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Press Release

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Hamamatsu Photonics K.K.
EX-Fusion Inc

A landmark step toward achieving laser fusion power generation
The world's first experiment [1] to irradiate targets continuously for one hour by applying high-energy pulsed lasers

Hamamatsu Photonics K.K. and EX-Fusion Inc have conducted a joint experiment to demonstrate essential technology for laser fusion research. This initiative involved the continuous irradiation of simulant fuel targets using high-energy pulsed lasers. If the technologies used in this demonstration are successfully established, this could lead to an innovative laser fusion approach that overturns conventional wisdom and could transform the energy industry.

Laser fusion research currently in progress around the world is mainly based on experiments using single-shot laser irradiation, "an experimental technique for irradiating a laser beam in just a single burst." In the future, the goal is to achieve a more efficient and stable energy generation. Experiments using continuous pulse laser irradiation as "a new experimental technique to constantly emit laser beams" are expected to become mainstream.

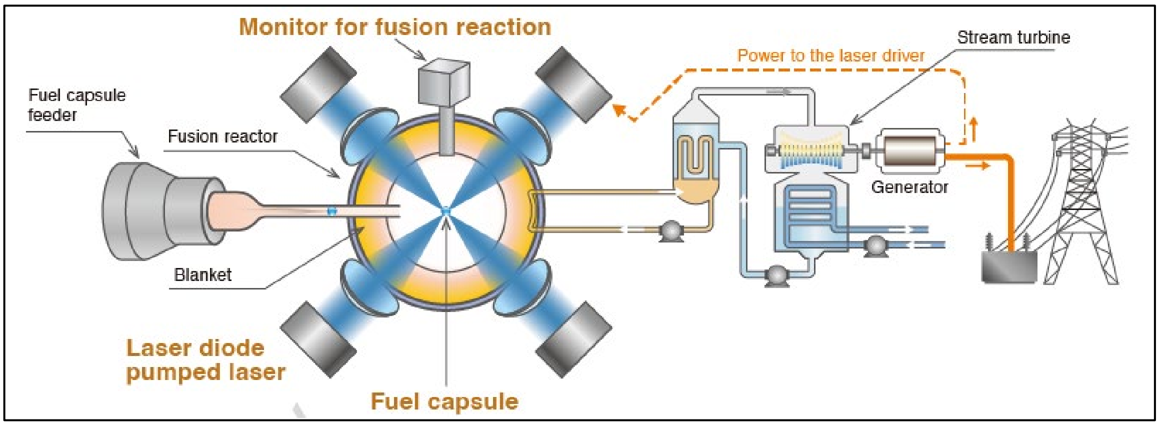
If the technologies established through this demonstration advance, it will become possible to continuously irradiate actual fuel targets using kilojoule-class pulsed lasers. This would significantly increase opportunities for researchers to conduct laser fusion experiments, potentially leading to the invention of innovative laser fusion approaches. Therefore, we believe that such an environment for continuous pulsed laser irradiation could become a game-changer in energy innovation.

Laser fusion research, utilizing continuous irradiation from kilojoule-class lasers, is expected to accelerate worldwide within the next five years. The results and knowledge gained from this demonstration experiment will inform future government-sponsored projects and serve as a significant step toward making laser fusion power generation a reality.

Background of Research

Currently, the most advanced laser fusion research relies on a reaction in which atomic nuclei in a fuel target or capsule containing deuterium and tritium are fused together by irradiation with high-energy lasers. An enormous amount of energy is generated at that moment, showcasing laser fusion as a promising new source of clean energy.

In a laser fusion power generation system, fuel targets or capsules are sequentially ejected from the feeder. Each fuel target is simultaneously irradiated with multiple high-energy lasers at the moment it reaches the center of the reactor. More than 100 lasers will likely be needed to generate electrical power.

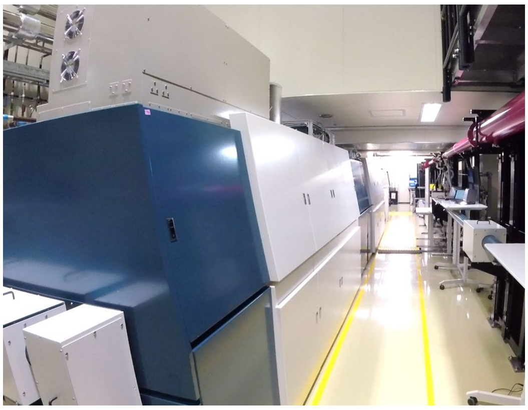


Schematic view of laser fusion power generation

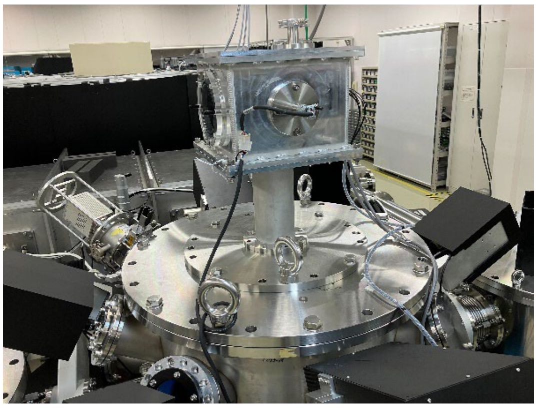
In December 2022, “ignition (self-sustaining fusion reaction)” by laser fusion was demonstrated for the first time in the world at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory in the United States [2]. This achievement has led to rapid progress in research and development of laser fusion power generation, particularly in Europe and the United States. However, the NIF was not actually intended for power generation. It was designed for the physical demonstration of laser fusion, where laser irradiation is performed once every few hours and fuel targets are installed on a case-by-case basis. Laser fusion power generation requires a sophisticated system that operates continuously and automatically feeds fuel targets at a rate of 10 times per second, irradiating them with high-energy lasers at precise timing.

