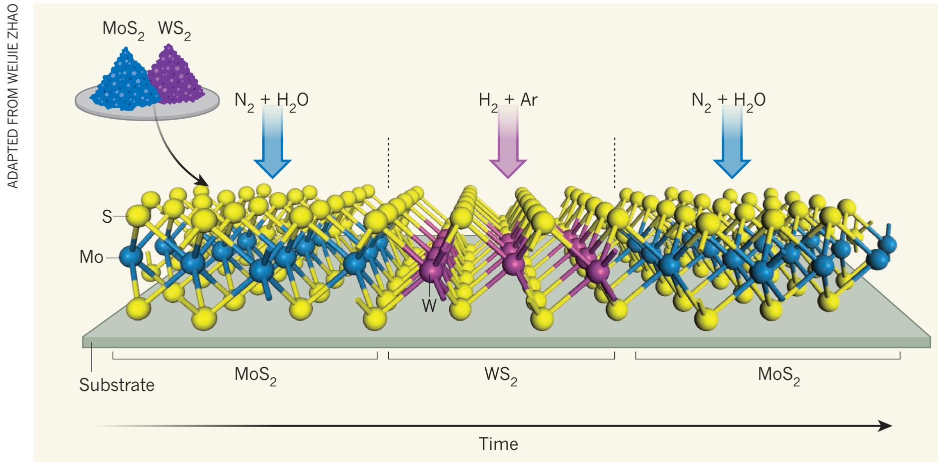

Figure 1 | A strategy for growing lateral multi-junction heterostructures. Interfaces between the edges of atomically thin sheets of different semiconductors are called lateral heterostructures, and have potential technological applications. Sahoo *et al.*[4] report a method for making lateral heterostructures from compounds known as transition-metal dichalcogenides (TMDs), which include molybdenum disulfide (MoS_2) and tungsten disulfide (WS_2). The authors heat a mixture of two powdered TMDs in a furnace, and pass carrier gases over them (coloured arrows). The carrier gases react with the TMDs to produce gaseous intermediates (not shown), which then react on the surface of a substrate to deposit sheets of the TMDs. When a mixture of nitrogen and water vapour is used as the carrier gas, only MoS_2 forms. When the carrier gas is switched to a mixture of hydrogen and argon, the growth of MoS_2 is terminated and WS_2 grows at the edge of the pre-grown MoS_2. By switching cyclically between the carrier gases, 2D multi-junction heterostructures are produced.

transition-metal dichalcogenides (TMDs).

Transition-metal dichalcogenides have the general formula MX_2, in which M is molybdenum (Mo) or tungsten (W) and X can be sulfur (S) or selenium (Se). Lateral TMD heterostructures can be constructed by 'stitching' the edges of two TMD sheets together using covalent bonds. In the past few years, there has been a flurry of papers[5–9] reporting methods for synthesizing TMD lateral heterostructures using edge epitaxial growth, a method that allows a second TMD to grow at the edge of another, pre-grown TMD crystal. These heterostructures can be fabricated into p–n junctions, which conduct currents in only one direction (a property known as rectification), and constitute one of the building blocks of modern electronic and optoelectronic devices. Two-dimensional p–n junctions hold great promise for the development of atomically thin devices such as light-emitting diodes, solar cells and integrated circuits (chips).

Lateral TMD heterostructures have previously been made in one-step procedures[5,6] that lacked the flexibility to make multi-junction heterostructures or more than one type of heterostructure, or in two-step or multi-step processes that involve many changes of TMD precursors and reaction chambers[7–9]. Sahoo and colleagues' method overcomes those constraints in a 'one-pot' procedure — a process that allows several steps to be performed in one reaction chamber. One of the many advantages of their strategy is the operational simplicity with which different TMDs can be selectively grown.

The authors' approach builds on a method known as chemical-vapour deposition (CVD), in which a substrate is exposed to gaseous precursor compounds (sometimes mixed with carrier gases) that react or decompose on the substrate to deposit the targeted solid product at an optimal temperature and pressure. The researchers found that 2D MoX_2 and WX_2 can be grown sequentially from a mixture of powders of the two compounds, thus forming lateral heterostructures, simply by switching the carrier gases in the CVD growth chamber (Fig. 1).

The secret to success lies in the intriguing and complicated chemical reactions that occur between the carrier gases and the powdered TMD solids. The reactions produce highly volatile species such as hydroxides and oxides, which undergo redox reactions at distinct rates to deposit MoX_2 or WX_2 selectively, depending on the carrier gases used. When the carrier is a mixture of nitrogen and water vapour, the growth of only MoX_2 is promoted. But when the carrier is switched to a mixture of hydrogen and argon, the volatile molybdenum compounds are quickly depleted by reactions with the hydrogen, so that only WX_2 grows. By switching carrier gases multiple times, as many alternating domains of MoX_2 and WX_2 as desired can be prepared — corresponding to a sequence of lateral heterostructures.

Sahoo and co-workers used high-resolution transmission electron microscopy to show that some types of junction in their heterostructures were seamless and atomically sharp. They also used spectroscopic techniques to confirm the alternating pattern of TMD domains, to verify that each domain contains just one type of TMD, and to show that the junctions in the heterostructures are made reproducibly.

50 Years Ago

As good trade unionists know, wage claims at times of economic belt-tightening are no more successful than whistling in a blizzard. However sweet the music sounds, it never carries far. The Association of University Teachers is far from being a trade union; if it were, it would probably not have persisted with its claim that teachers in universities are underpaid. The British Government has rewarded the association for its pains by asking the Prices and Incomes Board, a notoriously unsentimental body, to undertake a survey of university salaries … if the Prices and Incomes Board should conclude that there are no grounds for an increase, that is likely to be an end to the matter. And once the board … have the bit between their teeth, no government is going to feel moved to set up a review body more sympathetic to the teachers.
From *Nature* 6 January 1968

100 Years Ago

The Science Museum, South Kensington, was re-opened to the public on Tuesday, January 1. The museum has been closed to the public for nearly two years; it has, however, been open without interruption for students. As compared with 1914 conditions, the extent and the hours of opening for 1918 are somewhat reduced, but the greater part of the museum will be open free on every weekday from 10 a.m. to 5 p.m … The collections contain many unique objects of great interest as representing discoveries, inventions, and appliances that have been of first-rate importance in the advancement of science and of industry. Such objects as Watt's engines, early locomotives, steamships … and textile machinery are records of British contributions to the progress of the world.
From *Nature* 3 January 1918