Heterogeneous and Functional Integration Unit

Overview

Semiconductors for CPU and memory indispensable for personal computers and smartphones have improved performance through device shrinkages. However, we are encountering the physical limits of shrinking using conventional technology. The three-dimensional large-scale integration (3D LSI) technology that we developed has special vertical interconnect technology and special ultra-thinning technology for semiconductor die stacks, and improves performance while making the stacks smaller and thinner. Using this technology, we will integrate multiple semiconductor functions into a one-stack module, and our goal is to surpass the limits of shrinking devices two-dimensionally. Further, we will apply matured know-how of the semiconductor manufacturing process to heterogeneous fields and endeavor to create new industries in biotechnology and agricultural engineering.

Research Unit Leader

Takayuki Ohba

Profile

2013 Tokyo Institute of Technology, Professor
2004 The University of Tokyo, Professor
1984 Fujitsu Limited
National Chiao Tung University (NCTU), Visiting Professor
Ph.D received from Tohoku University in 1995

Unit members

- Professor Yasuko Yanagida
- Associate Professor Hiroyuki Ito
- Associate Professor Kim Young Suk
- Professor Hiroshi Kudo
- Professor Tomoji Nakamura

Research goals

To extend the Wafer-on-Wafer (WOW) Alliance, a global platform for industry–academia research started in 2008, we will pursue the following themes.

【Three-dimensional integration technology】 We will use the ultra-thinning technology and the vertical interconnect technology possessed by the WOW Alliance to integrate semiconductors three-dimensionally and create a next-generation semiconductor that is higher in performance and lower in power consumption. Furthermore, this work will accelerate the ultra-miniaturization of not only large-scale computing devices such as servers, but various devices equipped with semiconductors to 1/1000th of their current size.

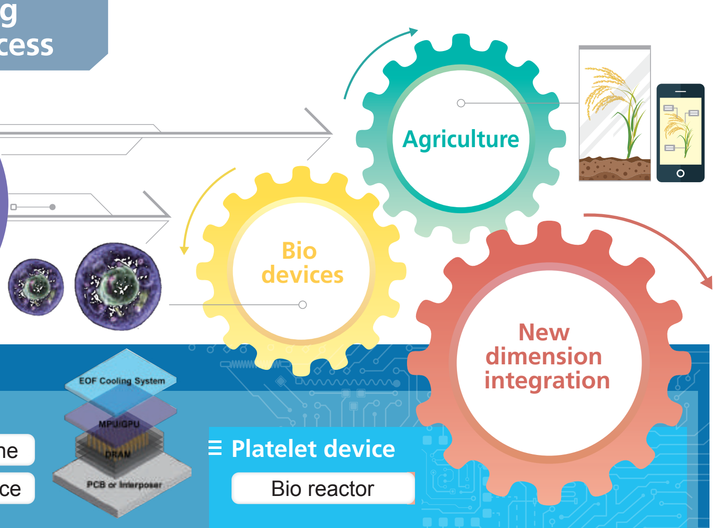
【Cooling technology】 By combining ultra-small cooling devices with three-dimensional stacked semiconductors, our work will allow for simplification of cooling technology and application to the miniaturization of IoT and mobile devices.

【Biotechnology】 We are developing MEMS devices that replicate the vital reactions that take place inside an organism. Specifically, the goal is to apply the semiconductor manufacturing process to prototype a platelet-producing device mimicking the structure and functions of the capillaries inside the spinal cord. We aim to realize stability and improved speed of platelet production at low cost by using fluid mechanics analysis to optimize the structure of the micro-fluid system.

【Agricultural co-engineering】 To reveal the conditions for a plant's maximum output, we will make it possible to monitor "what a plant wants." We will develop closed-system cultivation devices based on semiconductor manufacturing technology to control the growth environment and draw out the plant responses at high reproducibility. We will also create multimodal sensing technologies to quantify the various responses.

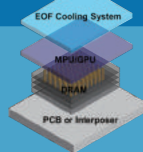
Creating new industries by utilizing semiconductor manufacturing process

- Semiconductor manufacturing process
- Semiconductor ultra-thin technology
- Interconnecting technology
- Circuit design

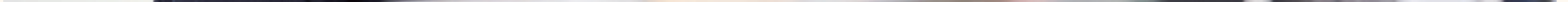


3D large scale integration
- DRAM
- Flash
- MPU

Cooling device
- MPU
- LED
- Smart phone
- Power device



An assembly of businesses from different fields focusing on semiconductor technology and aiming to become a technology platform based on win-win collaboration



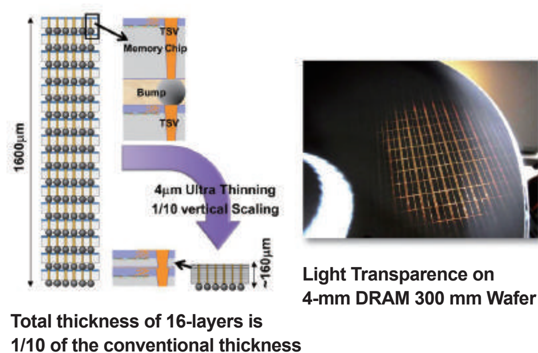
Why was this research unit established?

The technology for semiconductors in personal computers and smartphones was developed on a two-dimensional plane. In the case of CPUs, its performance is improved by shrinking devices to increase the number of transistors per unit area. However, that scenario for improving performance will reach its end in the near future. The industry is valued at 400 billion USD as a global market, and stagnation for its technology would greatly impact the global economy. However, expectation for AI and IoT is likely to increase demand for the miniaturization of semiconductors in association with performance. With the WOW Alliance, an industry–academia research platform, we have been pursuing research and development of vertical interconnect technology and ultra-thinning technology for high integration of semiconductors. We have started this new unit to apply these technologies to improve performance of semiconductors and to integrate multiple thinner and smaller semiconductors with different functions into one and thereby respond to the needs of society.

What are the strengths of this research unit?

Our feature is the co-development resulting from semiconductor processes, design, materials, process equipment, and a group of Tokyo Tech specialists. Businesses of different industries working together makes it possible for us to pioneer heterogeneous fields and share knowledge. This unit's strength is its potential to maximize the cost–performance of investment in development during the so-called "valley of death" phase by a single business. Using this strength, we are able to overcome development of next-generation products to the prototype level. With biotechnology, we will realize a system (a mechanism) utilizing ultra-small bio-MEMS devices to produce rare bioproducts stably and at low cost. Agricultural co-engineering is the application to analysis of the growth process of plants using know-how of semiconductor manufacturing. We would like to unravel the "feelings" of plants that have survived for hundreds of millions of years. We started these biotechnology and agriculture projects from the idea: what would happen if we layered together different technologies, like three-dimensional heterogeneous function integration technology?

Ultra thin semiconductor technology



Total thickness of 16-layers is 1/10 of the conventional thickness

Light Transparence on 4-mm DRAM 300 mm Wafer

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

We will continue our work on our proof-of-concept for three-dimensional integration of semiconductors and achieve ultra-small, ultra-low power consumption. We will then develop it further and combine a CPU, a communication module, and other components into one high-density stacked chip to enable the creation of ultra-small, high-performance IoT devices and even smartphone-sized ultra-high-performance servers. In agricultural engineering, we will establish the conditions for maximizing a plant's output in a closed environment and start applying it in large-scale production plants. These paths will require participation, by not only domestic companies, but also business abroad. We aim to become a technology platform creating one new industry after another as a result of a dream team of heterogeneous functions assembled from Asia and the rest of the world.

Contact us

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