

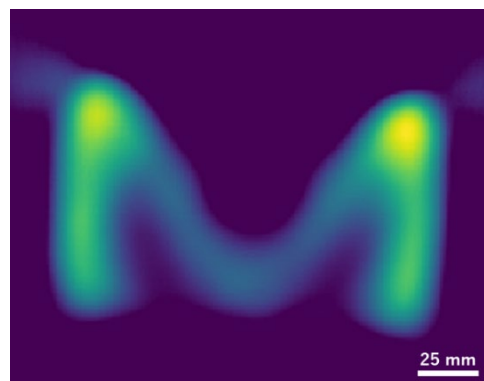
Mitsubishi Electric Corporation
Okayama University
Osaka University

Mitsubishi Electric, Okayama University, and Osaka University Develop Magnetic Particle Imaging Device Capable of Producing Images of Human Brain

*The world's first high-sensitivity imaging device capable of operating at low frequencies
with compact power supply, will facilitate diagnosis of pre-Alzheimer's*



New magnetic particle imaging device (prototype)



Example image

TOKYO, September 7, 2023 - [Mitsubishi Electric Corporation](#) (TOKYO: 6503), Okayama University and Graduate School of Engineering, Osaka University announced today that they have developed a magnetic particle imaging device capable of sensitive imaging of magnetic particles in an area equivalent in size to that of the human brain, in a project supported by the Japan Agency for Medical Research and Development (AMED). The device operates at low frequencies of 1 kHz or less, a world-first,¹ allowing the use of a significantly smaller power supply unit. The utilization of this device to image magnetic particles that bind to amyloid- β ,² the causative agent of Alzheimer's, will allow the accumulation and distribution of amyloid- β to be quantified. The aim is to allow imaging-based assessments of the likelihood of Alzheimer's developing prior to the onset of the disease.

The number of dementia patients aged 65 and older in Japan is expected to reach 7 million in 2025.³ Significant statistical findings indicate that Alzheimer's accounts for 67.6% of these dementia cases.⁴ In June of this year, Japan enacted the Dementia Basic Law, aimed at advancing dementia prevention efforts. In August, a panel of

¹ According to Mitsubishi Electric's own research as of September 7, 2023

² A type of protein produced in the brain. It is believed it may cause cognitive decline if it accumulates in the brain

³ Source: "A study on the future estimation of the elderly population with dementia in Japan" (Ministry of Health, Labour and Welfare Grants System for 2014)

⁴ Source: "Dementia prevalence in urban areas and responses to impairment of life" (Ministry of Health, Labour and Welfare Grants System for 2012)

experts from Japan's Ministry of Health, Labour, and Welfare gave a green light for the manufacture and sale of a drug that targets the accumulation of amyloid- β in the brain, a potential factor in the development of Alzheimer's, thereby inhibiting the progression of the disease. Initiating medication early during a phase of low amyloid- β accumulation in the brain has been shown to help suppress the onset of the disease. This underscores the necessity for technology capable of measuring both the accumulation and distribution of amyloid- β .

The magnetic particle imaging device deploys an alternating magnetic field generated by a coil to induce magnetic signals from magnetic particles injected into the body; it then uses these signals to produce a three-dimensional image. A higher frequency alternating magnetic field enhances the sensitivity of signal detection. In compact devices designed for testing on small animals such as mice, which have already been commercialized, frequencies of approximately 25 kHz are used. One of the factors that hitherto hindered the practical application of this system in the treatment of humans was the extremely large size of the power supply unit needed to drive the much larger coil.

By leveraging its extensive electromagnetic technology know-how acquired through the development of various devices, and by fine-tuning the configuration of the coils that generate alternating magnetic fields and those dedicated to signal detection, Mitsubishi Electric has developed a process that minimizes extraneous signals (noise) that hinder the detection of magnetic signals. This has allowed the three participating organizations to successfully develop a magnetic particle imaging device capable of sensitively capturing images of magnetic particles across an area equivalent to the size of the human brain; while operating at low frequencies below 1 kHz, a world-first,¹ significantly reducing the size of the power supply unit required. This accomplishment marks a significant stride toward the realization of imaging tests that can assess the likelihood of the development of Alzheimer's prior to its onset.

