Ultra-thin foils for laser ion acceleration in the radiation-pressure regime

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Introduction

Recent developments by our and other groups on the mechanism of radiation-pressure driven acceleration of protons and heavy ions [1,2,3,4] emphasizes the strong dependence of the results on a very high laser contrast of > 10^9, as well as the development of suitable targets. Since a few years diamond-like-carbon (DLC) foils are an appropriate choice. The drawback is the low mechanical stability for foils having a thickness of just a few. We developed an alternative process using a polymer based film which is produced by vapor deposition. Test of the surface roughness as well as the mechanical stability show great advantage for this kind of material compared to normal DLC foil.

Setup

We use parylene, an industrial coating material which is hydrophobic and optical transparent [5]. Starting from a glass substrate which is wiped with a hydrophilic barrier layer (detergent) the polymer is attached by pyrolytic chemical vapor deposition (p-CVD) forming a homogeneous layer on all surfaces within the deposition chamber, see fig, 1

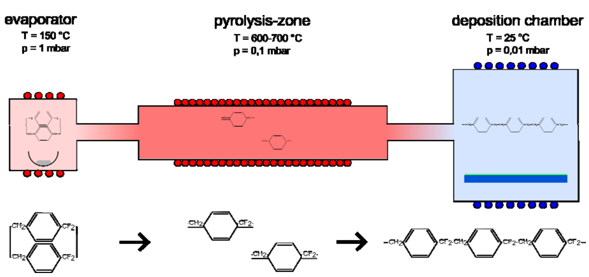

Fig.1 : Process of pyrolytic chemical vapour deposition (p-CVD) of parylene onto the glass substrates.

After deposition the glass substrate is removed and stored in inert gas, allowing storage times of more than one year before mounting as a target.

The foil can be flooded of the substrate by slowly casting in a bath of water and being attached to a target mount by adhesion, afterwards. For laser-acceleration experiments we used in previous experiments a 15nm thick foil attached on a special target mount (fig. 2a) creating more than 400 targets which can be used without opening the chamber in between shots. It was also possible to attach the foils self-supporting on very large apertures, up to 20mm, see fig. 2b

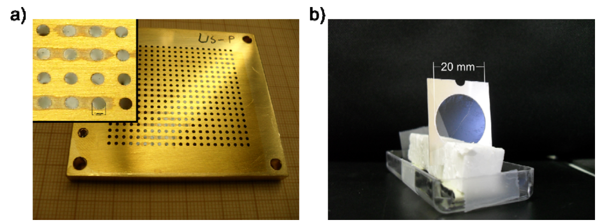

Fig.2 : a) Parylene foil attached to target mount used for laser-acceleration experiments. B) Self-supporting 15 nm foil freestanding on 20 mm aperture.

Characterization

For a proper characterization we measured the thickness of each processed foil by ellipsometry, resulting in a thickness derivation of not more than 1nm at different positions of a large (150 x 100 mm) foil sample and a average thickness of 15nm.

The mechanical stability of the parylene foil was compared to the stability of a DLC foil of the same thickness Here 30 nm thick foils were used. For this purpose both foils were attached on TEM-grids creating small self-supporting samples. The force-distance relation was measured via nanoindentation using an atomic-force microscpe (AFM). The measured elasticity of the parylene is 5 times higher than the one of the DLC, which explains the higher resistance against mechanical shock and temperature variation observed during hadling. Using AFM topography mode, we measured the surface roughness in addition. Both samples hade more or less the same average roughness of R_{DLC}= 5.7 ± 0.9 nm and $R_{Parylen}$= 8.6 ± 2.3 nm.

References

[1] B. Aurand et al. , in CLEO: QELS-Fundamental Science, OSA Techn. Digest (2012), paper JTh3I.2.
[2] A. Henig *et al.*, PRL 103, 245003 (2009)
[3] S. Kar *et al.*, PRL 109, 185006 (2012)
[4] B. Qiao et al., PRL 105, 155002 (2010)
[5] A. Greiner *et al.*, Acta Polymer 48, 1 (1997)