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Future Prospects of Semiconductor Industry

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1. Global Issues and Solutions

We live in the 21st century, where sustainable development is the commonly recognized global challenge. We hope to improve our quality of life and maintain healthy growth of the economy, while we are also becoming more and more conscious of exhaustible natural resources and our responsibilities to protect the environment. Solutions to these global issues can be found in semiconductor technology, whose capabilities and applications will continue to expand in the 21st century.

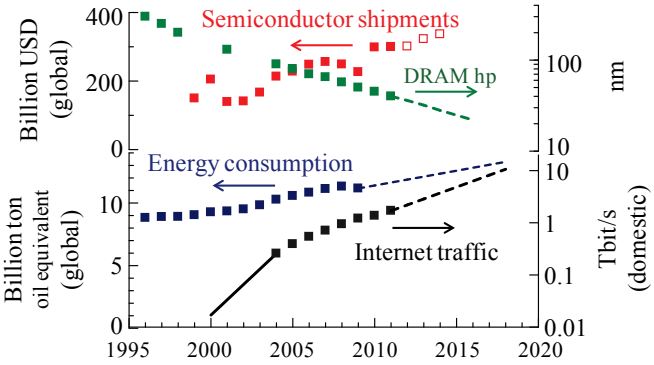

Fig. 1 Trends in energy demand, semiconductor shipments, Internet traffic, and LSI scaling [1-3].

Figure 1 illustrates the trends in energy demand, semiconductor shipments, Internet traffic, and LSI scaling. It shows that the semiconductor industry is still a maturing industry. It is expected to be a key enabler of various innovations. For instance, the rapidly increasing Internet capacity may potentially cause an increase in energy demand, but this problem can be solved by developing low-power semiconductor technology. The low-power technology will lead to innovative green-IT services that improve energy efficiency in various systems. Another example is individually customized IT services such as health monitoring, which is particularly important in aging societies such as Japan.

2. Current Aspects of Semiconductor Technology

Quest for ultimate scaling and mass production

The cutting-edge R&D on CPUs and memories foresees that the technology generations of the sub-10-nm design rule will come in less than a decade. Transition to the 450-mm wafer processes is no longer a story of the distant future. However, R&D on mass production of such ultimately scaled LSIs requires a huge investment that also incurs a risk that is too high for any single company to take.

Emerging diversity

Recent developments in low-power devices and network technology triggered expansion of their applications, e.g., smart phones and sensor networks. The social needs mentioned in the previous section will further diversify the application fields. For a given target application, the technological options are also becoming diverse as new materials, processes, and devices are being developed. Creating innovations under such diversifying circumstances requires many trials to integrate technology and knowledge of a wide range of disciplines. In particular, integration of hardware and software (i.e., embedded software) is an essential ingredient of successful products and services. Since such trials are hardly available within a single company or organization, diversity among the participating players is also essential. New players outside the conventional semi-

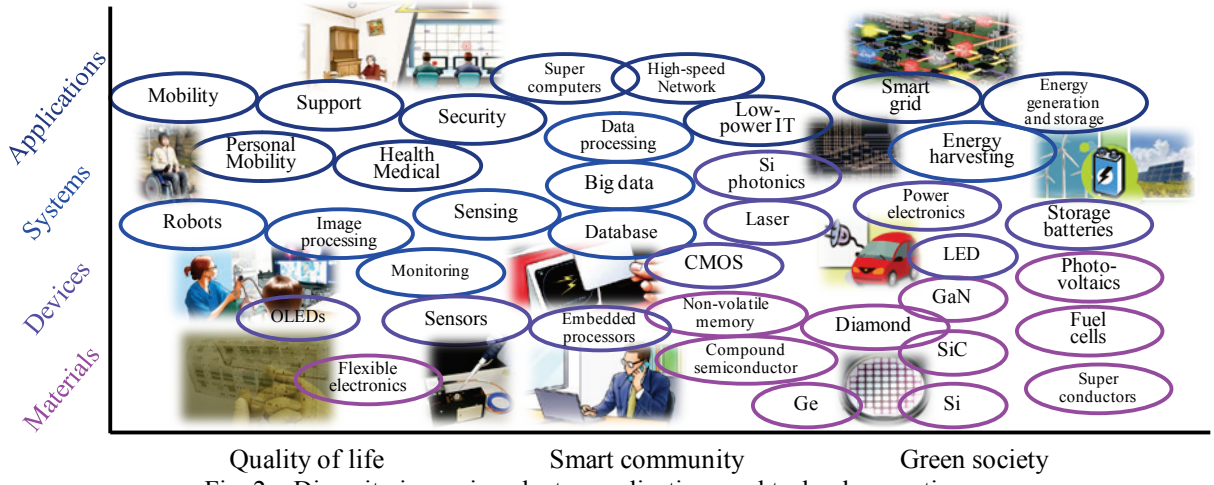

Fig. 2 Diversity in semiconductor applications and technology options.

conductor industry are now invited to join these innovation activities.

