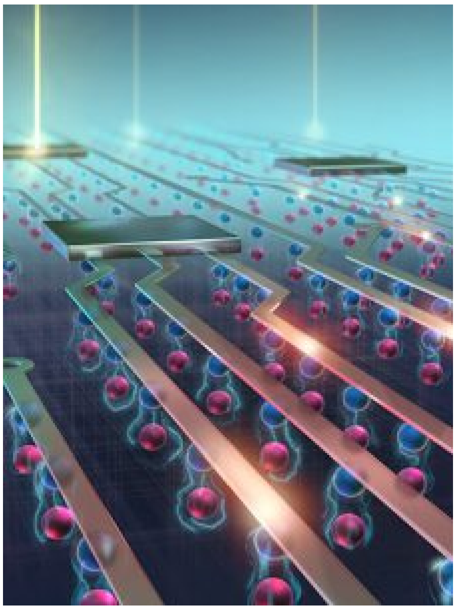
Could Excitons Aid Optical-Electronic Interconnects?

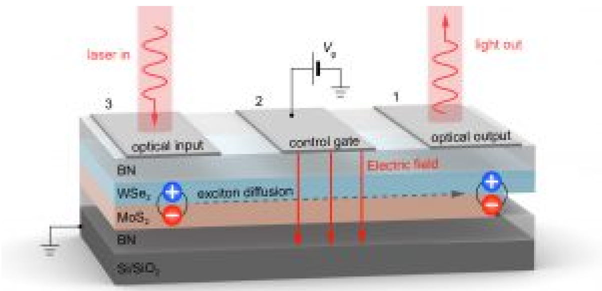
A nagging efficiency bottleneck in today's communications networks is the need to convert between the optical signals that transmit data over long distances, and the electrical signals used in data processing. One potential solution lies in devices that manipulate not electrons or photons, but "excitons"—the bound electron-hole pairs formed when photons excite electrons in a semiconductor. But thus far, the "excitonic" devices demonstrated using bulk semiconductor materials have had to operate at frigid temperatures, a disadvantage that has held back practical applications. Now, a Swiss-Japanese research team has used an ingenious stack of 2-D materials to develop a key component for practical excitonics: an excitonic transistor that can operate at room temperature.



The heterostructure difference

At the heart of the system are layers of two atomically thin TMDs, molybdenum disulfide (MoS_2) and tungsten diselenide (WSe_2). Because of the differing band structure of the two materials, when an exciton is created in the heterostructure (for example, by absorption of a photon), the electron tends to reside in the MoS_2 layer, while the hole stays in the WSe_2 layer. The result is a system in which the exciton "lives" not in a single 2-D material layer, but *between* the two layers.

Such an interlayer exciton, it turns out, has a spatial separation between the electron and the hole that's large enough to allow the exciton to survive 100 times longer than it would in a single 2-D material layer. Yet the exciton can still exist and thrive at room temperature. Further, the two-layer structure means that the exciton has a built-in out-of-plane dipole moment. That means it can be manipulated and controlled by an electric field and voltage bias in ways that would be impossible with excitons in a single 2-D layer.



Graphene gates

The team found that the interlayer excitons were sufficiently long-lived to diffuse across a distance as long as five microns within the structure before recombining and emitting light. Further, the flux of excitons could be controlled and manipulated electrically by applying different voltage biases using the graphene electrodes, in transistor-like fashion.

For more information: Nature, doi: [10.1038/s41586-018-0357-y](10.1038/s41586-018-0357-y)