Development of highly stable spin torque oscillators

Nanometer-scale microwave generator capable of implementing in LSI or wireless communication device

We have developed highly stable spin torque oscillators (STOs) using nanocontact-shaped magnetic tunnel junctions (MTJs). Our first demonstration of high-power STOs using nanopillar-shaped MTJs in 2008 unfortunately ended up with unstable oscillation frequency caused by the non-uniform precession of the in-plane magnetizations. The present study proposes a newly developed nanocontact-shaped MTJ with improved performance, uniquely suitable for STO. We applied a magnetic field along the out-of-plane direction of the surface inducing a stable out-of-plane precession in the STO. A very narrow spectrum with a high $f/\Delta f$ (f: oscillation peak frequency, ~10 GHz, Δf: peak width) value of over 3000 was achieved while maintaining a high emission power. Incorporating unique features, such as small size, auto-oscillative character without the need of a resonator, and high frequency tunability, the newly developed STO will be a potential candidate for nanometer-scale microwave generators in LSIs and communication devices as well as highly sensitive magnetic field sensors.

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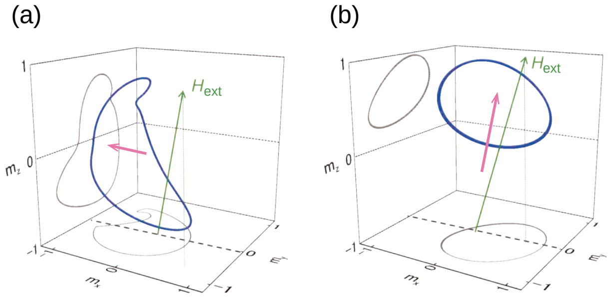

Simulated trajectories during magnetization precession
Blue line represents the trajectory of the magnetization vector during the precession. The green arrow indicates the external magnetic field (H_{ext}) direction and the pink arrow the center axis of the precession. When H_{ext} was small (1 kOe, Fig. (a)), the precession center remained in the in-plane direction, resulting in a distorted trajectory and caused fluctuation in the oscillation frequency. When H_{ext} was large (8 kOe, Fig. (b)), on the other hand, the precession axis aligned parallel to H_{ext}, yielding a circular trajectory with which a highly stable oscillation frequency was obtained. Copyright (2014) The Japan Society of Applied Physics.

Micro-patternable CNT-Cu composite material

High current density tolerance of such CNT-Cu composite wiring, enabling applications in microelectronics

Rapidly evolving architectural and functional complexity of electrical devices has resulted in increasing currents flowing through narrow conducting channels. This has resulted in increased susceptibility to failure of these conducting lines, mainly made of copper (Cu), due to their inability to handle high current density. This created a demand for a material with high electrical conductivity and high current-carrying-capacity (ampacity). To this end, we report micro-fabricated structures made from super-growth single walled carbon nanotubes (CNT) and Cu, capable of withstanding up to 100 times higher current density (600×10^6 A/cm^2) than pure Cu (6×10^6 A/cm^2). We demonstrate exhaustive micro-scale patternability of the CNT-Cu composite material into arbitrary two- and three-dimensional shapes resembling wires, inter-connects, junctions and arrays. The methodology adopted for achieving this is compatible with conventional lithographic techniques, ensuring their facile integration into existing devices and technologies, and targeting practical applications in micro- and nano-electronics.

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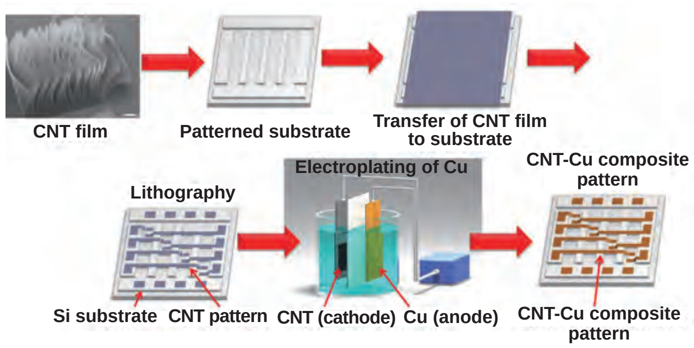

Fabrication protocol of the CNT-Cu composite