Development of an Image Diagnosis Technology Utilizing a High-Sensitivity Magnetic Sensor

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Yokohama National University, a national university corporation (Yokohama-city, Kanagawa pref. President: Izuru Umehara, hereinafter "YNU") and TDK Corporation (Tokyo, President: Shigenao Ishiguro, hereinafter "TDK") have developed a prototype image diagnosis technology utilizing a high-sensitivity magnetic sensor*.

The developed prototype technology is related to the magnetic particle imaging* method which is intended to detect and create images of magnetic particles* accumulated in a tumor or blood vessel.

Magnetic resonance imaging (MRI) diagnostics* and X-ray computerized tomography (CT) scanning* are used in clinical services in the diagnosis of organ health, tumors and other conditions using the contrasting density of imaged objects. In contrast, the magnetic particle imaging is intended for use in detecting only the tracers* in the imaged objects to create images similar to positron-emission tomography (PET)* and other similar technologies.

The principle of the magnetic particle imaging is to detect the magnetic signals generated by magnetic particles accumulated in a tumor or blood vessel from outside of the body (Figure 1). When intended for use in medical imaging, it is important for devices to be highly sensitive to enable the detection of small amounts of magnetic particles. Though magnetic particle imaging technologies primarily use a method that measures electromotive force electromagnetically induced through detection coils, the new technology developed by YNU utilizes a prototype high-sensitivity magnetic sensor to achieve this. The prototype high-sensitivity magnetic sensor was developed by TDK for use in the detection weak magnetic fields at room temperature. Although still under development, the prototype sensor has been shown in a prior feasibility study to measure magnetic field distribution in a heart.[1] In a new collaborative study between YNU and TDK, the sensor was shown to successfully reduce the strength of the alternate current magnetic fields applied to one tenth lower than conventional levels. This reduced strength of the applied field is achieved by the non-linear response characteristics of the sensor to the measured magnetic field strength.

Based on these study findings, it is expected that the utilization of high-sensitivity magnetic sensors will enable magnetic particles to be detected across wider imaging ranges including the head or whole body of a human. However, further research and development are required before these prototype sensors may be commercialized for clinical use.

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[1] 2019 feasibility study conducted using a prototype 99-channel sensor array in five healthy human subjects.

Going forward, YNU and TDK will continue to develop this technology, with the goal of creating magnetic particle imaging devices that can be used practically in clinical services.
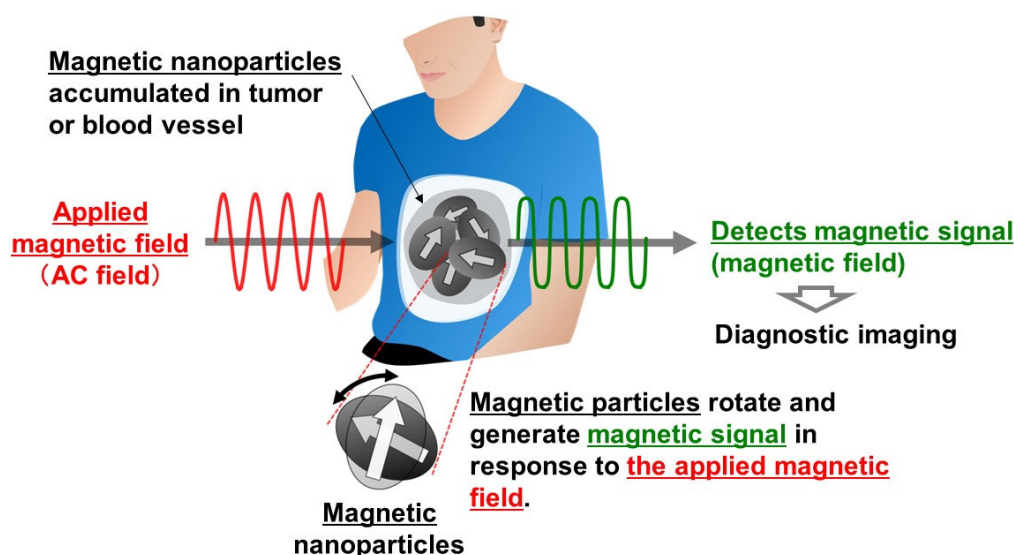

