

Highly stable diamagnetically levitated mechanical resonators with large masses exceeding 1.5 gram

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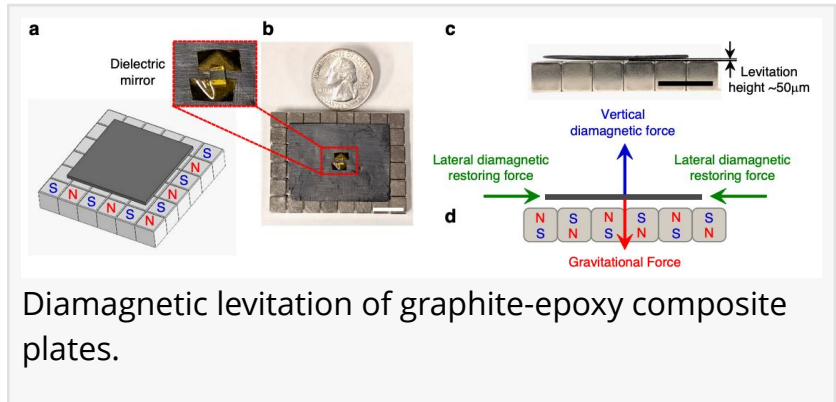
/EINPresswire.com/ -- In a quiet lab shared by the University of Central Florida (UCF) and the University of Florida (UF), a coin-sized black plate hovers above a checkerboard of silver magnets. No wires hold it up, no spinning parts keep it balanced, and no feedback electronics stabilize it. It simply floats—steadily and

silently—while a laser tracks its vibrations. That [levitating plate](#) is far more than a parlor trick. It's a gram-scale mechanical resonator, a new kind of vibrating sensor platform that could underpin next-generation accelerometers, gravimeters, and magnetometers for navigation, space missions, and precision metrology. In their recent study, the UCF-UF team demonstrated a 1.5-gram resonator suspended entirely by diamagnetic levitation at room temperature—a feat that eliminates mechanical supports and the energy losses they normally introduce. Despite its size, the device vibrates with exceptionally low dissipation and extraordinary stability, achieving performance on par with high-end MEMS sensors.

"The idea is simple but powerful: if you never touch the resonator, you never lose energy through its supports," says Jaesung Lee, who led the UCF effort. "Levitation gives us a practical way to do that."

Rethinking the Limits of MEMS Resonators

MEMS resonators, tiny mechanical structures etched from silicon, are the backbone of today's precision sensing. They measure acceleration, rotation, and force with exquisite accuracy, from smartphone IMUs to navigation-grade gyroscopes. But they all share one flaw: they're anchored to a substrate. Those anchors act like tiny energy drains, allowing vibrations to leak into the chip. This clamping loss limits how long a resonator can ring and, therefore, how sharp and stable its frequency response can be. Engineers have tried to overcome it with strain-engineered "soft-clamping" geometries and phononic crystals, but complete isolation has remained elusive. The UCF-UF researchers took a more radical approach: remove the supports entirely.



A “Designer” Diamagnet

The resonator floats using diamagnetic levitation, where materials with negative magnetic susceptibility are repelled by magnetic fields. Graphite is one such material, but it’s electrically conductive—so moving it through a magnetic field induces eddy currents that damp its motion. To overcome this, the team engineered a graphite–epoxy composite: millions of graphite microparticles uniformly dispersed within an insulating epoxy. The graphite provides strong diamagnetic lift, while the epoxy blocks eddy currents, dramatically reducing energy loss.

“We think of it as a designer diamagnet,” says Philip Feng of UF. “We keep the strong levitation response of graphite but suppress the electrical damping that normally kills performance.”

Each plate, a few centimeters wide and a millimeter thick, levitates above an array of cubic neodymium magnets arranged in alternating polarities. The magnetic gradient traps the plate in all three dimensions, keeping it stably suspended tens of micrometers above the array—no feedback, no cooling, just passive physics.

High Q and Extreme Stability

Using laser interferometry, the team measured resonance frequencies around 20–23 Hz with quality factors (Q) up to 32,000 in modest vacuum (~ 25 μ Torr). For a 1.5-gram levitated body, that’s remarkably high—proof that the design suppresses nearly all energy loss. Measurements of residual motion showed velocity fluctuations below 0.5 μ m/s, meaning the plate remains virtually motionless. When its frequency was tracked with a phase-locked loop, the device exhibited sub-millihertz drift and an Allan deviation as low as 1.5×10^{-6} at a 20 second averaging time. From these results, the researchers estimate a thermomechanical acceleration sensitivity of 2.4×10^{-11} g/ $\sqrt{\text{Hz}}$ —orders of magnitude better than commercial MEMS accelerometers. In addition, by bringing a small permanent magnet near the plate, they demonstrated magnetic-field sensing with a responsivity of 0.45 Hz/mT, confirming that the system can act as both accelerometer and magnetometer.

Toward Anchor-Less Precision Mechanics

This gram-scale, passively levitated platform bridges two frontiers: the high-Q world of engineered MEMS resonators and the emerging field of levitated opto- and magneto-mechanics. It combines the best of both—macroscopic mass, low dissipation, and ambient-temperature operation. Future work will focus on increasing the resonance frequency, isolating the system from environmental vibrations, and integrating compact optical readout. But even now, the message is clear: the ultimate way to eliminate energy loss is to remove every physical connection.

“By letting the resonator float freely, we gain mechanical stability that’s difficult to achieve any

other way.”

Quietly hovering above its magnets, the levitated plate points to a future of anchor-less, ultra-stable mechanical sensors—where precision is achieved not by holding a device tightly, but by letting it float perfectly free.

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