Characterization of Various Sn Targets with Respect to Debris and Fast Ion Generation

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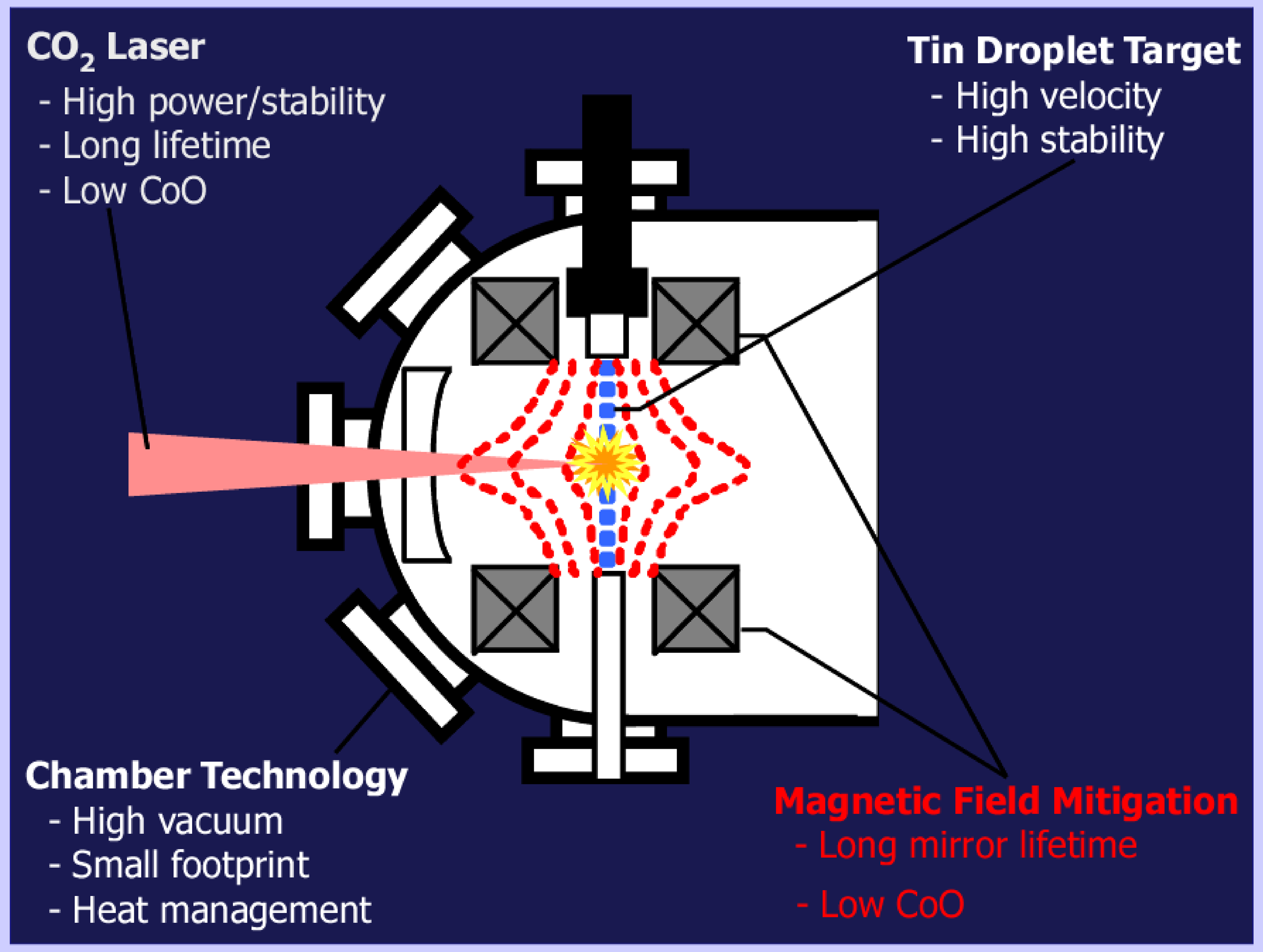
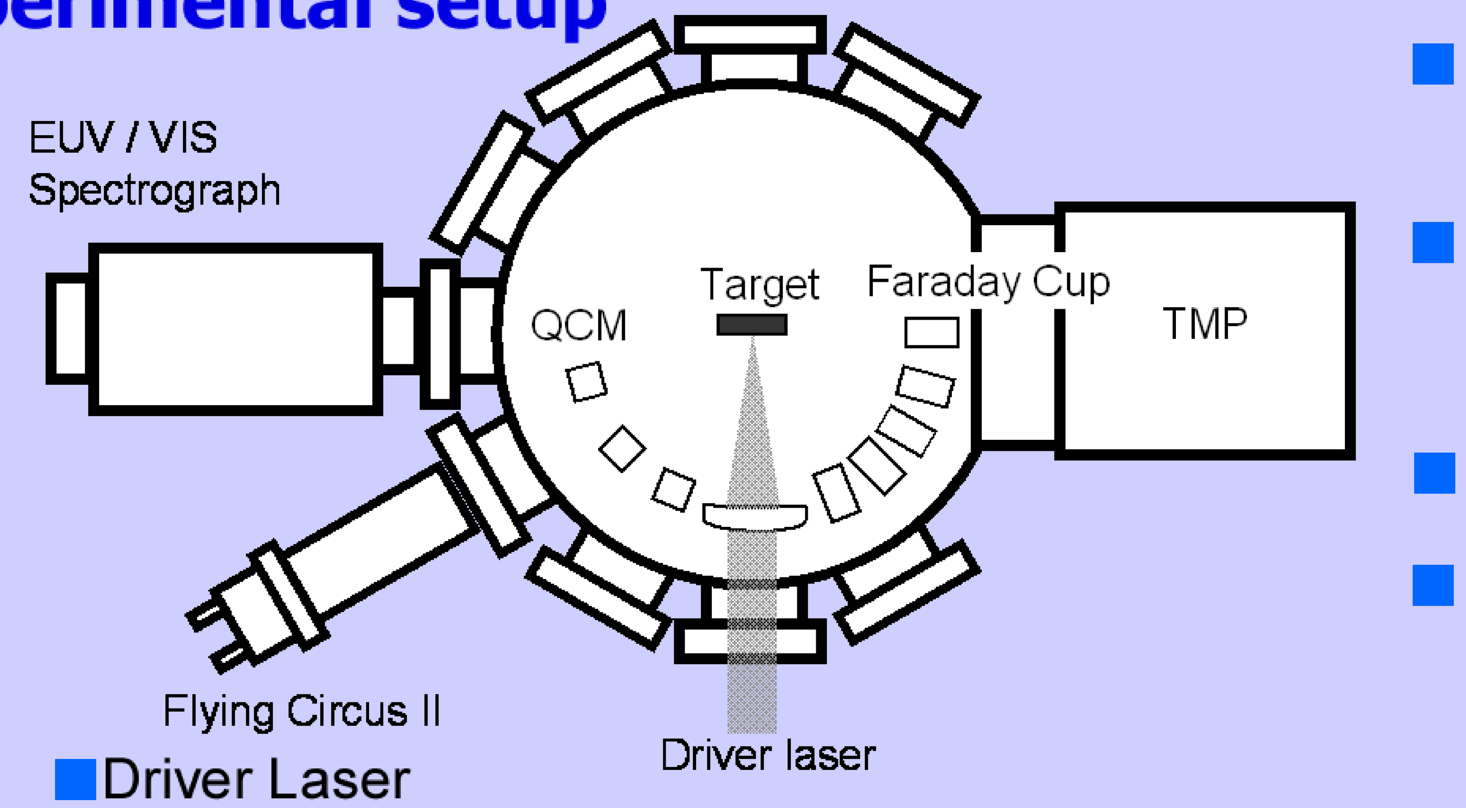
Abstract

