Development of Droplet-DIN Microplasma AES System for Individual Analysis of Single Cell/Particle

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Inductively coupled plasma (ICP) has been widely used as an ionization and excitation source for elemental analysis because of their excellent sensitivity. In recent years, target of elemental analysis has shifted to smaller amount samples such as bio-cells, nano-particles and atmospheric dust. Especially, demand for individual analysis of these samples is growing up. However, ICP system consumes large amount of sample solution (up to 1 mL/min) and individual introduction of these samples is difficult. Therefore, usual ICP system is not suitable for this requirement.

To realize high sensitive analysis of small amount of samples, we have developed high power microplasma device for elemental analysis. In this device, higher power density plasma than ICP is realized with the small plasma volume (0.24 μL). This device can generate high density plasma with helium gas, which has highest ionization energy in all elements and so all elements can be ionized and detected. In previous work, detection of halogens was confirmed with good sensitivity. And liquid sample introduction was achieved using a conventional ultrasonic nebulizer (USN).

In this study, our droplet direct injection nebulizer (D-DIN) system was applied for the microplasma to realize individual analysis of single cell or particle. In this system, sample solution is not nebulized but directly injected into the microplasma as a single droplet by the droplet injector which used piezoelectric element. The droplet volume is 30 pL and cell or particle will be contained in it. Figure 1 shows the schematic diagram of D-DIN microplasma atomic emission spectrometry system. To evaluate the analytical performance, 50 ppm sodium solution was introduced. With a 30 pL of single droplet, atomic emission of Sodium (Na I 588.99 nm) was observed. As a result, 16.7 % of RSD and 90 fg of limit of detection were obtained. To improve analytical ability, the performance dependency on operational conditions, such as plasma gas flow rate and plasma current were investigated. Figure 2 shows the emission intensity of Na I, He I and H_β in various discharge current. Experimental results indicate that higher plasma current and lower plasma gas flow rate increase emission intensity of analyte (Na) than plasma gas (He) or solvent (H_β). This fact results from increase of the power density and the plasma temperature. Improvement of analytical ability is expected, using higher power density plasma.

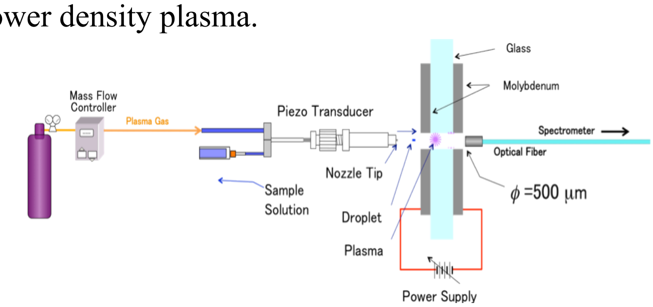

Fig.1 D-DIN microplasma system

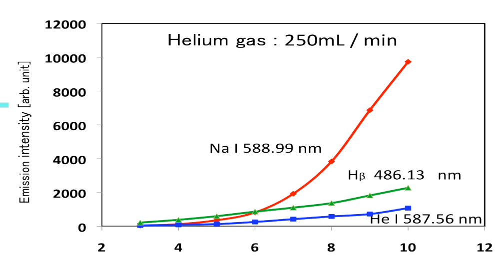

Fig.2 Na I, He I and H_β intensity against current