Extended-nano Fluidics and its Unique Characteristics and Applications

Takehiko Kitamori

Department of Applied Chemistry, School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Email:kitamori@icl.t.u-tokyo.ac.jp

We published the first paper concerning extended-nano fluidics in 2002. It was also the first report which fabricated the rectangular extended-nano cross section channels and controlled the fluid by pressure. After that, we developed the variety of technologies for extended-nano fluidics. Especially, detection and inner surface modification are the essential tools for extended-nano fluidics. Inside the extended-nano channels, the detection volume easily becomes under pL scale and the optical path length is shorter than Vis-UV light wavelength. Furthermore, many target molecules in the fluidics are non-fluorescent. That is why we developed the DIC-TL (differential interference contrast – thermal lens) detection method in which even countable number of non-fluorescent molecules and np can be detected in the extended-nano fluidic channels. And also, modification and functionalizing method of the inner surface of the extended-nano channels is a key technology for controlling the nature and function of the channels. For realizing this modification and functionalizing method, we developed the low-temperature bonding of glass substrates, in which the two glass substrates are bonded at even room temperature after fabrication and surface modification and functionalizing. Of course, fluidic control system at high pressure is also the essential technical component. In total, we could realize the fluidic device technology at extended-nano scale.

First of all, we were aware of the unique characteristics and properties of liquids and fluid in the extended-nano fluidic channels. The properties of water in the extended-nano channel are completely different. Viscosity is higher, dielectric constant is lower, proton mobility is larger, and etc, etc. Fluidic characteristics are also unique. For example, velocity at surface boundary is not zero under a laminar flow condition. The reason for these unique characteristics and properties is still unclear, but the surface may dominate these phenomena. We are now utilizing spectroscopic and structural analytical methods for elucidating these phenomena.

Concerning the applications, they have come into view as well as its Olympic game in which the smaller is the better at pico, femto, and atto subunits. Utilizing the ultimate smallness, aL chromatography, fL immunoassay, fL solvent extraction were realized. Especially, single and countable molecule immunoassay was demonstrated, and it is quite promising to single cell single molecule analysis. Concerning the unique properties of liquid and fluid, we applied them to the light driven self recharging fuel cell in which hydrogen was supplied and electricity was generated in a closed integrated fluidic system on a chip. These applications will be introduced in the lecture.

References: http://park.itc.u-tokyo.ac.jp/kitamori/