LIGHT-DRIVEN ULTRAFAST ELECTRIC GATING

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PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Published Application	20230110264	04/13/2023	2022-041

BRIEF DESCRIPTION

The inventors have discovered a new way to generate ultrafast back-gating, by leveraging the surface band bending inherent to many semiconductor materials. This new architecture consists of a standard bulk semiconductor material and a layered material on the surface. Optical pulses generate picosecond time-varying electric fields on the surface material.

The inventors have successfully applied this method to a quantum well Rashba system, as this is considered today one of the most promising candidates for spin-based devices, such as the Datta Das spin-transistor. The technology can induce an ultrafast gate and drive time-dependent Rashba and quantum well dynamics never observed before, with switching faster than 10GHz. This approach minimizes lithography and will enable light-driven electronic and spintronics devices such as transistors, spin-transistors, and photo-controlled Rashba circuitry. This method can be applied with minimal effort to any two-dimensional material, for both exfoliated and molecular beam epitaxy grown samples.

Electric field gating is one of the most fundamental tuning knobs for all modern solid-state technology, and is the foundation for many solid-state devices such as transistors. Current methods for in-situ back-gated devices are difficult to fabricate, introduce unwanted contaminants, and are unsuited for picosecond time-resolved electric field studies.

SUGGESTED USES

Semiconductor device manufacturers can use this gating technique for development of ultrafast gated 2D material devices as well as photo-electronic components. This technology can also serve as a clean method to explore/test material properties under ultrafast external fields.

Examples of device applications include:

- photo-transistors
- spin-transistors/spin-current filters (the inventor prototype demonstrated ultrafast gate controlled Rashba splitting)
- photodetection
- solar cells

ADVANTAGES

Typical gating geometries require a physical backgate which requires lithography steps as well as an additional electrode to supply the voltage. That typical method sets a determined location for the region of gating and, for ultrafast applications, requires careful consideration of the AC characteristics of the gate voltage wiring to ensure proper ultrafast gate operation.

In contrast, the new method removes the need for a lithographed backgate. The gate is the substrate material itself, in which many semiconductor materials already used in typical semiconductor processing can serve as suitable SPV substrate candidates. Since the gate is operated with focused laser light, the geometry, location, and timing of the gating region is flexible, allowing for complex operations across an integrated wafer without intricate arrangements of gating structures. Moreover, the light-driven aspect of the gating method enables novel

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OTHER INFORMATION

KEYWORDS

gating, semiconductor, electric field

CATEGORIZED AS

- **Optics and Photonics**
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- **Computer**
  - Hardware
- **Energy**
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device creation for applications that combine photonic and electronic processes. 2022-041-0

RELATED MATERIALS

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