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マイクロ波を用いた小型原子源の開発
Development of a Compact Microwave Driven Atomic Beam Source

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1. Research Background

A microwave driven atomic hydrogen beam source has been being developed to utilize for biomedical analysis through Post Translational Modification (PTMs) of peptides and proteins. Fragmentation study with hydrogen radical source has revealed the effectiveness for preserving PTMs.[1)] In this original study, thermal cracking cells with a tungsten high temperature heater served as an atomic hydrogen beam source. High temperature components in the source not only produce contaminants, but also limit the operational lifetime, and thus, RF plasma excitation based atom sources are considered promising. Power fed by a coaxial cable miniaturizes the atom beam source compared with the one by a waveguide[2)]. The atom beam source driven by a RF Power can also dissociate reactive gases other than hydrogen, such as nitrogen, to enhance applicability into the new methods for biopolymer analyses.

2. Experimental apparatus

A 2.45 GHz forced air-cooled solid-state microwave power supply drives the discharge up to 100 W. Regulated DC voltages control the frequency and power of the main amplifier. A triple stub tuner matches the microwave power to the discharge load. Commercially available tuners are often supplied with magnetic materials to cause induction heating (IH). Therefore, this tuner was made of aluminum and duralumin to prevent IH.

2.1. CCP microwave atomic source

In Capacitively Coupled Plasma (CCP), a pyrex glass vessel encloses a needle shaped tungsten electrode. The ground electrode contains the pyrex glass torch to maintain a discharge at the tungsten electrode tip as shown in Fig. 1.

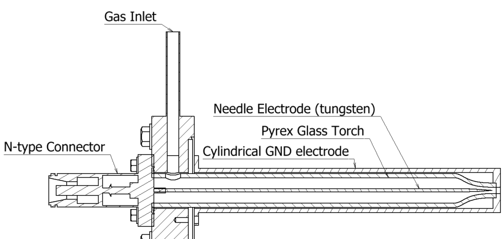

Fig.1. A sectional view of a CCP atom beam source.

2.2. Atomic hydrogen sensor

To detect atomic hydrogen flux, atomic hydrogen sensors are designed. Metal oxides and semiconductors can be utilized as hydrogen sensing elements.[3)4)5)] These sensors measure the change of conductivity as they are exposed to atomic hydrogen.

3. *Status quo*

A nitrogen discharge characteristic of CCP is shown as a function of gas pressure in Fig. 2. Necessary gas pressure to ignite plasma was quite high, while power to sustain plasma was relatively low. A result of optical emission spectroscopy is shown in Fig. 3. From Fig. 3 a degree of dissociation of nitrogen seems low without the line spectrum of atomic nitrogen. Inductively Coupled Plasma (ICP) atom source should improve the performance as the atom source. In ICP configuration shown in Fig. 4, a cylindrical Sm-Co magnet forms the magnetic field corresponding to Electron Cyclotron Resonance (ECR).

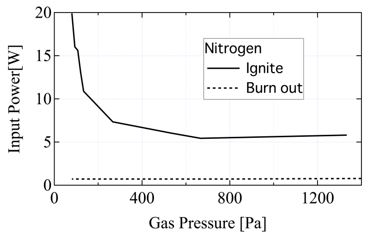

Fig.2. A nitrogen discharge characteristic of CCP.

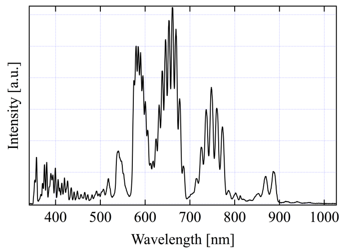

Fig.3. OES measured by USB 2000+ under 2Torr, 50W, Nitrogen

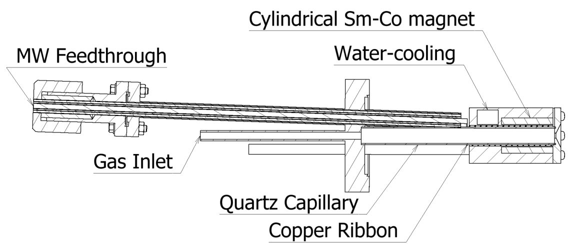

Fig.4. Sectional views of atom beam sources.

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