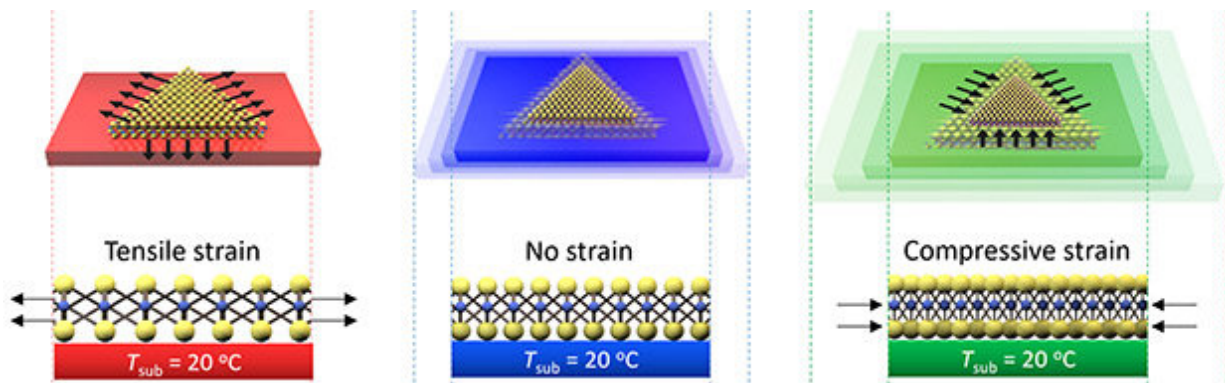


Stretching to perfection of 2-D semiconductors

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Semiconducting films are grown on different substrates at high temperatures and then rapidly cooled to induce deformation. This process can be used to controllably modify the films' electronic properties. If the substrate (blue) contracts the same as the semiconductor film, then the material is not stretched or compressed (referred to as having “no strain”). When the substrate (green) contracts more, the 2-D material is compressed. When the substrate (red) contracts less, the semiconductor is stretched. Stretching leads to a change in the electronic properties of the film and significantly improves its photoluminescence efficiency, which is important for developing high-efficiency lights and lasers. Credit: US Department of Energy

Compressing a semiconductor to bring atoms closer together or stretching it to move them farther apart can dramatically change how electricity flows and how light is emitted. Scientists found an innovative

way to compress or stretch very thin (monolayer and bilayer) films of tungsten diselenide by placing the film on different surfaces at high temperatures. The underlying surface stretched or compressed upon cooling. Why? With few exceptions, all materials expand when heated and contract when cooled. However, this change happens at different rates. Because the films respond at a different rate than the surface, the films stretch or compress upon cooling. Excitingly, the electronic properties of the stretched films were dramatically different.

Stretching [films](#) to alter how they conduct electricity could lead to brighter LED lights, more efficient lasers, and high-performing electronics. Stretching or compressing films allows for controlled modification of [electronic properties](#) that can be used to explore the underlying physics of the materials. The technique has been used to make 2-D semiconducting films that can be used in different devices.

The electronic and optical properties of materials are directly related to their atomic [crystal structure](#). By bringing atoms closer to each other (compressing) or moving them apart (stretching), one can dramatically change the electronic and [optical properties](#) of materials. Now, researchers in Berkeley, California, have developed a new method to controllably induce up to 1 percent strain due to stretching and 0.2 percent strain due to compression in 2-D [tungsten diselenide](#) (WSe₂). In this study, the researchers grew a semiconductor at a high temperature on different substrates with mismatched thermal properties. Upon cooling, these substrates contracted more or less than the semiconductor. If the substrate contracted more, the 2-D semiconductor film was in compression.

When the substrate contracted less, the crystal structure of the 2-D semiconductor film was stretched. Stretching the film produced a novel change in the electronic properties of the film, and the material changed from being an "indirect" to a "direct" bandgap material which resulted in

the strained material emitting light with the same amount of energy (that is, an increased photoluminescence efficiency). This new method can be used to develop strain engineered 2-D semiconductors and controllably tune their electronic properties. This will allow scientists to develop a better understanding of the material's underlying physics as well as produce new [materials](#) for the development of highly efficient electronic devices.

More information: Geun Ho Ahn et al. Strain-engineered growth of two-dimensional materials, *Nature Communications* (2017). [DOI: 10.1038/s41467-017-00516-5](#)

Provided by US Department of Energy

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