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'Negative stiffness' used to damp vibrations

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PORTLAND, Ore. — Angstrom-level accuracy is needed to stabilize platforms used in applications like microelectromechanical system testing, nanoscale metrology and semiconductor fabrication tools. One company is developing products based on a mechanism called negative stiffness to cancel vibrations.

"The U.S. Air Force couldn't find a place quiet enough to test their next-generation accelerometers and gyros," said David Platus, CEO of Minus K Technology Inc. (Inglewood, Calif.). "That got me thinking about a negative stiffness mechanism to cancel out vibrations."

Since the 1960s, the best way to isolate precise instruments like atomic-force and scanning-tunneling microscopes along with fab tools from vibration was passive air tables that support weight on a cushion of air. A recent alternative is using active electronic feedback to send canceling forces that damp out oscillations in springs.

Platus claimed his patented negative stiffness mechanism outperforms active systems while undercutting the price of passive systems.

"Our negative stiffness mechanism exerts an opposing force which cancels out the stiffness in a spring," said Platus. The result is "isolation that is twice as good as other active systems, but for half the price of air table-style passive vibration isolation systems."

Minus K has amassed a patent portfolio covering its negative stiffness mechanism. Its products offer vibration isolation payload capacities ranging from a 10-pound tabletop unit to 10,000-pound floor panels. When adjusted to a 0.5 Hz natural frequency, the vibration isolators achieve 93 percent isolation efficiency at 2 Hz, 99 percent at 5 Hz and 99.7 percent at 10 Hz, the company claims.

Most platforms, even those with active stabilization, have a certain positive stiffness coefficient that determines their natural resonant frequency—usually 1 Hz or higher. By subtracting a spring's negative from positive stiffness, Minus K's negative stiffness mechanism can block nearly all vibrations higher than 0.5 Hz, it claimed.

A key application is controlling vibrations in chip manufacturing equipment. "Transistors have critical dimensions down around 25 nanometers and the most critical dimension is the oxide thickness, which is 1 nanometer," said David Ferry, a nanotechnology researcher and engineering professor at Arizona State University.

"You have to control 1-nanometer vertical thickness over 300 millimeters of lateral dimension," Ferry added. "That defines modern manufacturing technoloy's need for effective vibration isolation, which has never been greater than today, and will continue to become more demanding as the nano industry progresses."

Arizona State University isolates its atomic-force and scanning-tunneling microscopes with Minus K's vibration isolation technology.