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Changes for the Better

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FOR IMMEDIATE RELEASE **No. 3844**

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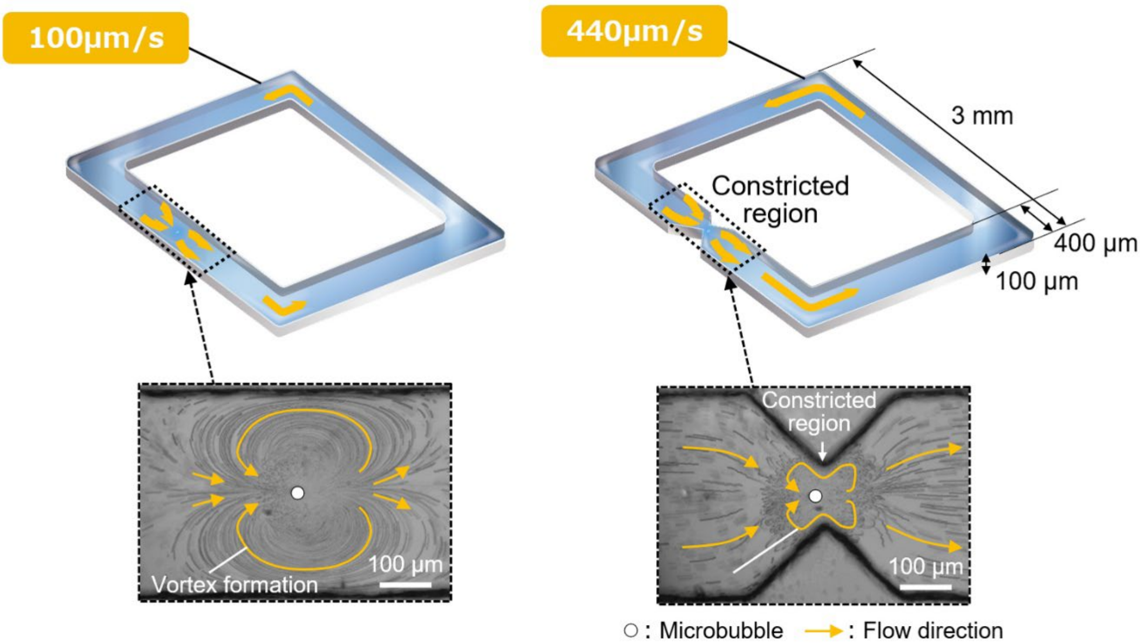
Mitsubishi Electric Develops World's First Technology to Use Microbubbles to Generate Millimeter-scale Flow in Channel

Will support carbon neutrality by helping to eliminate the need for external pumps in cooling systems



Flow generation in a microchannel by microbubbles

TOKYO, December 4, 2025 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that it has developed the world's first[1] technology to generate millimeter-scale flow within a channel by using microbubbles with a diameter of 10μm as the driving source. Developed through joint research with Suzuki & Namura Laboratory at Faculty of Engineering and Graduate School of Engineering, Kyoto University, this technology is expected to reduce power-consuming external pumps for water cooling in electronic equipment, thereby contributing to carbon neutrality.

Thermal management is becoming increasingly important for electronic devices due to their high output and the growing computation load of AI servers as generative AI rapidly spreads. Electronic devices that generate

[1] According to Mitsubishi Electric research as of December 4, 2025.

large amounts of heat require water cooling systems,[2] and demand is expanding for cooling systems that circulate liquid through microchannels to achieve greater efficiency than conventional water cooling systems. To further improve the efficiency of microchannel cooling, efforts are being made to reduce the microchannel width to 100µm or less. However, a powerful external pump is required to circulate liquid in microchannels, so the increasing power consumption of these systems has become an issue.

