論文の内容の要旨

Abstract of Dissertation

Title of Dissertation: Development of Scanning Microplasma Jet Process and Its Application to Micromachining and Biomicrosystems
(走査型マイクロプラスマジェットプロセスの開発とマイクロマシン及びバイオマイクロシステムへの応用)

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Abstract:

The motivation of microplasma research was based on the comprehensive study of the inherent characteristics of microplasmas, which can be derived from well-designed combinations of their extraordinary locality with the ordinal characteristics such as emissive, conductive, dielectric localized and highly-reactive properties, thus new applications which have not been realized, need to be developed. Hence, as an approach towards these objectives, this dissertation works towards the development of a novel scanning microplasma jet process and its application to rapid micromachining and biomicrosystems.

A miniaturized VHF-driven inductively coupled plasma jet source was initially developed for the production of high-temperature and high-density plasmas in a localized space. High electron density of 10^{15} cm^{-3} was diagnosed by optical emission spectroscopy and then applied it to silicon micromachining.

The microplasma process developed here is a combination of conventional electric discharge machining and the intrinsic characteristics of microplasma technology, enabling maskless pattern etching, localized and ultrahigh-rate etching to be achieved with smooth etched surface in silicon micromachining. A maximum etch rate of approximately 500 μm/min was attained.

The microplasma was also challenged for applications to surface modification of polymers and biocompatible PDMS polymer was used as the substrate material. Two different plasma systems of argon/oxygen and argon/nitrogen were implemented and HeLa and muscle cells were used in the studies. Water contact angles of 60-70° measured by home-assembly contact angle measurement revealed satisfactory good cells' adhesion.

Finally, after investigating the fundamental characteristics of the microplasma apparatus for silicon micromachining and surface treatment of PDMS, the main target of fabricating a robust biomicrosystem was worked towards. Successful results were attained from the etching of silicon and PDMS and then applied to the fabrication of microfluidics.

In conclusion, the developed scanning microplasma jet process has proven its novel applications to micromachining and biomicrosystem and the process will be useful for the fabrication of microfluidic devices and biosensing devices in the near future.