3. Era of Open Innovation

The above-mentioned situations have prompted the semiconductor technology community to adopt the open innovation scheme. In open innovation, the partners share ideas, resources, risks, and rewards in order to figure out the emerging needs of society and the market, to set common targets, and to execute R&D and start up business endeavors in a speedy manner. This scheme is particularly effective when the diverse applications require needs-pull (or solution-oriented) R&D. Well-formulated strategies for standards and intellectual properties are the prerequisites for successful open innovation where the players of different cultures collaborate.

4. AIST as an Innovation Hub

AIST is one of the largest research organizations in Japan with nearly 3,000 researchers covering a wide range of disciplines from IT-electronics to nanotechnology, environment/energy technology, life science, metrology, and geological surveying. AIST is responding to the increasing need for open innovation, and one of AIST's present missions is to serve as an innovation hub that facilitates integration through collaboration among industry, academia, and national institutes. Actually, AIST researchers are already working with more than 5,000 other researchers through partnerships with industry, academia, and other organizations.

The hub provided by AIST enables participating companies to share a clear target application and service, and to form a *vertical* alliance for combining technologies of materials, processes, devices, circuits, software, and so on. A typical example is Tsukuba Power-Electronics Constellations (TPEC), which has been launched basing on industry funding. In the field of nanoelectronics, much of the current research at the AIST hub is focusing on low-power technologies such as logic and memory devices incorporating new materials and operation principles, photonics-electronics integration for interconnects and networks, and spintronics for normally-off computing.

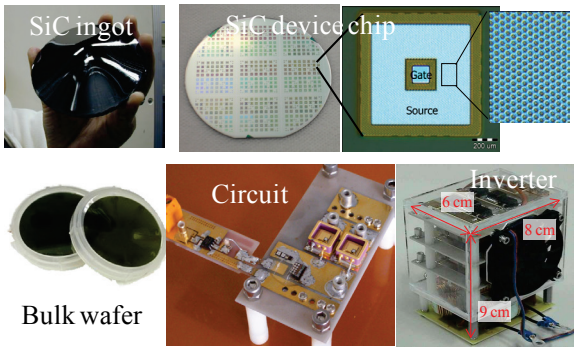

Fig. 3 Power electronics R&D conducted at the AIST innovation hub.

In addition, four institutes located in Tsukuba—the National Institute for Materials Science (NIMS), the University of Tsukuba, the High Energy Accelerator Research Organization (KEK), and AIST—have formed the Tsukuba Innovation Arena for Nanotechnology (TIA-nano), which aims to integrate the nanotechnology research resources accumulated in Tsukuba. Figure 4 shows six core research domains of TIA-nano and three core infrastructures, which include the 300-mm process line for nanoelectronics R&D. The research projects using these infrastructures have been accelerated due to the input and support from the expert researchers in the four institutes, which distinguishes TIA-nano from other semiconductor research centers in the world.

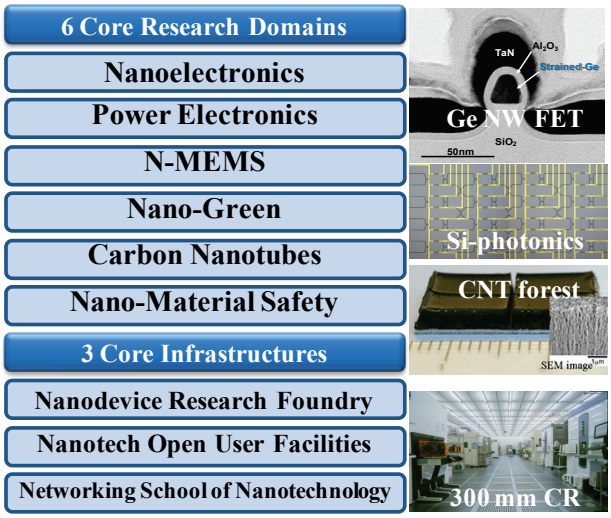

Fig. 4 Core research domains and core infrastructures of TIA-nano.

5. Future Visions

Historically, the main players of the semiconductor industry were the integrated device manufacturers, which were later followed by the materials and equipment suppliers. As semiconductor applications and technology options continue to diversify, the enterprises and organizations that were not involved directly in this industry will play more important roles. There are many frontiers to be explored, as well as many opportunities for new and impactful innovations. SSDM is a unique international conference in that it covers both device and materials research attracting both industry and academia researchers. I hope that SSDM will continue this tradition, embracing the new players of open innovation for our future.

References

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[3] http://www.soumu.go.jp/main_content/000149220.pdf