Electron spin resonance transistors for quantum communication and computing

E. Yablonovitch
UCLA

We apply the full power of modern electronic band structure engineering and epitaxial heterostructures to design a transistor that can sense and control a confined electron spin. Spin resonance transistors may form the technological basis for quantum information processing in the new century. This new type of transistor will be similar in size to the transistors on the SIA Roadmap, but their design will emphasize the manipulation of an electron spin confined near a Field Effect Transistor channel. The *spin transistor* is expected to be the enabling device for quantum information processing, and quantum communication.

One and two qubit operations are performed by applying a gate bias. The bias electric field pulls the electron wave function between layers of different alloy composition. Owing to the variation of the g-factor (e.g. GaAs: g = -0.44, AlGaAs: g = +0.4), this displacement changes the spin Zeeman energy, allowing single-qubit operations. By displacing the electron even further, the overlap with neighboring qubits is affected, which allows two-qubit operations. Certain silicon-germanium and III-V alloys allow a qubit spacing as large as 200 nm, which is well within the capabilities of current lithographic techniques. A key enabling device for quantum communication is an entanglement-preserving-photo-detector that converts photon polarization to photo-electron spin, and *vice versa*, based on semiconductor spin selection rules.