Kyoto University developed a technology that uses microbubbles generated by local heating and Marangoni forces[3] arising from temperature differences at vapor-liquid interfaces and self-oscillation to induce flow. Mitsubishi Electric researched methods to apply this technology to a microchannel and succeeded in generating a world-first flow speed of 100µm/s in a 3mm x 3mm square channel with a cross section of 100µm x 400µm, all without using external pumps. Later, the flow speed was improved to 440µm/s by optimizing the bubble layout and flow-path geometry. Going forward, Mitsubishi Electric aims to enhance the energy saving and high performance of next-generation cooling systems to contribute to carbon neutrality.

This research result was selected for publication in *Applied Physics* Letters,[4] an international journal on applied physics published by the American Physical Society.

Features

Millimeter-scale flow generated using 10µm microbubbles as the driving source

- Mitsubishi Electric achieved a world-first unidirectional flow using only microbubbles. The bubbles, generated by local heating in a 3mm by 3mm square channel with a cross section of 100µm x 400µm, used Marangoni forces at their vapor-liquid interfaces and self-oscillation to induce a flow speed of 100µm/s without the use of an external pump.
- Later, a constricted region installed in the flow path restricted the vortices generated around the bubbles, which increased the flow speed to 440µm/s.

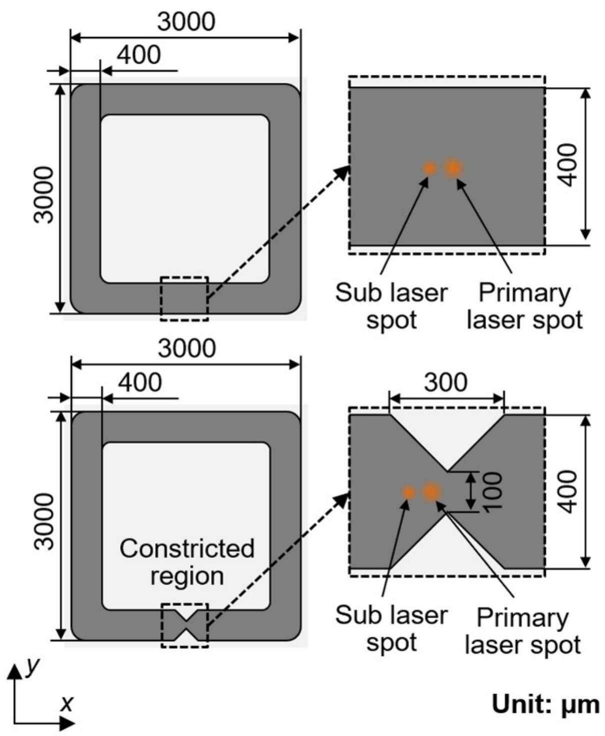
The direction of liquid flow parallel to the channel walls is controlled by managing the temperature distribution around the microbubbles. Previous studies had achieved flows of several hundred micrometers around bubbles, but Mitsubishi Electric's research using this technology has achieved millimeter-scale flows.

Using a 0.1-µm-thick $FeSi_2$ film,[5] which absorbs light and converts it into heat, the laser irradiation on the film created a primary laser spot for bubble generation and a sub-laser spot for controlling the temperature distribution. Microbubbles with a diameter of 10µm and filled with high-temperature vapor were generated inside a channel containing a water–ethanol mixture. Using only the driving force generated by microbubbles, the company achieved a flow speed of 100µm/s, equivalent to that of a conventional Electro Hydro Dynamic pump,[6] and

