High Pressure Radio Frequency Induction Thermal Plasma Generation Using T-LCL Immittance Circuit

M. A. Razzak, Y. Suzuki, S. Takamura and Y. Uesugi[1]
Department of Energy Engineering and Science,
Graduate School of Engineering,
Nagoya University, Nagoya 464-8603, Japan
[1)] *Department of Electrical and Electronic Engineering,*
Kanazawa University, Ishikawa 920-8667, Japan

In recent years, the immittance conversion topology has become attractive as a novel power conversion strategy because of its features that a constant voltage source is converted to a constant current source and vice versa. By taking these advantageous features, a T-LCL immittance circuit is employed to generate high-efficiency inductively coupled plasma (ICP) in a gas pressure with up to one atmosphere in Ar.

Because of high-power and high-efficiency, static induction transistor (SIT)-based inverter power source has become popular for its application to various kinds of plasma generations. However, at high operating frequencies in the MHz range, rf system shows dynamic and strongly non-linear characteristics, and inherent problems of the SIT inverter power source are observed during high-pressure plasma generation. At the initial phase of rf breakdown, an electrostatic (*E*) discharge is generated by the high rf voltage on the induction coil for few milliseconds, and then a rapid transition from electrostatic to electromagnetic (*H*) discharge occurs to form the rf thermal plasmas [1]. An increase of the coil loading resistance and decrease of the inductance are observed during these dynamic mode changes. The load of the SIT inverter, which is resistive without plasma, becomes capacitive in the *E* mode while inductive in the *H* mode. The rf coil current drops abruptly when the load changes to the *H* mode thereby decreasing the absorbed power and thus the power coupling efficiency at a value of about 40-50%. But, the power coupling efficiency should be high enough to promote induction plasmas into commercial and industrial applications. Therefore, in order to overcome these problems, a constant current T-LCL immittance circuit cascading with the SIT inverter power source is employed to generate high-pressure, high-efficiency induction thermal plasmas in Ar.

The immittance conversion system combines the SIT-based radio frequency (0.2-1.7 MHz), high-power (maximum 20 kW in pulse operation) inverter circuit and the immittance conversion elements. It is observed that the immittance circuit helps to inject higher power to the plasma thereby enhancing the power coupling efficiency of about 80-90%. The details analysis of the immitance circuit and the dynamic behavior of the generated plasmas will be discussed in the conference.

[1] M. A. Razzak, K. Kondo, Y. Uesugi, N. Ohno and S. Takamura, J. Appl. Phys., **95,** 427 (2004).

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Typed Name: M. A. Razzak

Affiliation/Institution/Company:
Nagoya University

Mailing Address
Department of Energy Engineering and Science, Graduate School of Engineering, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

City: Nagoya

State/Province: Aichi
Zip Code: 464-8603
Country: Japan
Phone: +81-52-789-5429
Fax: +81-52-789-3944
E-mail: razzak@ees.nagoya-u.ac.jp

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