Tokyo Tech Research Units

Nano Sensing Unit

Overview

Healthy and safe food is fundamental to society's happiness and well-being. Our goal is to apply ultrahigh-sensitivity accelerometer systems in providing sustainable medical care and food production. Accelerometers are able to detect temporal changes in three dimensions in physical space, and are already used in various technologies, such as smartphones and self-driving vehicles. The ability to measure minute amounts of acceleration that cannot be detected by existing sensors would make it possible to predict changes in humans and other living organisms, and it is expected that this will lead to ultra-early diagnosis of diseases and improvements in animal welfare. It also has the potential to open up new paradigms in other fields.

Research Unit Leader **Hiroyuki Ito**

Profile

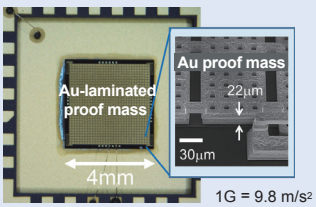
2016 Associate Professor, Institute of Innovative Research, Tokyo Institute of Technology
2013 Associate Professor, Advanced Microdevices Division, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2008 Researcher, Platform Technology Research Laboratory, Fujitsu Laboratories Ltd.
2007 Assistant Professor, Advanced Microdevices Division, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2006 Visiting Researcher, Intel Corporation
2006 Research Fellow (PD), JSPS Research Fellowship for Young Scientists
2006 Ph.D., Department of Advanced Applied Electronics, Tokyo Institute of Technology

Research goals

To systematize, commercialize, and industrialize our technology, we are pursuing the following themes: in fundamental research, "development of ultrahigh-sensitivity accelerometer systems", and in applied research, "early diagnosis of intractable neurological diseases based on low-level mechanomyography" and "prediction and early detection of illnesses in cattle". In ultrahigh-sensitivity accelerometers, we are working on significantly reducing device and circuit noise in order to be able to measure microgravity-level accelerations, equivalent to those in environments such as space stations. For early diagnosis of neurological diseases, we are focusing on Parkinson's disease (PD). There is no basic treatment for PD, but its onset and progress can be delayed through early diagnosis. As for early detection of illnesses in cattle, if we can accurately detect minute changes in the animals' behavior, and simultaneously internal sounds such as ruminal activity, it would be possible to identify risks to production, which could greatly impact the livestock industry. We are also aiming to take the lead in Japan's integrated circuit field in cooperation with other research groups, as well as to train early-career researchers.

Contributing to sustainable medical care and food production for the happiness and well-being of society

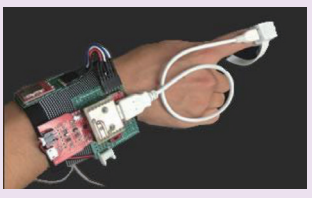
Basis Measurement of nano-G acceleration



Seeds

Needs

Application From monitoring to early diagnosis and risk prediction



Intractable neurological diseases

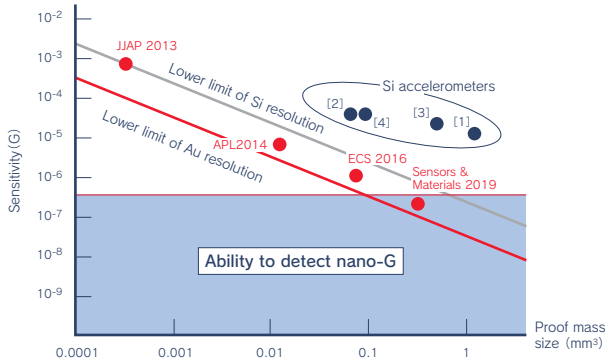
Livestock

Applying ultrahigh-sensitivity accelerometry in animal welfare and early diagnosis of neurological diseases

Q What are the strengths of this research unit?

We have developed accelerometers with some of the highest sensitivities yet achieved, and for the first time in the world, have successfully applied these to the measuring of very week mechanomyograms, which are the weak vibrations generated by muscles. Currently, the mainstream in the medical and other fields is performing image analysis using AI. But the advantage of using the accelerometers developed in our unit is that neural activity and in-vivo information can easily be acquired non-invasively. Skill is needed to use the sensors due to their high sensitivity, so it is also important to develop based on understanding of how they will be used in the field. This unit includes researchers from various backgrounds, so another strong point is that we can simultaneously promote both basic and applied research.

Sensitivity of capacitive accelerometers



1. IEEE JMEMS, 13, 2004, "An In-Plane High-Sensitivity, Low-Noise Micro-g Silicon Accelerometer With CMOS Readout Circuitry"
2. IEEE Sensors J., 8, 2008, "A Monolithic CMOS-MEMS 3-Axis Accelerometer With a Low-Noise, Low-Power Dual-Chopper Amplifier"
3. Proc. IEEE SENSORS 2009, "Micro-G Silicon Accelerometer Using Surface Electrodes"
4. Sensors and Actuators A, 172, 2011, "Pull-in-based mg-resolution accelerometer: Characterization and noise analysis"

Compared to conventional accelerometers that use silicon (Si) as the proof mass, using gold (Au) increases the sensitivity by at least one order of magnitude. This unit will pursue even greater sensitivity, and work with industry to achieve practical application.

Q What is the path to achieving the unit's goals?

We are working to significantly reduce noise in our accelerometer systems so that within three years, it will be possible to measure micro-G level acceleration. To reach commercial adoption, we will collaborate with industry on triaxialization, low power consumption, high linearity, and wirelessness. At the same time, we will develop prototypes for measuring muscle activity and cattle behavior, and continually conduct early-stage, proof-of-concept experiments in order to reach practical application.

Q What impact will the unit's research have on society?

In Japan alone, over 150,000 people are severely affected with PD. If the research of this unit enables early detection of the PD, rehabilitation treatments such as physical therapy can be prescribed prior to the stages requiring medication. This will help to alleviate deterioration of quality of life and medical costs. In regards to food production, our work will provide solutions to issues such as increased environmental impact and improving production efficiency in harmony with the increasing demand for meat. Also, creating new measurement technologies can have other incalculable benefits for both academia and industry. The sensors that are being developed by this unit will make it possible to detect new symptoms that up to now have not been noticed, and predict major changes that will occur later. We expect utilization to spread to other areas, such as structural inspection and predicting natural disasters.

Contact us

Tokyo Institute of Technology
Nano Sensing Unit

S2-14, 4259 Nagatsuta-cho, Midori-ku, Yokohama, Kanagawa 226-8503 Japan
Tel : +81-45-924-5010 Fax : +81-45-924-5022
Email : ito@pi.titech.ac.jp
http://masu-www.pi.titech.ac.jp/index_e.html