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Semiconductor quantum devices & Quantum physics in emergent crystalline materials/strongly correlated electronic systems

Our group "Quantum Device Laboratory" of Electrophysics Department, NCTU works on development of functional quantum devices for fundamental research and also their applications for quantum electronics.

Our primary research interests include:

a. **Quantum Control of Electron Spins:** Coupling of electron spins to either electric or magnetic field has long been tantalizing for fundamental research and targeted for various applications. We have demonstrated: (1) Control of spin dynamics of both spin species by the effective magnetic field from spatially varying spin-orbit coupling (Fig. 1); (2) Access to the electron spins in a quantum wire by the entangled quantum dot spin (Fig. 2).

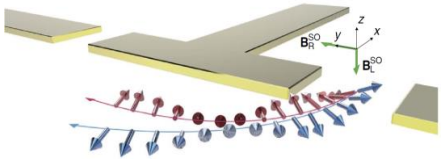

Fig. 1 Scheme to control spin dynamics

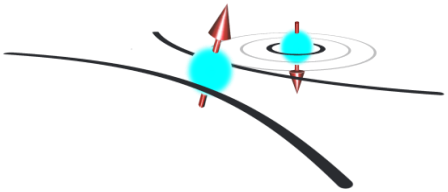

Fig. 2 Scheme to entangle dot and wire electron spins

b. **Superconducting Devices:** We have studied a hybrid nanoelectronic system which consists of an AlGaAs/GaAs two-dimensional electron gas (2DEG) in close proximity to an Al superconducting nanofilm. By tuning the current through the Al film, we can change the conductance of the 2DEG and furthermore vary the effective disorder in the Al superconducting film itself in a controllable way. Our results may open a new avenue of experimentally understanding superconductivity (Fig. 3).

c. **Quantum Transport in Crystalline Materials:** We have studied quantum transport properties in various crystalline materials involving functionalized graphene, transition metal dichalcogenides, complex oxide heterostructures, etc. Recently, we have demonstrated an approach to create a gate-free pn diode by integrating WSe_2 and ferroelectric $BiFeO_3$ substrate.

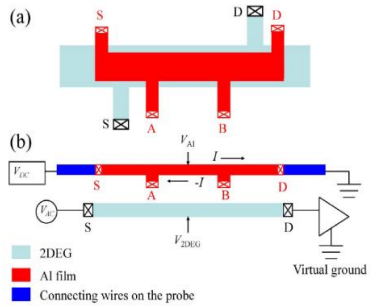

Fig. 3 (a) The sample layout, and (b) measurement circuit for superconductor-semiconductor devices

Quantum Device Laboratory

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