Probing charge Transport in quasi-1D Layered Semiconductors Towards Quantum Applications

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The advancement of quantum technologies in sensing and fault-tolerant computation hinges on the ongoing evolution of material platforms and the creation of scalable device architectures. The quantum leap has largely benefited from the maturity of silicon technology, but certain challenges still remain, prompting exploration into novel materials and concepts.

Unique properties of layered materials have already revolutionized electronic concepts, circumventing many challenges of conventional silicon-based technologies. However, many aspects of 2D materials remain unexplored. Among these, intrinsic in-plane anisotropy remains largely underutilized. For example, theoretical predictions [1, 2] suggest that the natural carrier confinement in transition metal trichalcogenide TiS_3 along the long in-plane crystallographic axis produces an order-of-magnitude higher electron mobility compared to the carrier mobility in the perpendicular direction. Moreover, the crystalline anisotropy in TiS_3 promotes anisotropic crystal growth, yielding quasi-1D nanoribbons that can be exfoliated down to a few-layered narrow crystals. With the ribbon width well below 100 nm, semiconducting TiS_3 presents a natural platform to engineer quantum confinement for quantum dots and solid-state spin qubits. In this talk, I will present our efforts toward implementing a quantum dot device based on semiconducting quasi-1D crystals like TiS_3. To this end, we engineered ohmic electrical contacts for TiS_3 at temperatures down to a few kelvins. We demonstrated a contact resistance below 2 kΩ/µm at 5 K, the lowest value reported for TiS3 to date. This allowed us to gain insights into the semiconducting behavior of TiS_3 at low temperatures and observe the Coulomb blockade effect in short-channel field-effect transistors (Fig. 1) [3]. At the end of the talk, I will discuss the feasibility of quasi-1D layered materials for quantum applications, their advantages, and important steps toward their rapid implementation.

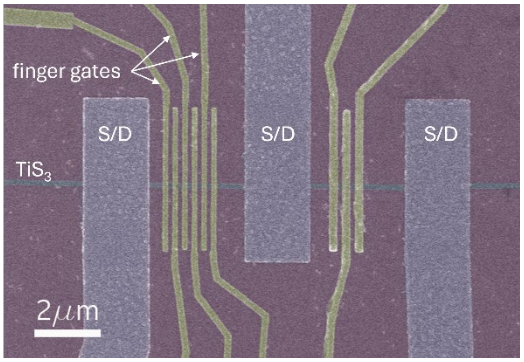

Figure 1. False colour scanning electron microscopy (SEM) image of the TiS_3 field effect device.

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References

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