Technology Offer

Magnetic-Field-Free Nonreciprocal Solid-State Quantum Device Using Quantum Wave Collapse and Interference

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A novel solid-state quantum device that enables nonreciprocal transport of quantum waves without external magnetic fields has been developed. The invention combines longitudinally asymmetric transmission structures with quantum-wave interference and controlled wavefunction collapse (decoherence) to preferentially transport photons, electrons or other quantum waves in one direction. The technology offers a fundamentally new approach to realizing nonreciprocal devices that can be implemented in semiconductors, molecular electronics, integrated photonics and optical systems.

Background

Nonreciprocal components such as isolators and circulators are essential for photonic, electronic and quantum systems. Existing solutions generally require magnetic fields, magneto-optic materials or chiral structures, which increase device complexity, complicate miniaturization and limit integration into semiconductor platforms.

Technology

The patented invention comprises a transmission structure connected between at least a first and a second port. The transmission structure is engineered so that quantum waves travelling in opposite directions experience different propagation times or different probabilities of decoherence. The asymmetry can be created by: geometrically asymmetric transmission paths, asymmetric electrical contacts, different materials at the two ports, incorporated defects or inelastic scattering centres, molecular conductors, semiconductor nanostructures, optical projection systems.

Quantum waves generated at one port propagate through the transmission structure where partial wavefunction collapse or decoherence occurs. Because of the longitudinal asymmetry, the probabilities for transmission differ for opposite propagation directions, resulting in nonreciprocal transport without the need for externally applied magnetic fields. Embodiments for electrons, photons and other quantum waves, together with implementations in semiconductor, molecular and optical systems are possible.

Innovative Aspects

- Magnetic-field-free nonreciprocal transport
- Longitudinally asymmetric transmission structures
- Utilisation of quantum-wave collapse and decoherence
- Passive operating principle
- Scalable arrays of multiple quantum devices
- Flexible implementation across multiple material platforms.

Advantages

- Eliminates the need for external magnetic fields
- Facilitates chip-scale integration
- Compatible with semiconductor manufacturing technologies
- Suitable for integrated photonics and molecular electronics
- Multiple implementation routes
- Platform technology for future quantum transport devices.

Potential Applications

- Integrated photonic circuits
- Optical isolators and optical routing devices
- Quantum communication systems
- Quantum information processing
- Semiconductor electronics
- Molecular electronics
- Nanophotonic devices
- Quantum sensors
- Scientific instrumentation
- Wave-based signal processing
- Quantum transport research

Patent Information

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