# Quantum Energy Density Resonant Transistor Using Magnetic Confinement for Subthermal Switching

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## Background

Current CMOS scaling is severely constrained by the thermionic subthreshold swing limit of 60 mV/decade due to the Boltzmann tail of carrier distribution. Though novel approaches such as tunneling field-effect transistors (TFETs), negative capacitance FETs (NC-FETs), and cryogenic superconducting logic exist, they either suffer from practical limitations or fail to deliver on energy efficiency and manufacturability.

The present invention discloses a transistor structure that utilizes quantum energy density resonance via magnetic field confinement to enable switching behavior that bypasses the thermal limit, allowing sub-10 mV/decade performance with low power consumption and potentially room-temperature superconducting-like behavior.

## Summary of the Invention

The proposed device operates on a principle whereby an injected carrier matches a critical energy density threshold established by the field configuration in space, leading to frictionless, full-transmission switching behavior analogous to that observed in superconductivity or topologically protected transport.

## Claims (Draft Outline)

### Claim 1: Device Structure

A quantum resonant transistor comprising:

- A semiconductor or quantum well channel;
- A gate electrode modulating the energy level of carriers;
- A top and a bottom magnetic confinement layer producing a vertical magnetic field aligned through the channel;

- Said magnetic field establishing quantized Landau levels or equivalent density-defined modes for resonance.

### Claim 2: Resonant Switching Condition

Wherein switching occurs when the carrier's spatial energy density equals a quantized threshold defined by the field confinement, leading to zero reflection, maximum transmission, and subthermal subthreshold swing behavior.

### Claim 3: Magnetic Field Control

Wherein the magnetic field applied ranges between 10 T to 50 T, sufficient to induce quantized energy gaps of several meV, enabling control of switching thresholds at energy densities corresponding to the FQHE or Landau quantization regimes.

### Claim 4: Superconducting-like Transport

Wherein the device shows minimal scattering, resembling superconducting transmission due to field-induced coherence, and operates at room temperature in specially engineered channel geometries.

### Claim 5: Fabrication and Integration

Wherein the device is fabricated on a silicon or compound semiconductor platform using permanent magnet or microcoil-induced vertical fields and is compatible with standard CMOS processing.

## Applications

- Energy-efficient AI and logic processors
- Quantum–classical hybrid computing
- Cryogen-free superconducting logic
- Ultrafast, low-noise analog switches

## Figures

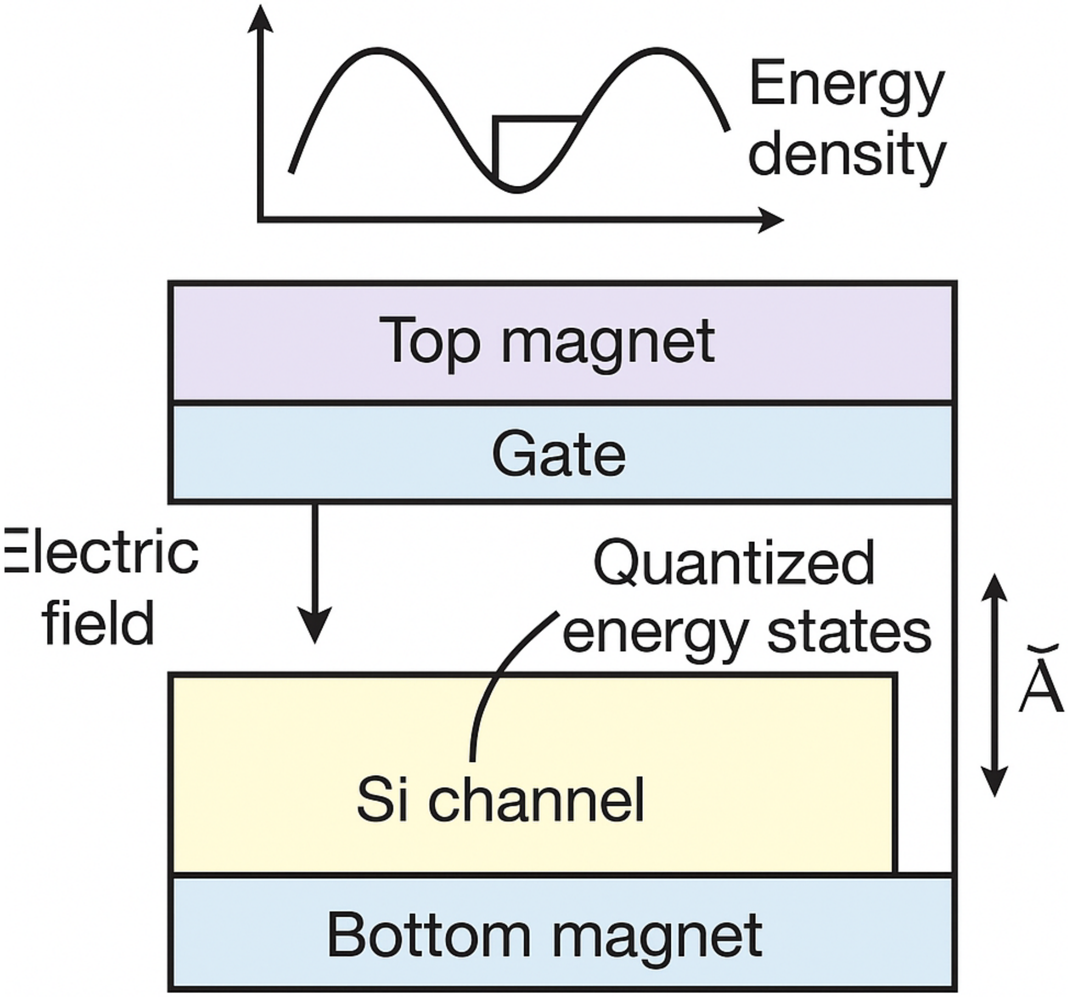

Figure 1: Cross-sectional schematic of the transistor showing vertical magnetic confinement.

