

TITLE

Plasma Dynamics and Future of LPP-EUV Source for Semiconductor Manufacturing

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ABSTRACT

Recently progress of LPP EUV light source is remarkable. Ten years ago, power level is only several 10 W level. At present 250W power level is realized in semiconductor mass production factories¹⁾ by ASML. On the other hand, pioneer of this Unique technologies including; combination of pulsed CO₂ laser and Sn droplets, dual wavelength pico second laser pulses for shooting and debris mitigation by magnetic field have been applied by Gigaphoton²⁾. They have demonstrated high average power >300W EUV power with CO₂ laser more than 27kW at output power in cooperation with Gigaphoton and Mitsubishi Electric³⁾. (Fig.1) In near future more higher power (>600W) EUV source is required to fit High NA (>0.55) lithography of semiconductor industry.

In this paper we will discuss about the Sn plasma dynamics which dominate the EUV emission by using Thomson scattering (TS) measurement⁴⁾ (Fig.2). Recent TS results have revealed whole profiles of electron temperature and ion density in the EUV sources. These results mention that there is still sufficient potential to increase EUV output power and conversion efficiency in near future. This conceptual investing encourage us to improve EUV Light Source performance. In the EUV Source Workshop we also discuss about experimental data about latest high power experiments.



Fig.1 27kW Driver CO2 Laser System (Gigaphoton

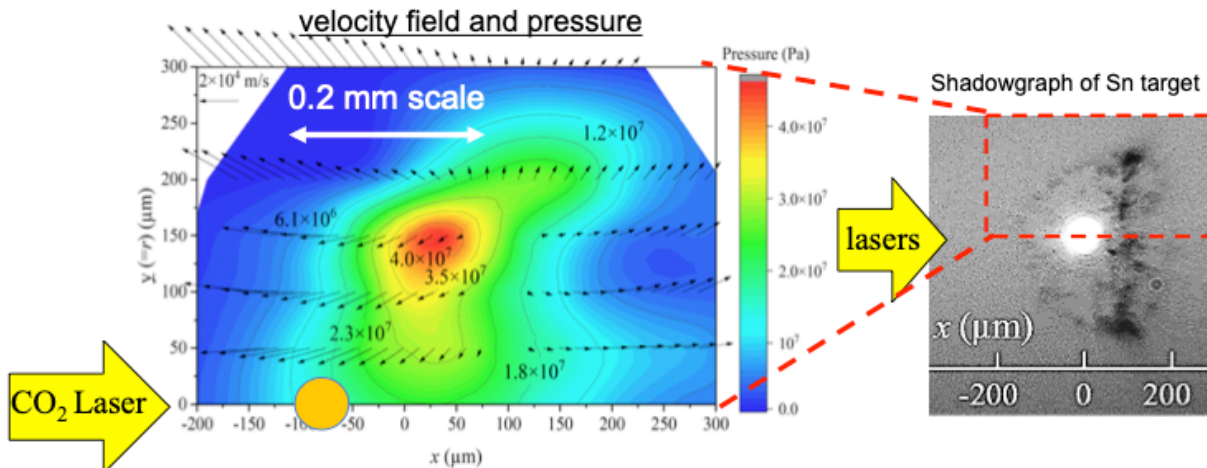


Fig.2 Tomsong Scattering Measuremen

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Biographies



Hakaru Mizoguchi

Title/ Position: Guest Professor of Kyushu University. (He was Senior Fellow of Gigaphoton Inc.) He is Fellow of The International Society of Optical Engineering (SPIE), and member of The Laser Society of Japan and The Japan Society of Applied Physics.

He received a diplomat degree in plasma diagnostics field from the Kyushu university, Fukuoka, Japan in 1982 and join Komatsu ltd.. He joined CO2 laser development program in Komatsu for 6 years. After that he was guest scientist of Max-Plank Institute Bio-Physikalish-Chemie in Goettingen in Germany 2 years, from 1988 to 1990. Since 1990 he concentrated on KrF, ArF excimer laser and F2 laser research and development for lithography application. He was general manager of research division in Komatsu Ltd. until 1999. He got Dr. degree in high power excimer laser field from Kyushu university in 1994. In 2000 Gigaphoton Inc. was founded. He was one of the founders of Gigaphoton Inc.. From 2002 to 2010 he organized EUV research group in EUVA program. Now he is promoting EUV light source development with present position. He got Sakurai award from OITDA Japan in 2018, and IAAM Scientist Award in Advanced Materials Lecture Series 2020.



Kentaro Tomita

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He received B. S., M. S., and Ph. D. degrees from Kyushu University, Japan, in 2002, 2004, and 2014, respectively. In November 2006 he was appointed Research associate at Kyushu University and became Assistant Professor in April 2007 at the same university. He became Associate professor in July 2020 at Hokkaido University, Japan. He is engaged in research of laser-aided diagnostics of industrial plasmas such as laser produced plasma for extreme ultra-violet light sources, atmospheric-pressure non-equilibrium plasma, arc discharge plasma, etc., which are produced under high pressure.

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