We evaluated Sn debris generated from a CO_2 laser (10.6um) and a Nd:YAG laser (1064nm) plasma. Experiments were performed with bulk Sn-plates (t=1mm) and freestanding Sn-foils (t=15um). Quartz Crystal Microbalances (QCM) were used for debris analysis. We observed a drastically lower deposition for the CO_2 laser driven plasma compared with the Nd:YAG laser plasma. In addition, several Sn coated targets with different Sn thickness were investigated for the CO_2 drive laser with respect to the generated plasma debris. In general, a 100nm Sn coated glass target generated more debris than the solid Sn target. Especially, we observed for the Sn-plate target that the deposition rate is smaller than the erosion (sputter) rate caused by the plasma ions.

Concept of EUV Light source



Experimental setup



Driver Laser

Nd:YAG laser
- Wavelength : 1064nm
- Pulse energy : ~300mJ
- Pulse length : ~8ns(fwhm)
- Rep.rate : ~10Hz

CO_2 laser
- Wavelength : 1.06um
- Pulse energy : ~30mJ
- Pulse length : ~15ns(fwhm)
- Rep.rate : ~10Hz

Target
Solid Sn-plate/foil,Sn coated glass/copper

Electromagnet
Magnetic field : 0 ~ 1.1T (center)
Coil spacing : 50mm

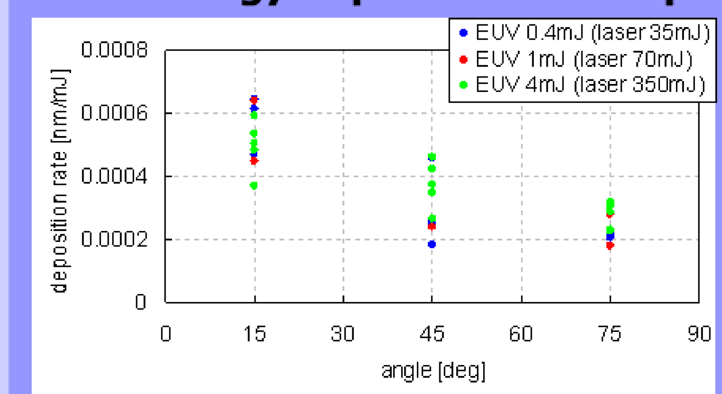
Chamber pressure : 10^{-2}~10^{-3}Pa

Evaluation
EUV energy : Flying Circus II
Debris (depositon / erosion)
: Quartz Crystal Microbalance
: Si, Mo/Si witness plate
Fast Ion : Faraday Cup

Experimental Results

Nd:YAG results

Laser energy dependence of deposition rate

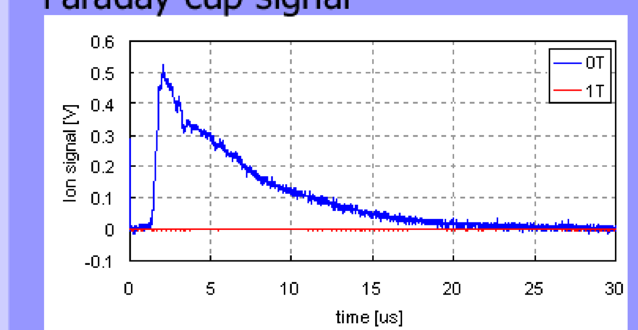


Target : solid Sn-foil (t=15um)
Plasma~QCM : 100mm

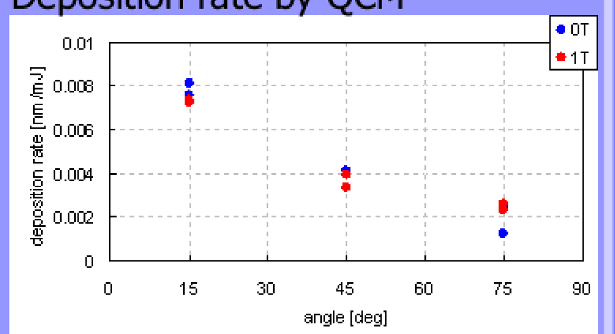
Deposition rate is constant (EUV pulse energy:0.4-4mJ)
Deposition rate = Deposition thickness/EUV pulse energy(2%BW 2nsr)[nm/mJ]

