Extreme ultraviolet ablation of solid targets at 46.9 nm

J Lolley*, S A Wilson, E Solis Meza, C Beardall, H Bravo, E Wagenaars, C S Menoni, J J Rocca, and G J Tallents

*jal538@york.ac.uk

1 York Plasma Institute, Department of Physics, University of York, York YO10 5DD, U.K.
2 Center for Extreme Ultraviolet Science and Technology and Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, U.S.A.

Summary

• A compact source of extreme ultraviolet (EUV) radiation at 46.9 nm [1] was used to produce single- and multi-shot ablation features on Al, Cu, Au and PMMA targets.
• The ablation profiles achieved are shown and, in the single-shot case, compared to two simple models – an ablation ‘velocity’ model [2] and a modification of the Gamaly femtosecond pulse model [3].

Profile of ablated craters

• Irradiances of $2 \times 10^{11}$ W cm$^{-2}$ and $5 \times 10^{10}$ W cm$^{-2}$ were achieved for the Sc/Si and Au mirrors respectively.
• Single shot ablation features were generated on all four materials. Ablation profiles generated at focus with the Sc/Si mirror are shown below.

Capillary Discharge Laser

• The EUV light source in question lases at 46.9 nm between two excited levels of Ne-like Ar.
• Fast electrical discharge drives a z-pinchoff along the plasma column in the capillary, generating laser conditions.
• Average pulse energies are ~50 µJ with a pulse width of ~1.2 ns.

Experiment

• Experiments were conducted in-line with the mirror behind the target – see figure below – to reduce spherical aberrations.

Capillary laser with HeNe laser in foreground for scale [4]

• Two different spherical mirrors (both f = 100 mm) focussed the beam, constructed from Sc/Si multilayers (R = 45%) and unprotected Au (R = 8%) respectively.
• Thin strips of each material were mounted on the target post to minimise obstruction of the beam to ≈ 10%.

Simple modelling

• Two methods were used to model the depth of ablation features – a modified version of the Gamaly femtosecond pulse model [3] and an ablation velocity model [2].
• The Gamaly femtosecond pulse model assumes that the radiation penetrates to half the skin depth and deposits energy over this range – for long attenuation lengths $l_a$, as in Al, we predict that similarly:

$$d = l_a \ln \left( \frac{I}{I_{th}} \right)$$  \hspace{1cm} (1)$$

where $H$ is the energy density required for bleaching.
• Integrating over time gives the depth to be

$$d = \frac{I}{H}$$  \hspace{1cm} (4)$$

• Improvements to the approximation of $H$ are currently in progress.

References


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