A Topological Insulator Field Effect Memristor

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Our current computing architectures face fundamental limitations such as the Boltzmann tyranny, which sets a lower bound on efficiency, and the von Neumann bottleneck, which limits computation speed due to data transfer between components. In recent decades, two non-classical architectures have emerged: quantum computing and biology-inspired computing. Both offer massive parallel processing and potential exponential speed-ups for specific tasks. Quantum computing relies on qubits' coherent properties, while biology-inspired computing depends on unit-environment interactions. Though these approaches seem distinct, devices with non-trivial band topology could bridge them, creating new computing schemes with coherent properties in an interacting environment.

In my talk, I will present a topological insulator (TI) based on InAs/Ga(In)Sb/InAs trilayer quantum well (TQW) that exhibits the Quantum Spin Hall effect (QSHE) up to 60K. The TQW offers a rich phase diagram, including direct or indirect inverted band gaps and gapless phases. With memristive functionalities, this device can emulate synapse-like behavior and neural networks. Non-local measurements show current carried in helical edge channels with spin-polarized coherence. The realization of a Topological Insulator Field Effect Memristor paves the way for biology-inspired networks utilizing these coherent edge states.