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The University of Tokyo – TSMC Advanced Semiconductor Technology Alliance

The University of Tokyo (Bunkyo-ku, Tokyo; President: Makoto Gonokami) and TSMC (Hsinchu, Taiwan; Chairman: Mark Liu) held a joint press conference today to announce an alliance to pursue organization-wide collaboration in world-leading semiconductor technology to investigate the design and manufacturing of data-driven systems that enable the emerging knowledge-intensive society. Under the alliance, prototype chips developed through industry-academia collaboration at the Systems Design Lab (abbreviated and hereafter referred to as d.lab) (note #1) of the Graduate School of Engineering at the University of Tokyo will be fabricated using TSMC's leading-edge processes. In addition, the two organizations will jointly develop semiconductor technology for the future of computing. While d.lab serves as a design hub (note #2), this alliance will serve as a gateway (note #3) for design and manufacturing.

To lay the groundwork, the University of Tokyo launched d.lab on October 1st of this year. It is a research organization for the design of data-driven, domain-specific systems encompassing everything from software to device, for the age of digital inclusion where every individual is empowered by digital technology. The University is adopting TSMC’s Open Innovation Platform® Virtual Design Environment (VDE) for d.lab’s chip design process, and TSMC will provide its CyberShuttle® multi-project wafer service to manufacture d.lab’s prototype chips on the company’s most advanced process technologies.

Since domain-specific chips can only be developed with deep understanding of the specific application, d.lab is building an organization that facilitates close collaboration with the industry. Its goal is to create a design and manufacturing platform (note #4) that enables anyone with innovative ideas to rapidly develop highly energy-efficient chips to realize their systems.

In another preparatory effort, University of Tokyo researchers from diverse disciplines visited TSMC on November 1st to participate in a symposium to discuss semiconductor devices, processes and materials of the future. While the industry is able to continue to scale semiconductor process down to 3 and 2nm, it will require new knowledge in materials, physics and chemistry outside the realm of conventional silicon technology to advance the industry into the future of semiconductors. At the symposium, TSMC technologists and University of Tokyo researchers were able to discuss in great depth and achieve common understanding of the vision for the semiconductor device of the future, the challenges to overcome, and areas of collaborative research to pursue. The alliance plans to continue such interaction in order to collaborate on research in the area of semiconductor device and process as well.

The alliance is created by the leaders of the two organizations who share a common goal of overcoming a major challenge. It is an endeavor to lead the world in semiconductor research through organization-wide collaboration between industry and academia across national boundaries.

“Japanese industry is making a paradigm shift to a knowledge-intensive society, and this alliance with TSMC will connect us to the world's most advanced factories, contributing to the realization of Japan’s national strategy of Society 5.0,” said Makoto Gonokami, President of the University of Tokyo. “We are pleased to collaborate with TSMC, a world-leading semiconductor company, to establish this alliance between industry and academia across national boundaries.”
“There are many paths to improving semiconductor technology for the industry to explore, and TSMC actively collaborates with many top academic institutions around the world. We are delighted we now have University of Tokyo as one of our partners,” said Dr. Mark Liu, Chairman of TSMC. “TSMC’s role in the semiconductor industry is to facilitate more innovators and unleash the power of their innovation. I believe this alliance between TSMC and University of Tokyo will be able to transform many innovative ideas into real products that will enrich our society.”

The alliance is formed against the backdrop of the following societal, economic and industrial trends.

The world is driving towards Society 5.0 (note #5), a human-centric, ultra-smart society. In such a society, value-added is primarily provided through services. The key to creating services with high value-added is the innovative use of data that seamlessly connects between the physical world and cyberspace. In other words, what is desirable are data-driven systems that utilize IoT (note #6) devices to collect analog data from the physical world in real time and convert it into digital data in cyberspace, then utilize advanced communication networks such as 5G (note #7) to freely and reliably transmit the data (Data Free Flow with Trust, note #8) with minimal delay for sophisticated AI processing, and finally deliver smart services such as automated driving based on the analysis results. The key element that determines the performance and reliability of such data-driven systems is their semiconductor chips. Until now, in a capital-intensive society, the mainstream semiconductor chips have been general-purpose chips (note #9) which are adopted in a wide range of applications to take advantage of the economy of scale. However, power consumption of such general-purpose chips is excessive for applications such as sophisticated AI and cryptographic processing. Meanwhile, with the exponential growth of data and rising demand for service quality and reliability resulting from the emergence of a knowledge-intensive society, the only way to improve processing performance and enhance security while staying within the system power constraints is to increase energy efficiency. Consequently, reduction in energy consumption of data processing both at the edge and in the cloud has become the most important challenge to overcome.

By adopting specialized, domain-specific chips (note #10) which are customized for a specific application with no superfluous circuits, it is possible to achieve an order-of-magnitude improvement in energy efficiency compared to using general-purpose chips. This is the reason why the world's leading technology companies are developing their own custom chips. To achieve the required energy efficiency, it has become necessary to perform system-level design and to implement the design using the most advanced semiconductor devices. However, developing specialized, domain-specific chips is resource-intensive – it can require several hundred man-years. As a result, it is also necessary to change the way chips are developed from a capital-intensive to a knowledge-intensive scheme. It is therefore an important mission of d.lab to develop and provide such a knowledge-intensive design methodology. By coupling the deliverables of the alliance with this design methodology, TSMC and the University of Tokyo will enable the semiconductor industry to deliver specialized, domain-specific chips to build the systems required for Society 5.0.

Glossary of Terms

Note #1 d.lab – See home page http://www.dlab.t.u-tokyo.ac.jp/

Note #2 Hub – Center of an activity

Note #3 Gateway – Hardware or software that connects between networks.

Note #4 Platform – A business model where products, services and information are all provided in one place in order to expand customer base and market share. It can also refer to a foundational technology that can be utilized in multiple products or multiple families of products.

Note #5 Society 5.0 – A human-centric society that promotes economic development while tackling societal problems through the fusion of cyberspace (the virtual world) with physical space (the real world). It is the next phase in the evolution of human society after the hunter-gatherer society (Society 1.0), the agricultural society (Society 2.0), the industrial society (Society 3.0), and the information society (Society 4.0). It was first advocated in Japan's 5th Science and Technology Basic Plan as the future of society. To realize Society 5.0, it is necessary to bring about a paradigm shift from a capital-intensive to a knowledge-intensive society. While value-added in a capital-intensive society is primarily found in products, in a knowledge-intensive society it is delivered by services.

Note #6 IoT (Internet of Things) – An internet of various connected things which interact with each other through information exchange.

Note #7 5G – The 5th generation of mobile communication system which is characterized by high speed, large capacity, low latency, and connection of many devices. Its service is expected to begin in 2020.

Note #8 Data Free Flow with Trust (DFFT) – A concept proposed by Prime Minister Abe in his speech at the World Economic Forum's 2019 Annual Meeting in January in Davos, Switzerland.

Note #9 General-Purpose Chips – Integrated circuits that implement multiple electronic components on a small semiconductor substrate which can be adopted in a wide range of applications. DRAM and CPU are two such examples.

Note #10 Domain-Specific Chips – Semiconductor chips customized for application in a specific domain. AI accelerator is one example.

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