GIANT ENERGY AND POWER DENSITY MICROCAPACITORS VIA FERROIC ORDER SUPERLATTICES

Tech ID: 33483 / UC Case 2024-082-0

PATENT STATUS

Patent Pending

BRIEF DESCRIPTION

UC Berkeley researchers have developed a high-performance microcapacitor technology that achieves record-breaking energy and power densities for on-chip storage. The microcapacitor is constructed within a 3D trench in an insulating layer, featuring a unique superlattice structure composed of alternating atomic layers of antiferroelectric and dielectric films. By engineering these films (such as hafnium oxide and zirconium oxide) near a field-driven phase transition, the devices leverage a "negative capacitance" effect that significantly amplifies charge storage. This architecture scales energy storage beyond the conventional thickness limits of standard thin films, delivering an energy density of at least 20 mJ/cm² and a power density of at least 10 kW/cm². These microcapacitors can be fabricated in large arrays using standard microelectronic processes, making them ideal for seamless integration directly onto silicon chips.

SUGGESTED USES

- On-Chip Energy Storage: Providing local power delivery for next-generation microprocessors and high-performance computing chips to reduce power distribution losses.
- Internet-of-Things (IoT): Powering autonomous miniaturized sensors and edge computing systems that require long lifespans and rapid charge-discharge cycles.
- Artificial Intelligence Processors: Supporting the high power-delivery demands of specialized AI hardware and neural network accelerators.
- Micro-Electromechanical Systems (MEMS): Serving as stable, integrated micro-power supplies for miniaturized mechanical and electronic sensors.
- Mobile and Wearable Electronics: Enabling smaller, more efficient battery-management systems by providing high-frequency power buffering on-chip.

ADVANTAGES

- Record Performance: Offers simultaneously high energy and power densities—up to 9 times more energy and 170 times more power than the best-known current electrostatic capacitors.

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INVENTORS

- Salahuddin, Sayeef

OTHER INFORMATION

CATEGORIZED AS

- **Computer**
  - Hardware
- **Energy**
  - Other
  - Storage/Battery
- **Research Tools**
  - Other
- **Semiconductors**
  - Design and Fabrication
  - Materials
- **Sensors & Instrumentation**
  - Other
  - Scientific/Research

RELATED CASES

2024-082-0

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Ultrafast Operation: Enables charge and discharge rates significantly faster than electrochemical batteries or microsupercapacitors.

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CMOS Compatibility: Fabricated using materials and techniques already widespread in the semiconductor industry, allowing for monolithic integration with standard silicon electronics.

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Overcoming Thickness Limits: Superlattice engineering allows the material to retain its high-storage properties at thicknesses (up to 100 nm) where standard films typically lose efficiency.

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Longevity and Reliability: As an electrostatic device, it supports a theoretically infinite number of charge-discharge cycles without the degradation typical of chemical batteries.

RELATED MATERIALS

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Dynamic Read FEFET Memory
- Superlattice, Ferroic Order Thin Films For Use As High/Negative-K Dielectric

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