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Gas-Liquid Interfacial Non-Equilibrium Plasmas for Structure Controlled Nanoparticles

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Plasmas generated in liquid or in contact with liquid have attracted much attention as a novel reactive field in the nano-bio material creation because the brand-new chemical and biological reactions are yielded at the gas-liquid interface, which are induced by the physical actions of the non-equilibrium plasmas. In this study, first, size- and structure-controlled gold nanoparticles (AuNPs) covered with DNA are synthesized using a pulse-driven gas-liquid interfacial discharge plasma (GLIDP) for the application to next-generation drug delivery systems. The size and assembly of the AuNPs are found to be easily controlled by changing the plasma parameters and DNA concentration in the liquid. On the other hand, the mono-dispersed, small-sized, and interval-controlled AuNPs are synthesized by using the carbon nanotubes (CNTs) as a template, where the CNTs are functionalized by the ion and radical irradiation in non-equilibrium plasmas [1]. These new materials are now widely applied to the solar cell, optical devices, and so on. Second, highly-ordered periodic structures of the AuNPs are formed by transcribing the periodic plasma structure to the surface of the liquid, where the spatially selective synthesis of the AuNPs is realized. This phenomenon is well explained by the reduction and oxidation effects of the radicals which are generated by the non-equilibrium plasma irradiation to the liquid and resultant dissociation of the liquid [2]. In addition, it is attempted to form nano- or micro-scale periodic structures of the AuNPs based on the self-organizing behavior of turbulent plasmas generated by the nonlinear development of plasma fluctuations at the gas-liquid interface.

[1] T. Kaneko and R. Hatakeyama, Jpn. J. Appl. Phys. **51**, 11PJ03 (2012).
[2] T. Kaneko, S. Takahashi, and R. Hatakeyama, Plasma Phys. Control. Fusion **54**, 124027 (2012).