Magnetic field Ion mitigation effect

Faraday cup signal



Deposition rate by QCM

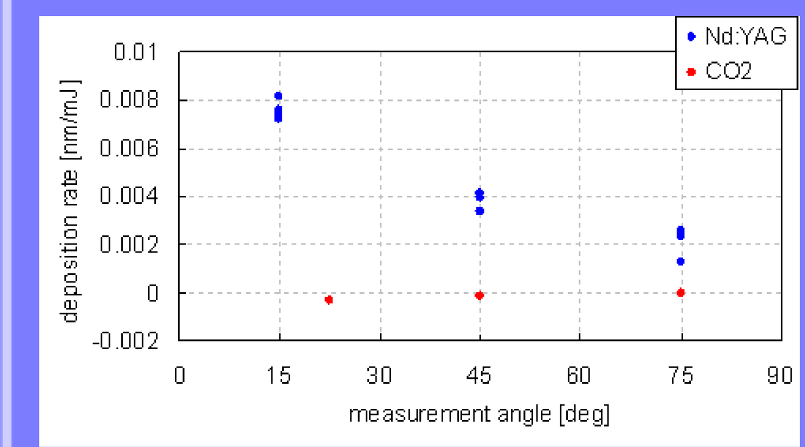


Target : solid Sn-plate (t=1mm), Plasma~Faraday Cup/QCM : 100mm

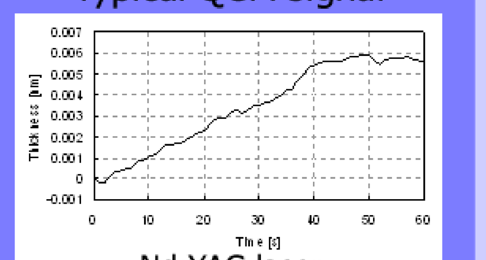
Ion deposition below 1%
The ion signal decreased below Faraday cup detection limit (about 3 orders) with a magnetic field of 1T. (See Faraday cup signal)
On the other hand, the QCM signal does not change. (See deposition rate)

Comparison of Nd:YAG/CO_2 laser

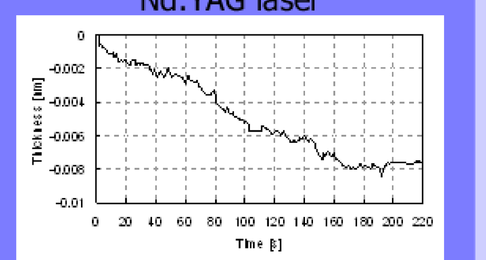
Deposition / Erosion rate by QCM



Typical QCM signal



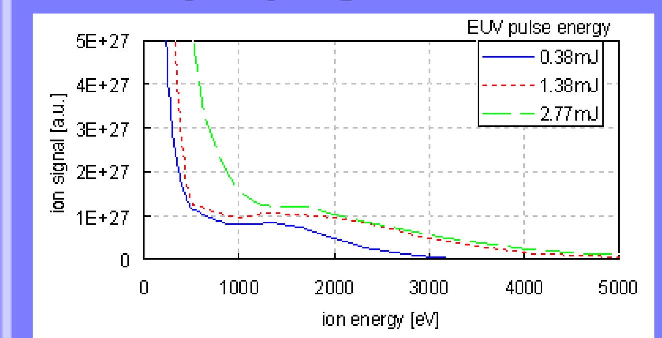
Nd:YAG laser



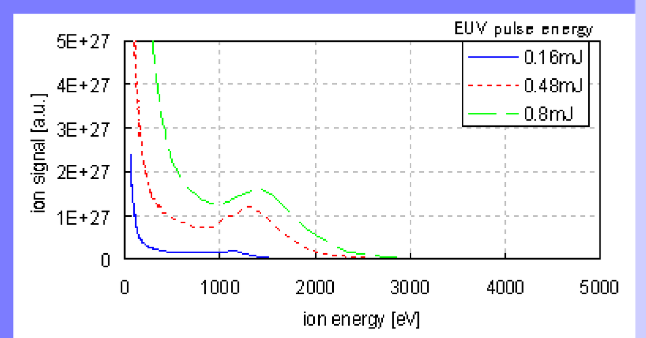
CO_2 laser

Nd:YAG laser : deposition
CO2 laser : Erosion(sputter)

Faraday cup signal



Nd:YAG laser



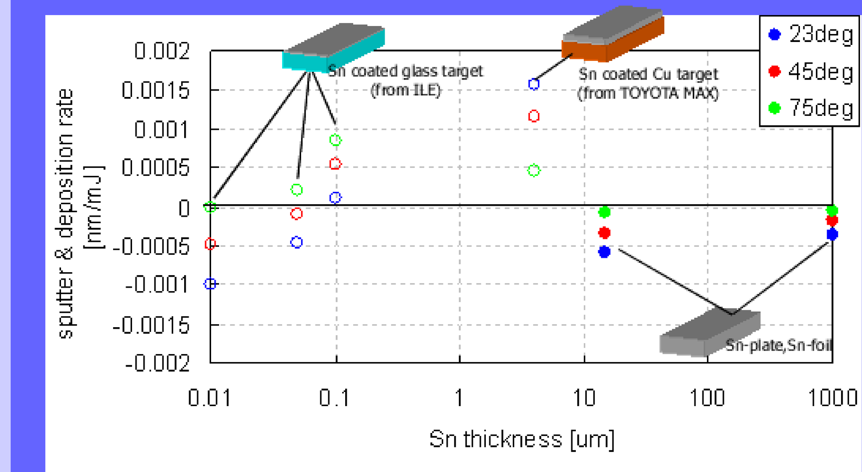
CO_2 laser

Max and peak ion energies are almost identical at same EUV

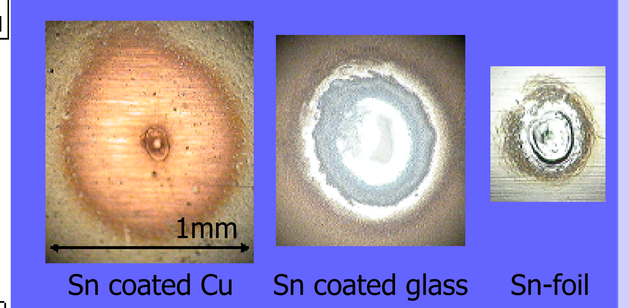
Target : solid Sn-plate (t=1mm),Plasma~Faraday Cup/QCM : 100mm