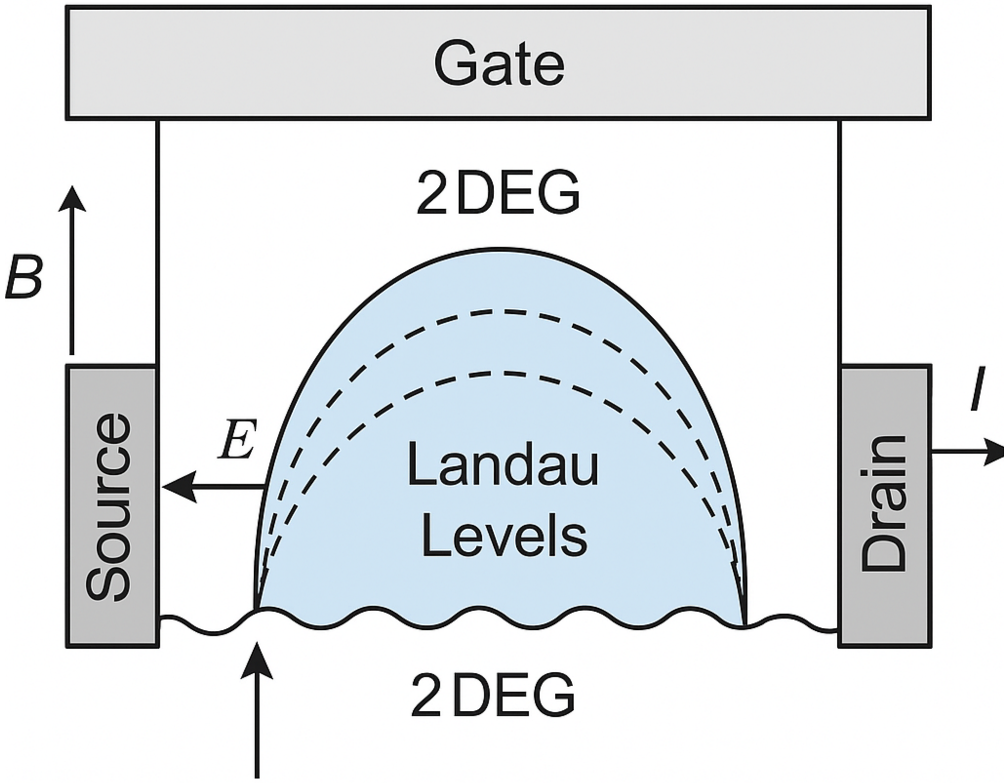

Figure 2: Magnetic quantization energy band structure illustrating Landau levels.

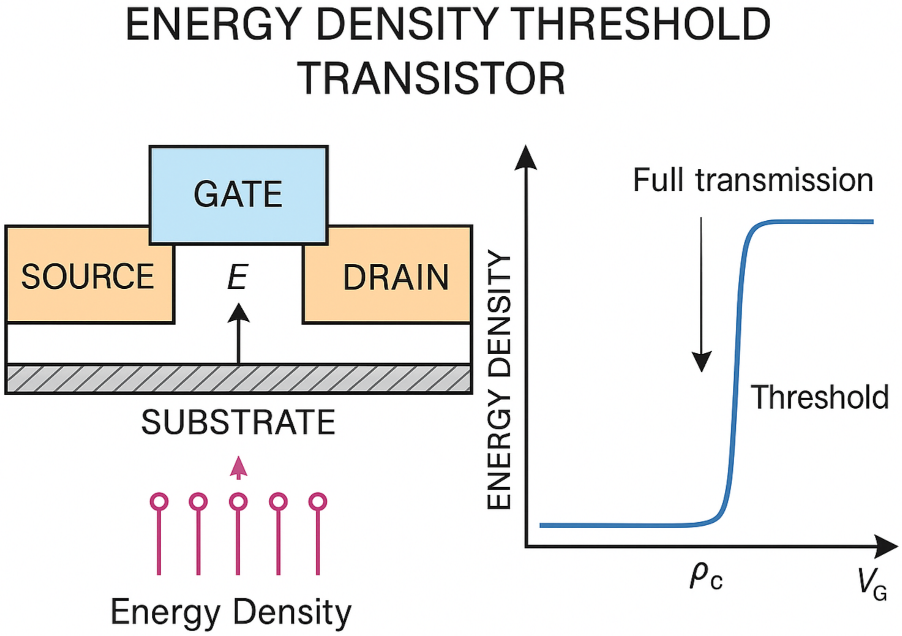

Figure 3: Subthreshold resonance operation diagram for 3 mV/decade steep slope transistor.