Pressemitteilung

Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF

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New high-performance mirrors for laser fusion: New SHARP research project launched

Laser-driven fusion power plants are considered a key technology on the road to climate neutrality. Highly reflective and thermally stable mirror systems are crucial for these fusion power plants in order to transport the laser light from the beam source to the tiny capsule of fusion fuel. In the new SHARP research project, new types of high-performance mirrors are being developed for this purpose. The project is being funded with 8.4 million euros by the German Federal Ministry of Education and Research (BMBF).

The aim of the joint project SHARP ("Scalable Highpower Reflectors for Petawatts") is to develop a new generation of highly reflective laser mirrors that meet the extreme requirements of future petawatt laser fusion reactors. To this end, large-area and internally cooled high-performance optical mirror systems are to be developed that have not yet been realized in this form.

"The SHARP project aims to lead to new manufacturing technologies that enable large-area mirrors with novel properties," explains Dr. Yakup Gönüllü from SCHOTT. He is coordinating the new joint project, which officially began its three-year term with a kick-off event on March 4. "These high-performance mirrors represent an indispensable contribution to the realization of commercial laser fusion power plants in reliable continuous operation," continues Gönüllü.

The research project has a total volume of 10.4 million euros, of which 8.4 million euros are being funded by BMBF as part of the "Basic technologies for fusion - on the way to a fusion power plant" initiative.

New production technologies for continuous operation of commercial power plants

Earlier work on laser mirror systems did not take the thermal aspect of laser radiation into account. In the future, however, the absorption-induced thermal energy input into the mirror systems will be crucial in the continuous operation of laser-driven fusion power plants. Key properties of the high-performance mirrors to be developed in the project are therefore the highest optical quality and a new type of thermal management for the optical components used.

In addition to the thermal stability of the new mirrors, the scalability of the technology is also a key factor in the project. Efficient production processes should contribute to the economic and ecological balance and thus to the commercialization of laser fusion power plants.

Development of scientific and technical foundations

In order to achieve this goal, the SHARP consortium will develop the scientific and technical foundations for novel manufacturing technologies for superpolished, curved, large-area optics as well as methods for removing imperfect substrate areas and so-called "zero-defect" cleaning strategies. For thermal stabilization and active cooling, novel integrated cooling structures in glass substrates and thermomechanical effects are included in the coating development.

"The challenge is that the laser mirrors have to withstand extreme loads over a long period of time," explains Dr. Nadja Felde, the responsible project coordinator at Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena. "The main aspect of this research project is therefore understanding and controlling the thermal properties of large-area mirror systems in design and production while maintaining reflectivity at the highest level."

Application potential beyond laser fusion

Prof. Dr. Thomas Höche from the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) adds: "Beyond laser fusion, the targeted developments have great potential for applications in other future markets, especially for high-power laser applications and laser material processing, but also in space communication and especially for the next generation of substrates and coatings for EUV lithography."

Partners from industry and research in the "SHARP" project

The SHARP consortium is coordinated by SCHOTT AG and brings together leading companies and institutes in the field of optics, including LAYERTEC GmbH, asphericon GmbH, 3D-Micromac AG, optiX fab GmbH, Cutting Edge Coatings GmbH, robeko GmbH & Co. KG, Laser Zentrum Hannover e.V. as well as Fraunhofer IOF and Fraunhofer IMWS.

Laser fusion: Clean energy through the fusion of atomic nuclei

Laser fusion is inspired by nature: Similar to what happens on the sun, energy is to be generated through the fusion of atomic nuclei. In a laser fusion power plant, several high-power lasers are directed at a fuel capsule to vaporize it at extremely high temperatures and then fuse the atomic nuclei under high pressure.

Enormous forces are at work in this process: the laser power in a fusion power plant is in the order of several petawatts. For comparison: one petawatt corresponds to 1,000,000,000,000,000 watts. A coal or gas-fired power plant has an output of 1,000,000,000 watts, a standard electric kettle 2,000 watts

The laser beams are guided via several mirror systems, which must have special optical, mechanical and thermal properties. A combination of the required properties has not yet been realized in this way. The consortium in the new SHARP research network aims to change this by developing new production technologies and realizing new types of laser mirrors for use in the petawatt range.

About Fraunhofer IOF

The Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena conducts application-oriented research in the field of photonics and develops innovative optical systems for controlling light - from its generation and manipulation to its application. The institute's range of services covers the entire photonic process chain from opto-mechanical and opto-electronic system design to the production of customer-specific solutions and prototypes. At Fraunhofer IOF, about 500 employees work on the annual research volume of 40 million euros.

For more information about Fraunhofer IOF, please visit:
www.iof.fraunhofer.de

About Fraunhofer IMWS

The Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) offers microstructure-based diagnostics and technology development for innovative materials, components and systems. Building on its core competencies in high-performance microstructure analysis and microstructure-based material design, the institute addresses questions of functionality and application behavior as well as the reliability, safety and service life of materials that are used in various market and business areas with high significance for social and economic development. For its partners in industry and for public clients, the Fraunhofer IMWS pursues the goal of contributing to the accelerated development of new materials, increasing material efficiency and cost-effectiveness and conserving resources. In this way, the institute contributes to securing the innovative capacity of important future fields and to sustainability as a central challenge of the 21st century.

Further information about Fraunhofer IMWS can be found at:
www.imws.fraunhofer.de

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URL zur Pressemitteilung:
https://www.iof.fraunhofer.de/en/pressrelease/2025/New-high-performance-mirrors-for-laser-fusion.html

A researcher holds a highly reflective mirror for laser applications. The technology is to be optimized for laser fusion.
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