SEMICONDUCTORS & MICROELECTRONICS
QUANTUM MATERIALS

University of Arizona researchers harness quantum materials to dramatically improve power consumption in electronic devices.

LabMonti™ uses the most advanced methods to study the electronic structure of quantum materials, including their spin degrees. Quantum materials support novel types of behavior that are robust to external perturbations, impurities and extreme environments. Understanding how such behaviors emerge and how they can be controlled from the atomic to the device level requires fabrication and tailoring of the materials. LabMonti™ achieves this understanding by assembling the materials into precisely-controlled heterostructures and investigates their electronic and magnetic structure, including on extremely short timescales and at the absolute nanoscale of single molecule devices.

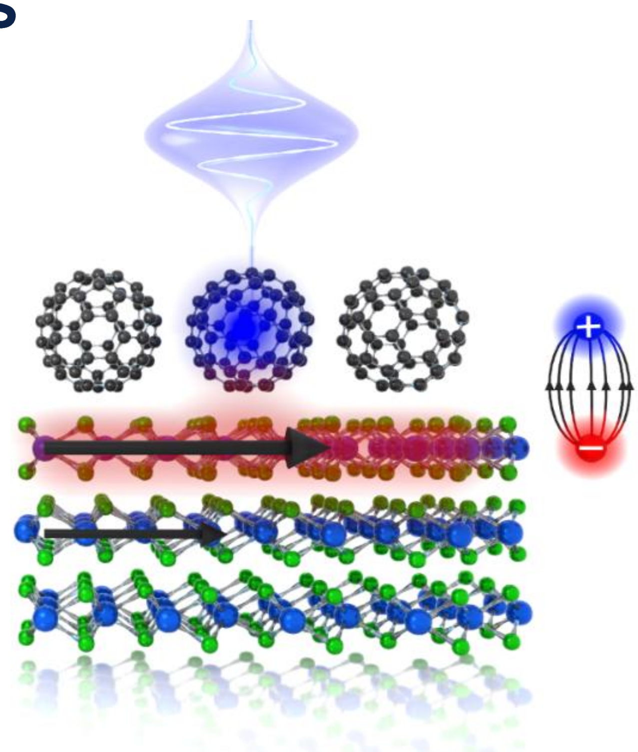

Figure 1. Generation of magnetism in 10^{-13} s in molecular-2D semiconductor heterostructure.

Quantum materials and electronics

The research miniaturizes electronics to their ultimate size limits at molecular length-scales and reveals new low-energy properties that lend themselves to efficient low-power electronics and spintronics. Our ability to tailor quantum materials, as well as to control charge-flow through single molecules, aims to make the emerging quantum effects stable at elevated temperatures and under extreme conditions, and enables new modalities for electronics and spintronics.

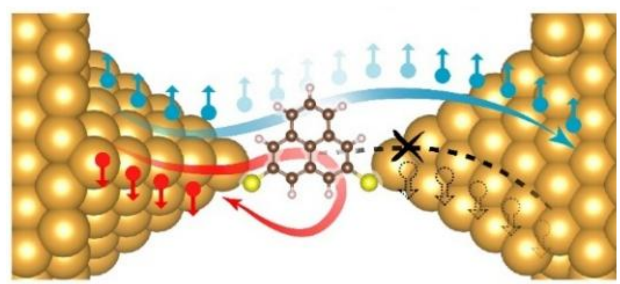

Figure 2. Single molecule device acting as spin filter.

How it fits in semiconductor fabrication processes

New materials and device concepts are needed to overcome the challenges of increasing power consumption of semiconductor-based devices. This need requires low-energy modes for charge and spin to flow, which are supported by quantum materials. LabMonti™ develops fabrication protocols to tailor these materials, including at the single molecule level, with the purpose of both understanding and controlling their properties.

Applications for next-generation microelectronics

New materials will have to play a central role in next-generation electronics, perhaps pivoting from charge currents to spin currents so as to lower power consumption and enable new and potentially ultrafast operation. We investigate how such materials may be tailored and reliably controlled.

More information: S. Steil et al., Spin-dependent trapping of electronics at spinterfaces. *Nature Physics* (2013). doi: 10.1038/nphys2548

B. Arnoldi et al., Revealing hidden spin polarization in centrosymmetric van der Waals materials on ultrafast timescales. *Nature Communications* (2024). doi: 10.1038/s41467-024-47821-4

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