Worldwide R&D

# Kitamori Laboratory, University of Tokyo; Micro Chemistry Group, Kanagawa Academy of Science and Technology; et al.

The Kitamori Laboratory has conducted research on integrating chemical and biotechnological systems on microchips on the basis of applied spectroscopy techniques. The research is broadly divided into four categories: extremely basic research on chemical reactions and the behavior of fluids in microspaces and nanospaces, basic technology research necessary for integrating chemical and biotechnological systems on microchips, applied research on the practical use of integrated microchemical systems, and commercialization research on problems to be overcome for practical use of microchip-integrated devices.

Of these four categories, the basic research has been conducted at the initiative of the Kitamori Laboratory and the basic technology research at the initiative of the Micro Chemistry Group in the Kanagawa Academy of Science and Technology (KAST). The applied research has been advanced as a joint research project with private companies. The Institute of Microchemical Technology (IMT), which we started as a venture company, is responsible for commercialization research. The New Energy and Industrial Technology Development Organization (NEDO) also takes part in some areas of applied research and commercialization research. Our group cooperates with all aspects of the research and development. There are no defined boundaries separating the four categories of research, allowing us to work flexibly according to the research topic. Incidentally, the Micro Chemistry Group became a permanent laboratory to succeed the five-year "Integrated Chemistry Project" that was successfully completed in March. Our research is organized around these four research groups, in which some fifty researchers-about twenty students, seven permanent researchers including professors, seven postdoctoral fellows, several technical assistants, IMT employees, and researchers from private companies-are engaged.

Experiments and simulations conducted in the basic research surprised researchers by shedding light on unrevealed chemical phenomena. The findings include the acceleration of chemical reactions (enzyme reactions, etc.), the formation of vortex structures near the two-phase (liquid-liquid) flow interface regardless of low Reynolds number flows, and the appearance of disordered flow at the interface. In addition, it was found that water approaches the properties of ice at normal temperatures in a mesospace, which is slightly larger than a nanospace.

The basic technology research provided us with a new methodology for integrating normal macrochemical processes on microchips, thereby nearly completing the first step aimed at establishing the principle for "what to do and how to do it." Now, we have begun the second step in which more complicated systems, such as a 3D system and the system consists of liquid and gas phase, are integrated on microchips.

The applied research enabled us to develop a microanalysis device system. With conventional analysis systems, we had difficulty analyzing disease markers and environmental pollutants because of the highly skilled techniques required. However, the new microanalysis device reduced the analysis time to several tens of seconds instead of half a day, demonstrating superior performance and effectiveness on actual samples. For the field of chemosynthesis, we also developed an innovative chemosynthesis device capable of reducing reaction time and processing time, improving efficiency and yield, and controlling an intermediate reaction through instantaneous heating and cooling. Moreover, we developed a new device for cell culture equipped with a life-sustaining function to supply oxygen and nutrients for a microculture vessel created on a microchemical chip. The device provided us with the prospect of developing a device for use in time-consuming experiments and assays on cells and microorganisms.

In the commercialization research, we developed a mass-production system of microchemical chips, a microchip reader equipped with highly sensitive sensors and microsystems for performing diagnoses and health checks and monitoring the environment and are close to completing the prototypes. With the chemosynthesis plant, a gel manufacturing plant the size of a small building was scaled down to the size of shoe cupboard. Despite the downsizing, the gel manufacturing plant has a production capacity of thirty tons per year, which exceeds that of a large-scale plant. The world's first microchemical plant has entered pilot operations through our joint research partner Tosoh Corporation.

IMT, a university-launched venture company, offers standard and custom-made microchemical chips and thermal lens microscopes capable of highly sensitive sensing and serves to restore and disseminate university research findings by providing research materials, enabling inexperienced researchers and engineers to engage in research quickly and easily.

Since there are no foreseeable commercial markets for original technologies, small-scale companies are expected to pioneer the development of new technologies and establish a foundation for creating a new market before major companies can enter. Hence, it is not an exaggeration to say that a process resulting in the creation of a new industry from a university-developed original technology is more an experiment than a pragmatic approach. We work to develop an industry, government, and academia relationship in which universities; enterprises; the Ministry of Economy, Trade and Industry; the Ministry of Education, Culture, Sports, Science and Technology; the Ministry of Agriculture, Forestry and Fisheries; NEDO; the Japan Science and Technology Corporation (JST); the Japan Society for the Promotion of Science (JSPS); and others continue to provide us with considerable support.

We couldn't produce microchannels and microstructures on a microchemical chip smaller than a micron with microfabrication technique. However, we started a new study aimed at constructing a nanoscale infrastructure in a micron-size space in order to develop chemical and biotechnological devices superior in functions and integration capability. The research is based on a concept called a "Nano Bio-Physico-Chemical Architecture". We are looking for a breakthrough in chemical and biotechnological fields through the development of new nanotechnologies, such as nanoscale structures and chemical patterning, reaction and fluid control systems actively applying interface and surface properties, and cell control based on these nanostructures.

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