Figure 1

Glossary

- **High-sensitivity magnetic sensor**
  A magnetoresistance effect-based magnetic sensor (MR Magnetic sensor) developed by TDK that uses the Nivio xMR sensor. It has a compact sensor head and can also detect biosignals at room temperature. Its magnetic field detection performance almost reaches that of the superconducting quantum interference device (SQUID) flux meter, which requires cooling.
  https://product.tdk.com/ja/techlibrary/developing/bio-sensor/nivio_xmr_sensor.html

- **Magnetic particle**
  Also called magnetic nanoparticles, they are expected to be applied in magnetic particle imaging and hyperthermia cancer therapy. Typically, these particles are iron oxide(Fe_3O_4 and γ-Fe_2O_3) about 10 nm in diameter that are used in practice as contrast agents for MRI because of their biological compatibility.

- **Magnetic particle imaging**
  A new diagnostic imaging method proposed in 2005. It detects and creates images of magnetic particles accumulated in a tumor or blood vessel from outside of the body (Figure 1). The devices for small animals (animal testing) are available commercially from Europe and the U.S. However, a device for clinical use on humans has not been developed yet.

- **Tracer**
  Materials that are injected in the objects to be imaged for detection, to observe organs or tumors. These can be radioactive isotopes used for PET and magnetic particles for magnetic particle imaging.

- (Related information) **Magnetic resonance imaging (MRI) diagnostics, X-ray computerized tomography (CT) scanning**
  MRIs detect and creates images of hydrogen atoms in organs while X-ray CT creates tomographic images from X-ray images taken from multiple directions. Both technologies

are used for the diagnosis of organ health, tumors and other medical conditions based on contrasting densities in an image.

- (Related information) **Positron-emission tomography (PET)**
  It combines radioactive isotopes of materials such as glucose and detects the radioactive isotopes from outside the body to create diagnostic images based on the distribution of the radioactive glucose or other tracer in the body.

About Yokohama National University

Yokohama National University (YNU) is the only national university corporation located in Kanagawa Prefecture, where "Age of Local Autonomy" is advocated with various issues existing in its background. Located in the vast global city of Yokohama, YNU owns only one campus with full of green, and based on the principles of "Be ACTIVE", "Be INNOVATIVE", "Be OPEN", and "Be GLOBAL". YNU has brought together faculty members with diverse specialties such as humanities, social sciences, science, and engineering at One Campus to provide education and research. We aim to become a world-class research university centered on knowledge integration that contributes to the "proposal of new social and economic systems" as well as "innovation and development of science and technology" by mobilizing diverse academic and practical knowledge and by openly collaborating with various industries, regions, communities, and citizens, both domestically and internationally, across disciplines.

About TDK Corporation

TDK Corporation is a world leader in electronic solutions for the smart society based in Tokyo, Japan. Built on a foundation of material sciences mastery, TDK welcomes societal transformation by resolutely remaining at the forefront of technological evolution and deliberately "Attracting Tomorrow." It was established in 1935 to commercialize ferrite, a key material in electronic and magnetic products. TDK's comprehensive, innovation-driven portfolio features passive components such as ceramic, aluminum electrolytic and film capacitors, as well as magnetics, high-frequency, and piezo and protection devices. The product spectrum also includes sensors and sensor systems such as temperature and pressure, magnetic, and MEMS sensors. In addition, TDK provides power supplies and energy devices, magnetic heads and more. These products are marketed under the product brands TDK, EPCOS, InvenSense, Micronas, Tronics and TDK-Lambda. TDK focuses on demanding markets in automotive, industrial and consumer electronics, and information and communication technology. The company has a network of design and manufacturing locations and sales offices in Asia, Europe, and in North and South America. In fiscal 2021, TDK posted total sales of USD 13.3 billion and employed about 129,000 people worldwide.

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