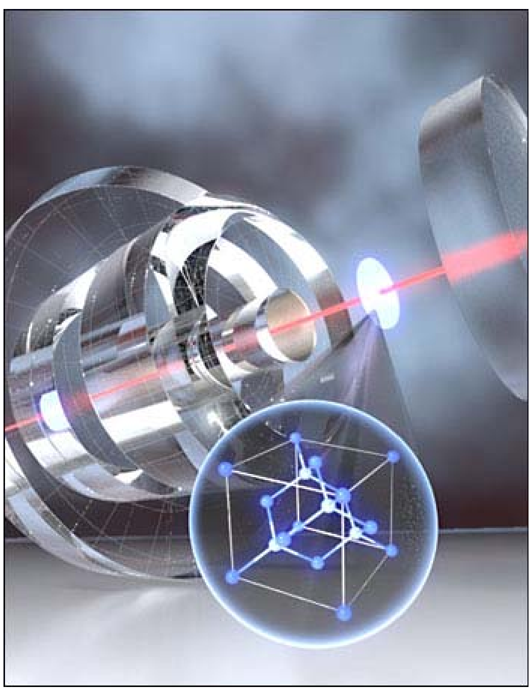
Optical Coatings Take a Leap Forward

VIENNA, and BOULDER, Colo., July 23, 2013 — A novel crystalline coating technique that produces low-loss mirrors could help accelerate progress in the development of lasers for precision measurement applications.

The work, a collaboration by the University of Vienna and JILA, a joint institute of the University of Colorado at Boulder and NIST, builds on advancements in semiconductor lasers, quantum optomechanics and microfabrication to demonstrate low-loss mirrors based on substrate-transferred epitaxial multilayers that exhibit both unprecedentedly low mechanical loss and high optical quality. This enables an order-of-magnitude reduction in coating Brownian noise, the team said in its paper, appearing online this week in *Nature Photonics* (doi: 10.1038/nphoton.2013.174). The creation of such high-quality optical coatings could have a significant impact on the performance of narrow-linewidth lasers used in precision sensing applications.

For the past decade, researchers working in precision measurement have been searching for a solution to the problem of excessive mechanical damping of the high-reflectivity coatings that make up the cavity and mirrors used in optical interferometry, and the inherent mechanical fluctuations they generate. Such fundamental thermal processes are becoming a barrier to ever more precise measurements of time and space, such as those obtained using optical atomic clocks and interferometric gravitational wave detectors.



An artist's rendering of an exploded view of the crystalline coating cavity. One of the bonded mirror discs, the key element of the low-noise reflectors, can be seen here separated from the glass substrate, along with a magnified view of a unit cell of the AlGaAs crystal structure. Courtesy of Brad Baxley, JILA Scientific Reports Office.

A solution needed to allow for the development of high-reflectivity mirrors that also exhibit high mechanical quality. The Austria-US team devised such a solution by combining aspects of semiconductor mirrors borrowed from surface-emitting lasers, an epitaxial layer transfer technique gleaned from advanced nanofabrication processes, and an extensive knowledge of mechanical loss gained from the field of cavity optomechanics to create a novel crystalline coating technology.

Their microfabrication process involves separating and then directly bonding (using no adhesives or intermediate films) high-quality single-crystal films onto curved glass substrates. This circumvents two previous impediments to using high-quality semiconductor materials in general optics applications: the difficulty of direct crystal growth on a curved optical surface, and the fact that glass optical substrates, with their amorphous structure, lack the order required for seeded crystal growth.

"The development of highly phase coherent optical sources is a key technology that impacts a vast range of scientific explorations," said professor Jun Ye of JILA. "In our own lab, we are able to demonstrate the most stable optical atomic clock thanks to these narrow-linewidth lasers, and the progress is marching on!"

demonstrated single-crystal silicon cavity developed by JILA and PTB in Braunschweig, Germany (See: Laser Stability Improved by an Order of Magnitude). Such an all-crystalline cavity (coatings, substrates and spacer) would set a record for stability, enabling a new milestone in laser technology, the team said.

For more information, visit: www.univie.ac.at/en/home or www.crystallinemirrors.com

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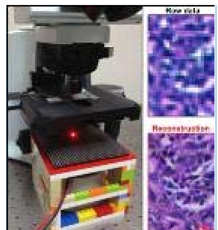

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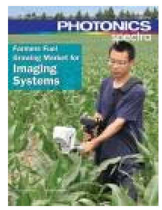

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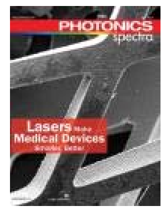

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