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"Redefining precision laser optics with substrate-transferred crystalline coatings"

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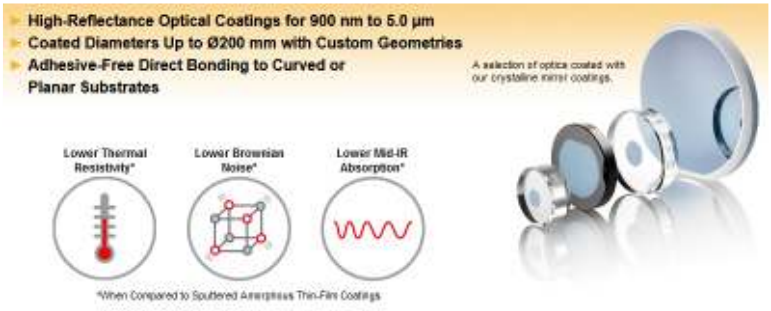

Abstract

Substrate-transferred crystalline coatings are a groundbreaking new concept in optical interference coatings, leveraging a combination of semiconductor materials and microfabrication techniques with super-polished bulk optics technologies.

These coatings are generated via a unique manufacturing process entailing separate crystal growth, microfabrication, and direct bonding that yields single-crystal coatings on arbitrary—including curved—optical surfaces. These "semiconductor supermirrors" were first demonstrated in 2013 with the key advantage being the ability to achieve ultralow levels of both optical and elastic losses.

With continuous refinement in production and metrology, we have reduced the scatter + absorption losses to < 5 parts per million (ppm) for near-IR wavelengths spanning 1064 to 1560 nm, enabling a cavity finesse exceeding 300,000 (mirror reflectance > 99.999%). In this spectral range, crystalline coatings are now fully competitive with ion beam sputtered films, while simultaneously yielding a significant reduction in Brownian thermal noise, a fundamental limitation in the stability of laser-based precision measurement systems including gravitational wave detectors and cavity-stabilized lasers for optical atomic clocks.

Additional advantages of these novel monocrystalline coatings include record-low-levels of mid-infrared optical losses, as well as an exceptionally high thermal conductivity for an ultralow-loss optical interference stack. Looking ahead, we see a bright future for crystalline coatings in applications requiring the ultimate levels of optomechanical and thermal performance.

About Our Speaker

Garrett D. Cole obtained his PhD in Materials from UC Santa Barbara in 2005 with his dissertation focusing on the development of novel MEMS-tunable vertical-cavity laser amplifiers.

Dr. Cole has held positions ranging from the first employee of a high-tech startup (Aerius Photonics LLC, now FLIR Electro-Optical Components), to a postdoctoral position at Lawrence Livermore National Laboratory, a Marie Curie Fellow of the Austrian Academy of Sciences, and a university assistant in the Faculty of Physics at the University of Vienna.

Dr. Cole has co-authored 2 book chapters and published 50 journal articles including papers in *Science*, *Nature*, *Nature Physics*, *Nature Photonics*, *Nature Nanotechnology*, *Nature Communications*, *Physical Review Letters*, and the *Proceedings of the National Academy of Sciences*.

Leveraging his expertise in micro- and nanofabrication, tunable semiconductor lasers, and cavity opto-mechanics, together with Professor Markus Aspelmeyer, Dr. Cole founded Crystalline Mirror Solutions (CMS), an international photonics start-up commercializing high-performance optics for laser-based metrology and manufacturing systems. CMS was successfully acquired by Thorlabs Inc. in December 2019 and has been rebranded as Thorlabs Crystalline Solutions (TCS), adding our high-performance crystalline coatings to Thorlabs' ever-growing product portfolio.