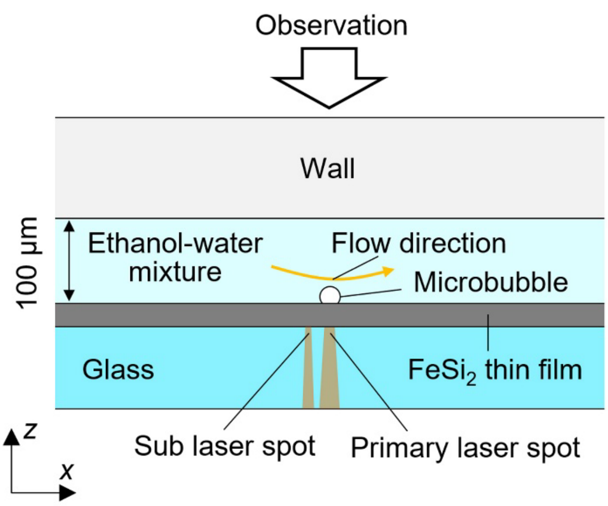
[2] Other methods such as air cooling and immersion are used depending on the application, heating value and installation environment of the electronic equipment.
[3] Fluid force driving mass transfer at liquid interface.
[4] https://pubs.aip.org/aip/apl
[5] Thin film made of iron and silicon, with high heat resistance and the ability to absorb light and convert it into heat.
[6] A pump that is driven by the Coulomb force generated by voltage application to electrodes. Because it has no mechanical drive unit, it can be miniaturized and used for liquid transport in microchannels, but it requires a high-voltage power supply.

achieved the world's first millimeter-scale flow in a 3mm square channel with a cross section of 100µm x 400µm.

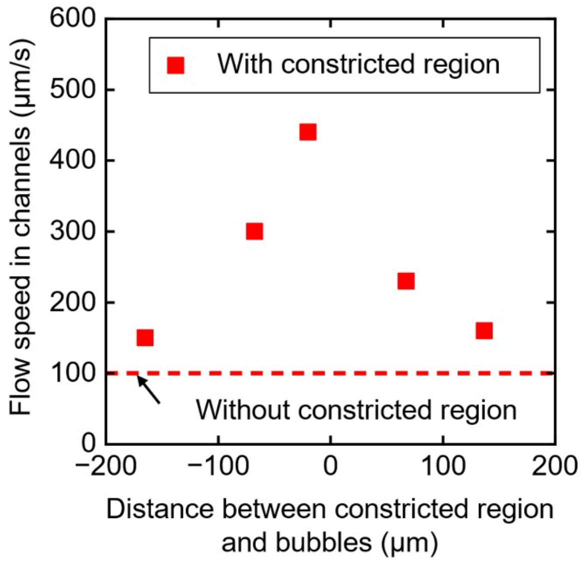
In addition, a constricted region with a locally small cross-sectional area was installed inside the flow channel to restrict vortices generated around the bubbles. This enabled the bubbles to flow in the direction of the channel and increased the flow speed to approximately 440µm/s.



Microchannel geometry in xy plane and laser irradiation position on $FeSi_2$ thin film



Bubble generation by localized laser heating of an $FeSi_2$ thin film in the xz cross-section



Flow speed improved through use of constricted region

Roles

Organization Name	Responsibilities
Mitsubishi Electric	Application of flow generated by microbubbles to cooling devices
Kyoto University	Fundamental study on generation of microbubbles and flow control around them

Future Development

In the future, fluid control technology using multiple microbubbles will be developed to greatly increase flow speed. In addition, Mitsubishi Electric and Kyoto University intend to develop a heat transfer surface with a heat transfer coefficient that is more than one order of magnitude higher than that of conventional microchannel cooling systems, using microbubbles generated on wall surfaces to achieve high-speed flow. Furthermore, Mitsubishi Electric expects to develop technology that generates microbubbles using waste heat from electronic devices. By integrating these technologies, the company aims to contribute to energy-saving, high-performance next-generation cooling systems that support carbon neutrality.

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About Mitsubishi Electric Corporation

With more than 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Mitsubishi Electric enriches society with technology in the spirit of its "Changes for the Better." The company recorded a revenue of 5,521.7 billion yen (U.S.$ 36.8 billion*) in the fiscal year ended March 31, 2025. For more information, please visit www.MitsubishiElectric.com

*U.S. dollar amounts are translated from yen at the rate of ¥150=U.S.$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2025