Detailed results of the development will be announced at 10:30 local time on September 9 at the World Molecular Imaging Congress (WMIC), which will be held from September 5 to September 9 in the Czech Republic.

Overview of Device

Description	A magnetic particle imaging device capable of imaging objects the size of the human brain
Operating frequency	1 kHz or less
Size	Main body : W1600 mm × D2000 mm × H1900 mm Coil inner diameter : 300 mm Diagnostic area diameter : 180 mm Power supply exterior : W2000 mm × D900 mm × H1500 mm

Future Plans and Prospects

In order to use a magnetic particle imaging device to conduct imaging tests that can assess the likelihood of the development of Alzheimer’s prior to the onset of the disease, it is essential to enhance the sensitivity and resolution of the device. Clinical trials to confirm its safety and effectiveness as a diagnostic tool are required before it can be put to practical use. With the goal of achieving commercialization by around 2030, the three organizations behind the development of this solution will continue to study the possibility of collaborating with other companies.

Development Process & Responsibilities

Mitsubishi Electric	Overall design of magnetic particle imaging device, development of image reconstruction technique, demonstrations
Okayama University	Development of high-sensitivity magnetic measurement techniques
Osaka University	Development of magnetic particle markers for Amyloid-β

Key Features

The world's first¹ "magnetic particle imaging device" capable of highly sensitive imaging of magnetic particles of an area equivalent to the size of the human brain, operating at low frequencies of 1 kHz or less, and with a much smaller power supply unit.

- By advancing the electromagnetic technology of Mitsubishi Electric, the three participating organizations have succeeded in creating a process that minimizes noise interference during signal detection. This is achieved through precise adjustments to the arrangement of the coils generating alternating magnetic fields and those used for signal detection. This innovation has enabled the pioneering achievement of highly sensitive detection and imaging of magnetic signals in samples comparable to the size of a human brain, even at frequencies as low as 1 kHz or less.
- The participating organizations have developed a magnetic particle imaging device capable of imaging areas the size of the human brain with a miniaturized power supply, achieved by reducing imaging frequency and thereby minimizing the capacity of the power supply required.

The sensitivity of the magnetic signal detection is directly related to the frequency of the alternating magnetic field. Magnetic particle imaging devices designed for testing on small animals, which are currently in production, can only operate at high frequencies of around 25 kHz. However, scaling up the magnetic particle imaging device from one that produces images of small animals (coil inner diameter 30 mm) to one that can produce images the size of a human head (coil inner diameter 300 mm), while maintaining the same frequency, would lead to a significant increase in coil load, equivalent to the square of both the coil radius and the frequency. This tenfold increase in coil diameter would necessitate around a hundredfold increase in loading and power supply capacity, with a correspondingly huge power supply. However, reducing the frequency of the alternating magnetic field to minimize power supply size would diminish the strength of the signals emanating from the magnetic particles, rendering these undetectable.

In order to improve signal detection sensitivity while simultaneously reducing frequency, the focus of the participating organizations shifted towards addressing the extraneous signals (noise) that impede magnetic signal detection. Significant progress has been achieved through the development of a coil structure specifically designed to minimize these noise effects. By precisely adjusting the layout of the AC excitation coil and the signal reception coil—both used to generate the alternating magnetic field—using a rail-type slide structure, they have effectively reduced the voltage induced by the alternating magnetic field on the signal reception coil, thus minimizing noise interference. Consequently, they have been able to detect and image the magnetic signals from samples equivalent in size to the human brain, even at frequencies of 1 kHz or less, with high sensitivity. In addition, by optimizing the power supply capacity to four times that of a magnetic particle imaging device designed for small animals, they have been able to substantially reduce the dimensions of the power supply. As a result, we have been able to develop the world's first¹ magnetic particle imaging device with a coil inner diameter of 300 mm and a diagnostic area diameter of 180 mm capable of imaging objects the size of the human brain at low frequencies and with a small power supply. This constitutes significant progress toward the realization of imaging tests that can assess the likelihood of the development of Alzheimer’s prior to the onset of the disease.

