Quantum Rivals in Nitride Materials

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Nitride-based semiconductors are now widely employed in high-frequency and opto-electronics applications. *However, nitrides are largely unexplored as hosts for quantum computation and cryogenic electronics.* To demonstrate the feasibility of nitrides for these applications, MagLab users developed a nitride superconductor / semiconductor heterostructure in which these two quantum states occur and in which electron transport exhibits high performance at low temperatures.

In particular, the team investigated an epitaxial heterostructure that combines the semiconductor GaN with the superconductor NbN. They measured longitudinal resistance and the Hall resistance in the GaN two-dimensional electron gas as a function of magnetic field and gate voltage to explore the quantum Hall effect. They also measured the longitudinal resistance in the NbN superconducting layer as a function of temperature and magnetic field to determine the limits of superconductivity. *They discovered that the quantum Hall state in GaN coexists with superconductivity in NbN in the same structure (Fig.1a) over a range of field and temperature*.

If the semiconductor enters the quantum Hall state in proximity to a superconductor, one could achieve topological superconductivity, which can be used for quantum computing.

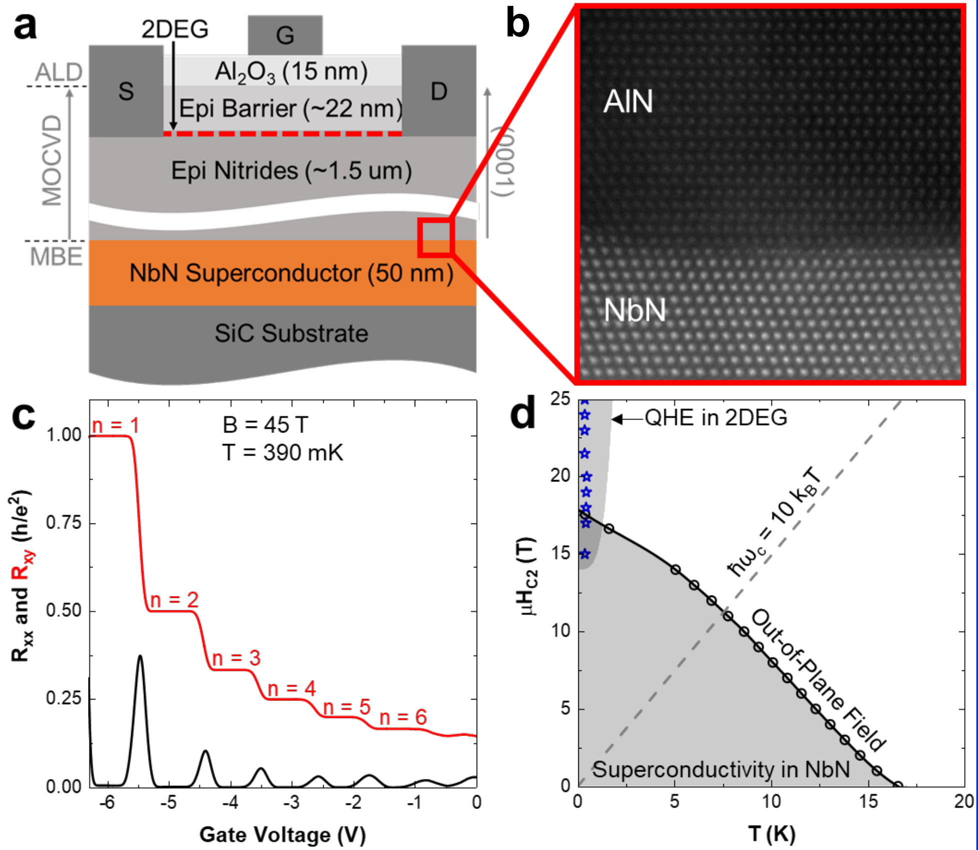

Fig.1 (a) Layer structure of the epitaxial nitride heterostructure. **(b)** High-resolution transmission electron microscopy image of the semiconductor /superconductor interface. **(c)** The quantum Hall effect in the GaN semiconductor. **(d)** The temperature and magnetic field region where superconductivity in NbN and the quantum Hall effect in GaN coexist.

Instrumentation used: 45T Hybrid magnet, DC Field Facility

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