Hamamatsu Photonics has been researching high-energy lasers for laser fusion power generation in collaboration with Osaka University since the 1990s. Hamamatsu Photonics is currently the only private company in the world [3] that possesses LD (laser diode)-pumped laser technology capable of producing the world's highest level of power, and a cutting-edge facility designed to shield against neutrons safely. The company also has an experimental environment optimized for laser irradiation at both high efficiency and a high repetition rate.

EX-Fusion is Japan's first start-up company aiming to put laser fusion power generation into practical use. Conceived in 2021 by Osaka University and the Graduate School for the Creation of New Photonics Industries, in 2024, EX-Fusion successfully developed technology to feed and track simulant fuel targets at high speed and accuracy, marking a significant step toward practical use.



Hamamatsu Photonics LD-pumped laser generating the world’s highest power (HALIANS) [4]



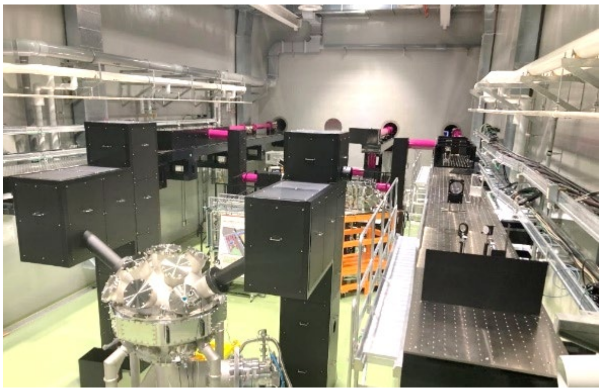
EX-Fusion’s fuel target feeder and tracker

Summary of Research Results

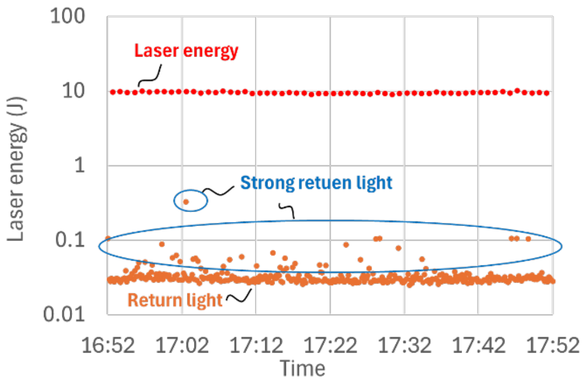
Toward making laser fusion power generation, Hamamatsu Photonics and EX-Fusion conducted a joint experiment using EX-Fusion's experimental chamber installed in the Hamamatsu Photonics laser fusion experiment facility. It aimed to construct a continuous irradiation system for high-energy lasers that utilizes the laser-related technologies of both companies, confirm current technology levels, and identify issues that must be addressed for future development needs.

In the experiment, we fed one-millimeter-diameter metal targets into the vacuum chamber at a rate of 10 targets per second and irradiated them with lasers accurately by predicting their position. After one hour of continuous irradiation, we verified that the error between the laser irradiation position and the target position was held within 500 micrometers and that the targets were successfully irradiated with a probability of more than 50%.

Furthermore, important data specific to high-energy lasers were obtained. This data indicates that laser beams of more than 10% of the laser shots irradiated into the targets returned to the laser device from the targets.



Hamamatsu Photonics laser fusion experiment facility and an experiment chamber owned by EX-Fusion



Return light measurement results

Parameter	Goal	Results	Achievements
Laser energy stability	< 1%	2.4% (RMS)	Identified issues relating to stable control of laser operation
Return light energy	< 0.5%	> 3% (Max.)	Identified technical issues in suppressing return light
Stability of beam pattern intensity	< 1%	< 1% (Intensity fluctuation)	Confirmed that the goal is generally achievable
Stability of laser focusing position	< 10 μrad	X : 85 μrad (4σ) Y : 168 μrad (4σ)	Obtained useful data for future R&D
Accuracy of target feed position	< 10 mm	< ±2 mm	Achieved stable and continuous feeding
Accuracy of laser irradiation	< 100 μm	~ 500 μm (σ)	Identified multiple issues needed to improve accuracy
Probability of successful laser irradiation	100%	> 50%	Confirmed that the measurement system needs improvement

Summary of experimental results obtained from joint experiment

This is the first attempt in the world to obtain statistical data over a long period of time under such scale and conditions [1]. This achievement will have a major impact on the development of technology for the next step of experiments. These will entail the use of lasers at energy levels exceeding 100 joules.

Similar technological developments are expected to emerge in the United States, China, and Europe over time. Moreover, advanced laser fusion research using 1 to 10 kilojoule-class lasers will begin within five years. This joint experiment will help us to stay one step ahead of these rapidly moving global trends.

In the future, laser-related technologies from Japanese companies are likely to play a strategic role in large-scale laser fusion research, which will be carried out as both government-led projects in Japan and international collaborations.

[1] According to our survey. Experimental conditions: laser energy 10 joules, repetition rate 10 Hz, target tracking

[2] Reference: DOE National Laboratory Makes History by Achieving Fusion Ignition | December 13. 2022

[3] According to our survey. A neutron-shielding facility equipped with a 250-joule class LD-pumped laser

[4] According to our survey. Reference: 253 J at 0.2 Hz, LD pumped cryogenic helium gas cooled Yb:YAG ceramics laser Optics Express Vol. 30, Issue 25, pp. 44385-44394 (2022)