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Combinatorial Analyses of Plasma-Polymer Interactions for Development of Advanced Nano-Process Technologies

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Materials systems with organic-inorganic hybrid structures have become significant for development of nano devices including next-generation ULSIs, NEMS and bio-chips; e.g., photoregist for EUV lithography, low-k materials and functional organic materials for semiconductors and sensors. Furthermore, flexible electronics or electronics on polymers attract great attentions as next generation devices with a variety of applications including flat panel displays and photovoltaic cells. For successful development of advanced devices with organic-inorganic hybrid structures, scientific understanding of plasma-polymer interactions and optimization of plasma processing of polymers and/or organic-inorganic interface are required in terms of chemical and physical properties.

For development of these process technologies, however, it is greatly anticipated that optimal process conditions can be attained at a pinpoint window of the process conditions, in which device structures and/or organic-inorganic interface should be controlled with a precision of nanometer size either via top-down or bottom-up process. On the basis of guiding principles to establish scientific basis of plasma nano processes, a plasma process analyzer has been developed via combinatorial methods, in which process examinations with a continuous variation of plasma-process conditions (ion flux, radical flux and/or radical-to-ion flux ratio) can be carried out on a substrate holder with an inclined distribution of process parameters (ion flux and radical flux) and the distributions of particle fluxes are finely controlled and characterized via particle diagnostics.

In this study density-inclination plasmas have been developed for the combinatorial plasma-process analyses, in which the density-inclination plasmas are generated via localized power-deposition profile of inductive RF discharge with low-inductance antenna (LIA) modules. The LIA module consisted of a U-shaped internal antenna with dielectric isolation, which allowed low-voltage and high-density plasma production.

In this paper, design issues involved in production and control of density-inclination plasmas are described for the plasma process analyzer via localized profile of power deposition to sustain discharge with inductive coupling of RF power using low-inductance antenna (LIA) modules. Furthermore, plasma-polymer interactions have been examined with the combinatorial plasma-process analyzer in terms of chemical bonding states, surface morphologies and etching characteristics.

Keywords
combinatorial method
plasma nano science
density-inclination plasma
plasma -process analysis