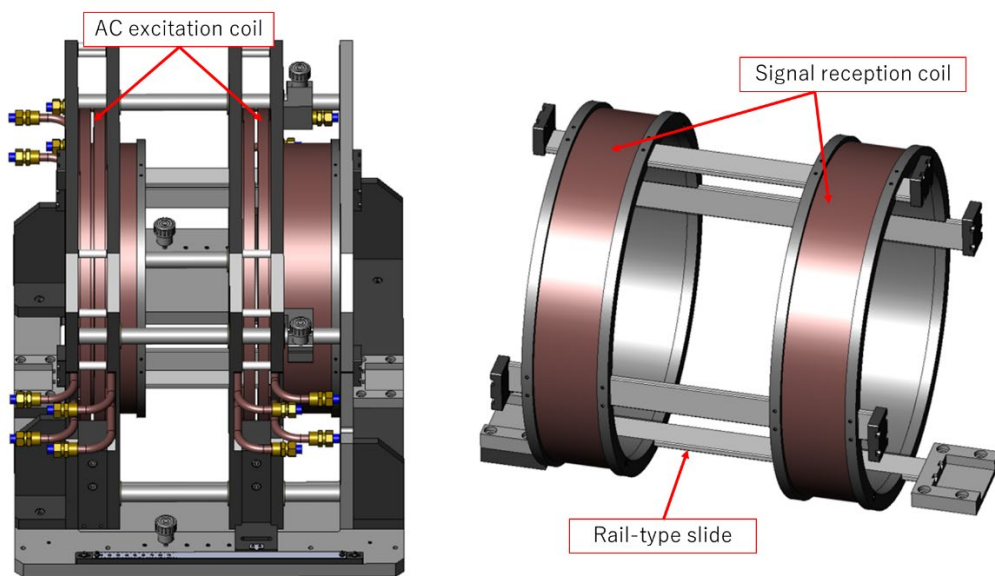


Fig. 1 Structure of the newly-developed AC excitation coil and signal reception coil

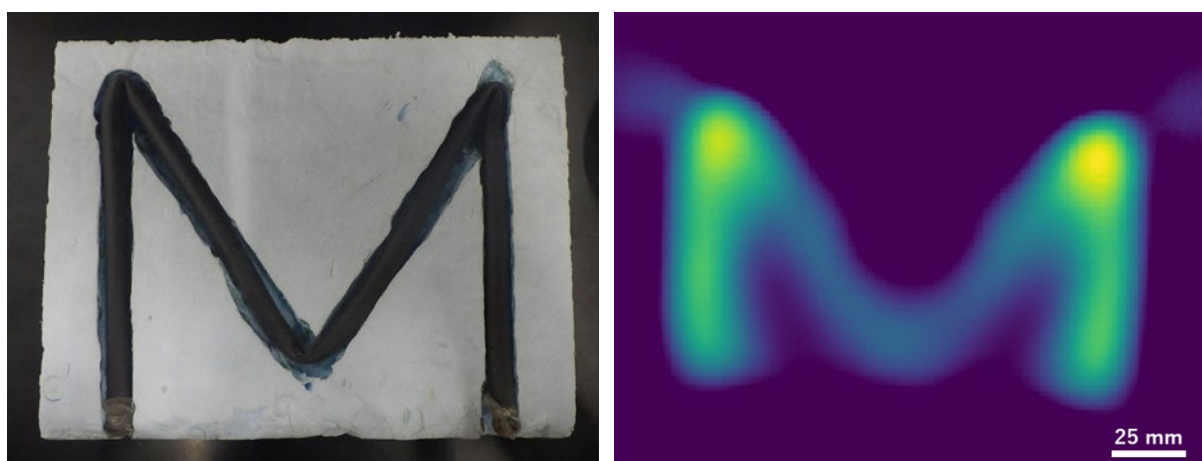


Fig. 2 Test of the new system: magnetic particles are injected into the tube and arranged in an M-shape (left) with an image subsequently created using the new device (right)

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