Update of >300W High Power LPP-EUV Source Challenge for Semiconductor HVM (Keynote)

Hakaru Mizoguchi, Hiroaki Nakarai, Tamotsu Abe, Hiroshi Tanaka, Yukio Watanabe, Tsukasa Hori, Yutaka Shiraishi, Tatsuya Yanagida, Georg Soumagne, Tsuyoshi Yamada and Takashi Saitou

Gigaphoton Inc. Hiratsuka facility:
3-25-1 Shinomiya Hiratsuka Kanagawa,254-8567, JAPAN

Gigaphoton develops CO_2 Sn LPP EUV light source which is the most promising solution as the 13.5nm high power light source for HVM EUVL [1]). Unique and original technologies including combination of pulsed CO_2 laser and Sn droplets, dual wavelength laser pulses for shooting and debris mitigation by magnetic field have been applied. We have developed first practical source for HVM "GL200E" in 2014[3]). Then it was demonstrated with high average power CO_2 laser more than 20 kW at output power in cooperation with Mitsubishi Electric[2]). Pilot#1 is up and running and it demonstrates the HVM capability; EUV power recorded at 111 W on average (117 W in burst stabilized, 95% duty cycle) with 5% conversion efficiency for 22 hour operation in October 2016[3]). Availability is achievable at 89% (2 weeks average), also superior magnetic mitigation has demonstrated promising mirror degradation rate (= 0.5%/Gp) at 100W or higher power operation with dummy mirror test. We have demonstrated >300 W operation data (short-term) and actual collector mirror reflectivity degradation rate is less than 0.15%/Gp by using real collector mirror around 125 W (clean power at intermediate focus) in burst power > 10 Billion pulses operation[4]). Also we will update latest challenges for >250W average long-term operation with collector mirror at the conference[5]). Next requirement for high-NA exposure tool is >800 W. The feasibility of CO2 laser driver is discussed.

Reference

1) Hakaru Mizoguchi, et. al.: "Sub-hundred Watt operation demonstration of HVM LPP-EUV source", Proc. SPIE 9048, (2014)
2) Yoichi Tanino et.al.:" A Driver CO2 Laser Using Transverse-flow CO2 Laser Amplifiers", EUV Symposium 2013, (Oct.6-10.2013, Toyama)
3) Hakaru Mizoguchi, et al: " High Power HVM LPP-EUV Source with Long Collector Mirror Lifetime", EUVL Workshop 2017, (Berkley, 12-15, June, 2017)
4) Hakaru Mizoguchi et al.:" Challenge of >300W high power LPP-EUV source with long collector mirror lifetime for semiconductor HVM", Proc. SPIE 11323, Extreme Ultraviolet (EUV) Lithography XI (2019) [11323-28]
5) Hakaru Mizoguchi, Hiroaki Nakarai, Tamotsu Abe, Hiroshi Tanak, Yukio Watanabe, Tsukasa Hori, Yutaka Shiraishi, Tatsuya Yanagida, George Sumangne, Tsuyoshi Yamada, Takashi Saitou:" Challenge of >300W high power LPP-EUV source with long mirror lifetime-III for semiconductor HVM",Proc. SPIE. 11609, Extreme Ultraviolet (EUV) Lithography XII (2021)

Presenting Author

Dr. Hakaru Mizoguchi is Senior Fellow, Gigaphoton Inc., and Fellow member of The International Society of Optical Engineering (SPIE). He joined CO_2 laser development program in Komatsu for 6 years since 1982. He was guest scientist of Max-Plank Institute Bio-Physikalish-Chemie in Goettingen in Germany from 1988 to 1990. Since 1990 he concentrated on KrF, ArF excimer laser and F2 laser development for lithography application. 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 product development up to now. He got Sakurai award from OITDA Japan in 2018. He got IAAM Scientist Award in 2020. He is also guest professor of Kyushu university since 2021.