Control of Novel Gas-Liquid Interfacial Plasmas for Nano-Bio Conjugates Creation

R. Hatakeyama, T. Harada, Q. Chen, and T. Kaneko

Department of Electronic Engineering, Tohoku University,
6-6-05 Aoba, Aramaki, Aoba-ku, Sendai 980-8579, Japan

hatake@ecei.tohoku.ac.jp

Novel gas-liquid interfaces sandwiched between ionic liquids and gas phase discharge plasmas have recently been formed [1]. These gas-liquid interfacial plasmas could contribute to the effective creation and modification of nano-bio materials, where the control of charged-particle behaviors in both the gas and liquid phases is desired. In this study, configurations of the plasma source containing the ionic liquids are contrived for clarifying the effects of the ionic liquids on the plasma generation and the potential structure formed in the gas-liquid interfacial region is investigated for controlling the motion of the plasma ions and electrons [2].

A direct current (DC) or a pulsed DC discharge plasma is generated just above the ionic liquid by applying DC or pulsed DC voltages to a cathode electrode immersed in the ionic liquid or set in the gas phase region against a grounded electrode located at a distance of 70 mm from the cathode electrode. The precise potential structure between these electrodes through the gas-liquid interfacial region is clarified as shown in Fig. 1, where the cathode is (a) in the ionic liquid and (b) in the gas phase region. By means of the formation and control of the sheath electric field just above the ionic liquid, the behaviors of plasma ions and electrons can be manipulated and the effects of the plasma irradiation on the liquid medium are for the first time quantitatively revealed.

The control of the plasma irradiation flux and energy to the ionic liquid is found to lead to the creation of various kinds of nanoparticles. Furthermore, we realize the synthesis of highly-ordered and small-sized metal nanoparticles intercalated into carbon nanotubes, where the size of the nanoparticles can be controlled by changing the plasma irradiation conditions as shown in Fig. 2. Finally, we attempt to insert DNA-nanoparticle conjugates into the carbon nanotubes for the application to drag delivery systems, where the DNA is manipulated using the nanoparticle dynamics.

[1] K. Baba, T. Kaneko, and R. Hatakeyama, Appl. Phys. Lett. **90** (2007) 201501.
[2] T. Kaneko, K. Baba, and R. Hatakeyama, J. Appl. Phys. **105** (2009) 103306.

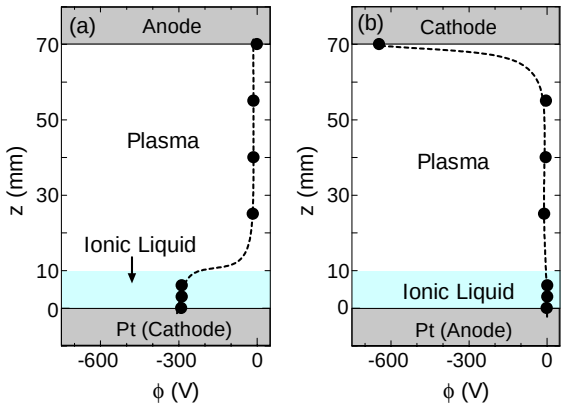

Fig. 1: Potential structures in the gas-liquid interfacial plasmas.

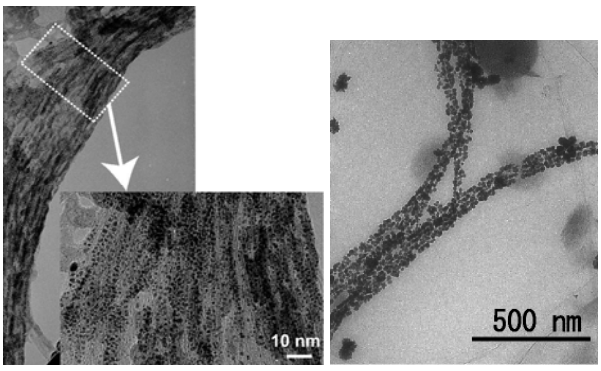

Fig. 2: Transmission electron microscopy images of Au nanoparticles synthesized using the carbon nanotubes as a template under different plasma irradiation conditions.