Crystalline Mirror Solutions

Aims of the activity/of the project	The starting point of this transfer-activity was a technology (crystalline supermirrors) developed in 2008 at the University of Vienna in the context of fundamental quantum physics research. The foundation of the spin-off Crystalline Mirror Solutions (CMS) in 2012 facilitated successful transfer of this technology from the University to industry. CMS is a high-tech start-up, commercializing high-performance optics for laser-based precision measurement and manufacturing systems. The proprietary manufacturing process and the final application area are covered by international patents.
Persons responsible for the project	Univ.-Prof. Dr. Markus Aspelmeyer (University of Vienna, Faculty of Physics, Quantum Optics, Quantum Nanophysics & Quantum Information) Dr. Garrett Cole (University of Vienna, Faculty of Physics, Quantum Optics, Quantum Nanophysics & Quantum Information)
Cooperation partners	Jun Ye Group, JILA, University of Colorado Boulder Leibniz Universität Hannover & Albert-Einstein Institute for Gravitational Physics Various scientific and industry partners of the firm Crystalline Mirror Solutions (CMS)

Project Description

Fundamental research in the field of experimental quantum physics repeatedly reaches the limits of existing technologies. In these cases, continuing experiments requires further or new development of technologies. In this process, new application possibilities arise, also outside of the area of quantum physics.

One example for such a technology are crystalline supermirrors, which were developed in 2008 at the University of Vienna in the context of fundamental quantum-optomechanics research. Originally, the aim was to investigate the interaction of heavy, massive objectives and quantum physics using these mirrors. For this purpose, micro-mechanic solid-state systems are being manipulated using light. In order to isolate quantum phenomena in such macroscopic objects the material has to reflect light well and has to have good mechanical features at the same time. By merging two seemingly disparate fields, namely expertise in fundamental quantum optics (Markus Aspelmeyer) and expertise in Materials Science and semiconductor microfabrication (Garrett Cole, brought from the USA to the University of Vienna by a Marie Curie International Incoming Fellowship in 2008), a novel idea was generated: With the aid of a monocrystalline semiconductor materials system, which has rarely been used before in optomechanics, the technological problem could be solved and the quantum experiments could be continued.

In the process of the publication of results it became apparent that the new technology had other application possibilities in optical precision measurement (e.g. the atomic clock or the measurement of gravitational waves). In this field, the measurements are fundamentally limited by the material properties of mirrors used so far. In principle, the new technology had the potential to solve this problem; however, further development was required. In the context of discussions on the technology’s potential and presentations at international conferences a network with researchers from various disciplines was established.

Over a period of four years Garrett Cole and Markus Aspelmeyer developed a new mirror which could be used for laser-based precision measurements. In collaboration with the research group of Professor Jun Ye at the University of Colorado Boulder (one of the world-leading researchers in the field of precision measurement) evidence was provided that the sensitivity of precision measurements can be increased by up to a factor of ten with the new mirror, compared to prior technologies.

Due to strong demand from other research groups in the field of precision measurement Crystalline Mirror Solutions (CMS) was founded in 2012 as a spin-off of the University of Vienna and the Vienna Center for Quantum Science and Technology (VCQ). The first phase of the spin-off – prototype construction and patenting of the technology – was supported by the Pre-Seed Funding of the Austria Wirtschaftsservice (AWS) and an ERC Proof of Concept Grant. In 2013, the CMS GmbH was founded, with operations in Vienna, Austria, Santa Barbara, CA, and Zurich, Switzerland.

Results/Impact

By now, the application possibilities of crystalline supermirrors range from precision measurement to solutions for heat management of high-power lasers and systems for laser machining. The technology was awarded with various national and international prizes (see http://www.crystallinemirrors.com/about-cms/).

The international scientific network, which was established in the process of (further) developing the technology, could be maintained and extended, also generating new research questions for quantum research at the University of Vienna (e.g. in the area of gravitational wave-detector research).

A financial and scientific backflow of the developments of the spin-off CMS to the University of Vienna is currently underway in the form of a Christian Doppler Laboratory (CDL), which was started in 2017 at the Faculty of Physics and which is co-financed by CMS. The laboratory director, Dr. Oliver Heckl from the University of Colorado Boulder, is in Vienna since January 2017. The CDL focuses on completely new applications of semiconductor laser optics in the medium infrared range (e.g. for detecting trace elements).

Quality assurance/Achievement of objectives

In the field of experimental quantum physics, quality assurance takes place via classical indicators such as high-impact publications (incl. number of citations) and successful external funding applications.

In the context of projects involving industry partners (such as the CDL), there are clearly defined, quantifiable objectives/milestones. These have to be reached in order to ensure that results can be appropriately applied.

Webpage/Publications

Webpage CMS: http://www.crystallinemirrors.com/

Cole, G. D., Zhang, W., Martin, M. J., Ye, J., & Aspelmeyer, M. (2013). Tenfold reduction of Brownian noise in high-reflectivity optical coatings. *Nature Photonics*, *7*(8), 644-650.