/WSe_2$ bilayers was also analyzed using electron microscopy. An analysis of the intensity in annular dark field images shows that Se atoms of the WSe_2 layer align with the Mo atoms of the $MoSe_2$ layer in some of these heterojunctions. We expect that the growth of these lateral junctions will open new device functionalities, such as in-plane transistors and diodes integrated within a single atomically thin layer [1,2,3].

[1] C. Huang et al. *Nat. Mater.* **13** (2014) 1096
[2] Y. Gong et al, Nat. Mater. **13** (2014) 1135
[3] G.S. Duesberg *Nat. Mater.* **13** (2014) 1075