QCM results of various Sn targets with CO_2 laser

Deposition / Erosion rate by QCM

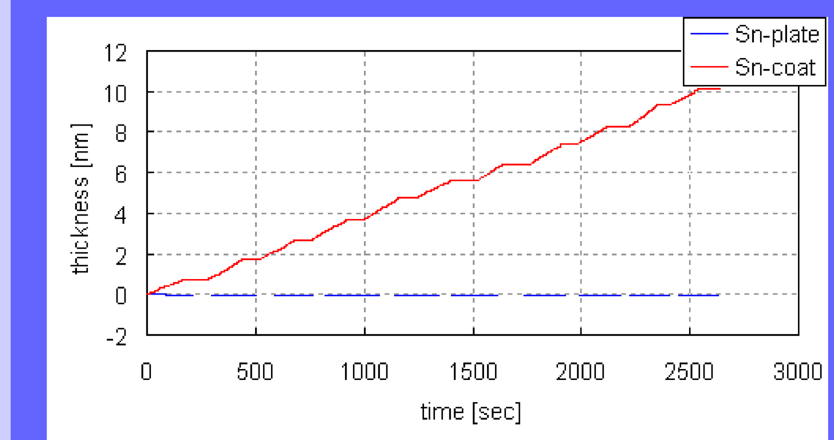


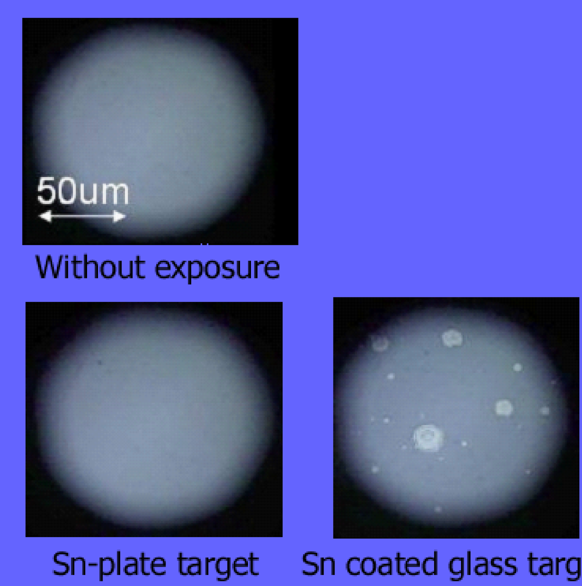
Target surface



CE : 2.0%(average, all target)
Deposition rate :
4um coat > 100nm coat > 50nm coat = Sn-plate > 10nm coat

QCM and Si witness plate result





Plasma~QCM, Si witness plate : 100mm

Conclusion

■Basic evaluation of debris and ion generation from a Sn plate irradiated with a CO_2 laser and a Nd:YAG laser was performed with several QCMs and Faraday cups.

→ We observed erosion for the CO_2 drive laser and deposition for the Nd:YAG drive laser. A largely different amount of molten debris is the reason for this observation.

■Several Sn coated targets with different Sn thickness were investigated with respect to the generated debris for the CO_2 laser.

→ We confirmed a mass limiting effect by the evaluation of these Sn targets.
The main difference was observed between the bulk Sn target and the coated Sn targets. Especially, the measured deposition for a 100nm Sn coated glass target is larger than for the bulk Sn target.

■In the future, more sensitive surface analysis has to be done in order to confirm the increased mirror lifetime expectation.

Acknowledgments

Part of this work was done in collaboration with the Institute of Laser Engineering (ILE), Osaka University, and the authors greatly acknowledge the support by K.Nishihara, K.Nagai, S.Fujioka, Y.Izawa, and K.Mima from ILE.

This work was performed under the management of the Extreme Ultraviolet Lithography System Development Association - **EUVA** - a research and development program of the New Energy and Industrial Technology Development Organization - **NEDO** - Japan