ARIZONA

SEMICONDUCTORS & MICROELECTRONICS
QUANTUM LIGHT SOURCES

University of Arizona researchers develop quantum dots for applications in computing and information technologies.

Quantum dots are devices that localize particles to nanoscale dimensions. Schaibley uses nanofabricated electronic devices to engineer quantum dots that trap single excitons (IX)—optically excited states in the semiconductor that couple strongly to light. By trapping single excitons, the quantum dots emit single photons which can be used as quantum bits (qubits) for optical quantum computers or to transmit ultra-secure quantum information.

Quantum engineering of electronics

Single photon sources are key resources for a variety of quantum computing, sensing and communication protocols. Two challenges limiting the application of quantum dots in quantum technology are the lack of controlled placement and control over emission wavelength. In our approach, the single photon sources are realized by nanofabricating a 2D material electrical gate that generates a trapping potential. This allows for the position of the quantum dot to be precisely controlled and for the wavelength of the quantum dot to be tuned. Our approach can potentially solve the two major challenges and allow for quantum photonic devices.

How quantum dots fit in semiconductor fabrication

Quantum dots are devices that will serve as crucial resources for the generation of single photons. In a future photon-based quantum computing architecture, the quantum dots can serve as sources of high quality semiconductor based single photons. These single photons can encode the quantum bits of information that form the basis of quantum processors.

Figure 1: Nanofabricated few-layer-graphene in the shape of Arizona.

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John researches electronic, optical and spin effects in solid state systems and their applications to technology. Interests include spin and optoelectronic physics of 2D semiconductors and other layered devices that take advantage of novel physics at atomically-sharp disparate material junctions.

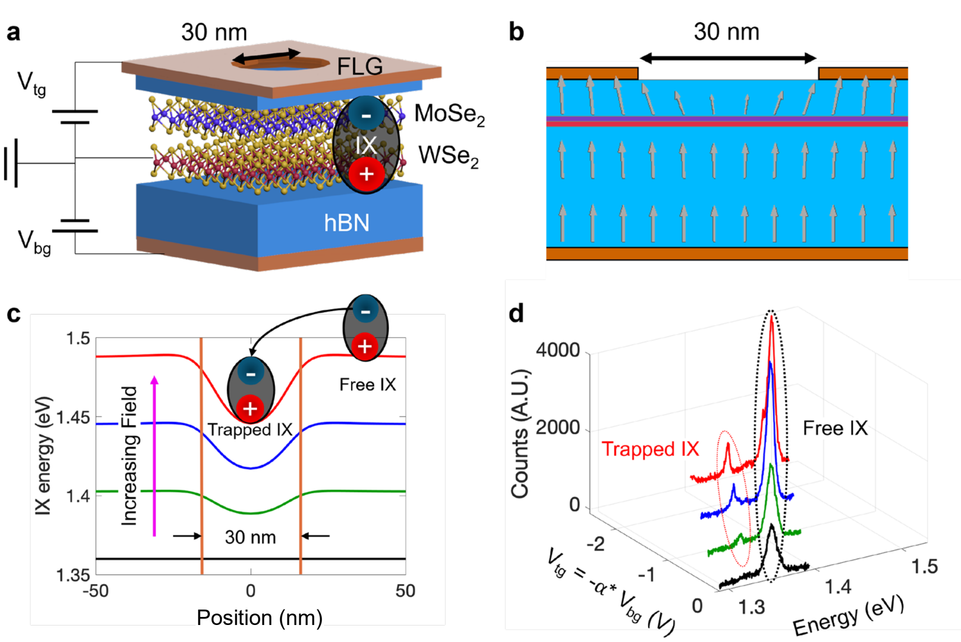

Figure 2: Nanoscale trapping of excitions (IXs) in an $MoSe_2$-WSe_2 heterostructure. (**a**) Depiction of the nanopatterned heterostructure device. (**b**) COMSOL model, showing the profile of the electric field (gray arrows) with a patterned graphene top gate. Graphene gates are shown in orange, hBN is shown in blue, and TMD layers are shown in purple and red. (**c**) Calculated IX energy as a function of position for four applied electric fields. The black line shows no applied field, green and blue lines show increasing fields, and the red line shows the IX potential energy profile for the maximum field applied to the device. Orange lines mark the edges of the graphene hole. (**d**) Photoluminescence (PL) from the free and trapped IX signals for different trapping gate strengths. The black line shows the PL signal with no applied field, and green, blue, and red lines show the PL signal as fields of increasing magnitude are applied.