R&D of atmospheric-pressure μplasma source and its application to material processing

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Keywords	Plasma, Etching, Thin Films Deposition, SiO_2, DLC, Water purification, Sterilization		
Technical Support Skills	1. R&D of atmospheric-pressure μplasma source and its application to on-site processing 2. Inner wall modification of narrow tubes and microfluidic devices by plasma 3. Decomposition of organic compounds and sterilization in a water by pulsed plasma 4. Material processing technology using a low to high pressure plasma sources		

Research Contents

1. Material Processing by atmospheric-pressure μplasma

An atmospheric-pressure μplasma jet source generated at a low power consumption of 1-5 W has been originally developed using a surgical needle with an outer diameter of less than 0.5 mm. Ar, He and also air μplasma jets have easily generated (as shown in **Fig.1**). The μplasma jet was applied to the localized Si etching using $SF_6/He/O_2$ gases, on-site removal of organic thin films such as polyimide insulator films and local cleaning of terminals of a circuit board.

2. Thin Films Deposition by atmospheric-pressure μplasma

Radio frequency (RF) excited μplasma has been generated inside a narrow tube and a microchannel with an inner diameter of less than 1 mm (as shown in **Fig.2**). The plasma source has been applied to SiO_2 thin films coating on the inner wall of polymer (PTFE and PP) tubes and TiO_2 deposition inside a glass tube. The on-site deposition of diamond-like carbon (DLC) thin films has also been studied using the RF excited μplasma. Hydrophilic or hydrophobic treatment of a microchannel with a cross section of 350×90 μm^2 on a commercial microfluidic polymer (COC) chip has been attained by a pulsed discharge.

3. On-site growth of Carbon Nanotubes (CNTs) by atmospheric-pressure μplasma

CNTs have been grown successfully by atmospheric-pressure μplasma chemical vapor deposition with catalyst (Ni) using CH_4/H_2 gas mixture (as shown in **Fig.3**). Field emission (FE) from the vertically grown CNTs bundle was observed. The on-site growth of CNTs will be available to bio-sensor and gas sensor.

4. Water purification and sterilization using a compact plasma bubbler

A compact plasma bubbler made up of a μplasma source and a porous ceramics (**Fig.3**) has been developed for the applications of water purification and sterilization. Chemical probe method using terephthalic acid revealed that OH radicals are produced by the O_2 plasma gas bubbling. The inactivation for *E. coli*, *Bacillus subtilis* and *Saccharomyces cerevisiae* was attained by O_2 and air plasma gas bubbling.

■Japan Patent No.5099612 "Water Treatment Device"

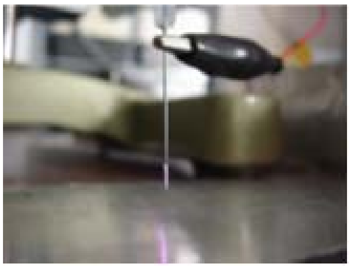

Fig.1 AP Ar μplasma jet

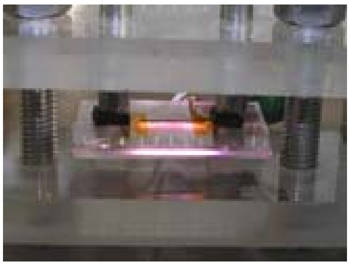

Fig.2 RF He μplasma jet

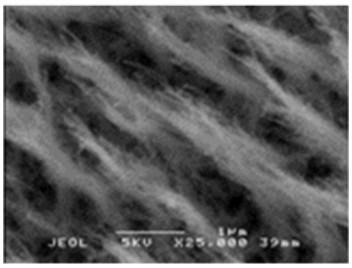

Fig.3 On-site CNTs growth

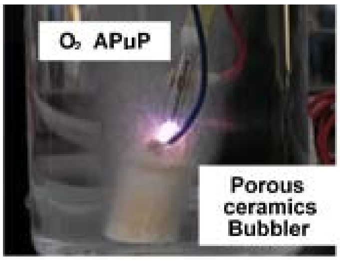

Fig.4 Plasma gas bubbler

Available Facilities and Equipment

Multichannel Optical Spectrometer (Hamamatsu Photonics PMA-11)	UV-Vis Spectrophotometer (Shimadzu UVmini-1240)
Quadrupole Mass Spectrometer (Cannon M-101QA-TDM)	
RF μPlasma Generation System, 13-50 MHz, 30W	
Microwave Generator, 2.45 GHz, 750 W (Nihon Koshuha)	