Carbon / Carbon Multilayer
a new approach in the development of nanometer-multilayer X-ray optics

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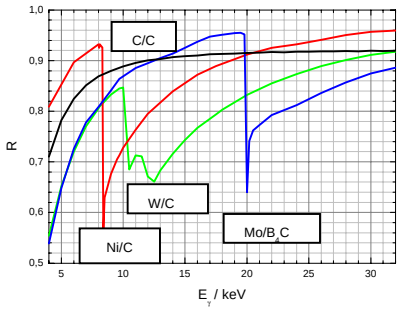
For the deposition of C- single and multilayers with low or high sp^3 / sp^2 bond ratios in the C- films i.e. low and high material densities, established PVD techniques like magnetron and ion beam sputtering, vacuum ARC deposition are mainly used. Because of the wide variability of film growth conditions, the high flexibility of the Pulsed Laser Deposition (PLD) process, the layer-by-layer process control and the UHV-clean deposition conditions PLD becomes more and more an interesting alternative for the deposition of C- single and C/C- multilayers. The high quality and the long term stability of pulsed laser deposited C- single and C/C- multilayer X-ray optics are demonstrated by investigations of the performance in the soft and hard X-ray regime.

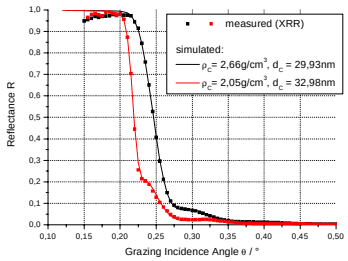
Performance



Selected material combinations for multilayer optics in the range between Ep= 4 keV .... 32 keV; Simulation of 1. order Bragg peak reflectivity of Ni/C, W/C, Mo/B4C multilayers (d= 4 nm / N= 100) and C/C multilayers (d=3nm / N= 1000); Ideal layer stack, bulk

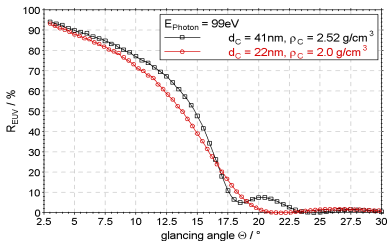
C- single layers

hard X-ray regime



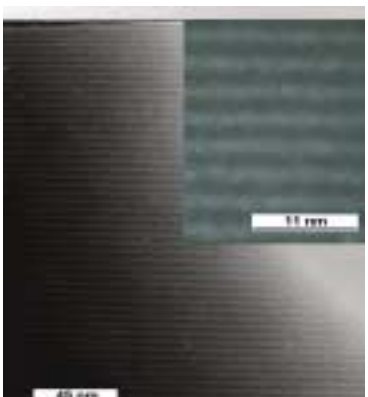
Measured reflectance at λ = 1.54 Å (Cu-Kα) of C- single layers prepared by LA-PLD. The simulations indicate material densities of about ρ_C = 2.66 g/cm³ and ρ_C = 2.05 g/cm³.

soft X-ray regime

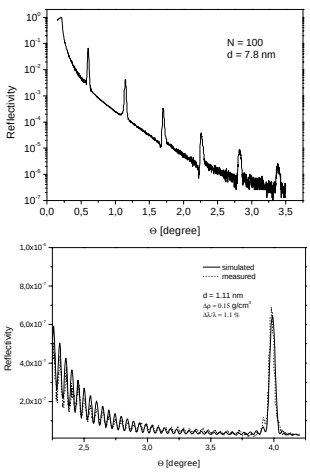


Measured reflectance in the soft X-ray range at E_p= 99 eV. For a C-layer with d=41nm and ρ_C= 2.52 g/cm³ experimental results of R= 94.0 % at Θ = 3° and 87.4 % at Θ = 6° are close to the theoretical values. The measurements were done with the new Fh-IWS soft X-ray-reflectometer (see also: Proc. SPIE Vol. 5038 (2003) pp. 12 - 21).

C/C- multilayers



TEM cross section image (R.Scholz / MPI Halle) of a C / C- layer stack (PL 307) d= 3.78 nm; N= 100; Δρ= 0.2 g/cm³ (Overview and at higher magn.)



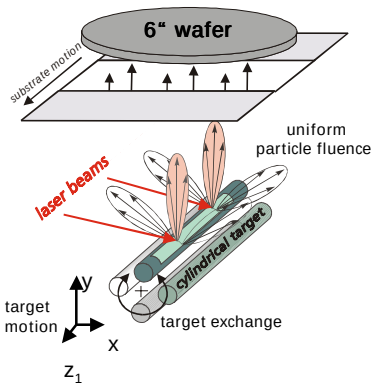
C/C-multilayers

X-ray reflectometry results R (Cu Kα) for a 100 period layer stack (PL 369)
d = 7.8 nm
R= 6.5%
ρ_A= 2.4 g/cm³
Δρ= 0.2 g/cm³
σ_R= 0.35 nm; Γ≈ 0.4

C/C-multilayers with low period thicknesses d

80 period C/C-multilayer
d= 1.11 nm
Δρ= 0.15 g/cm³
Δλ= 1.1%
σ_R= 0.44 nm; Γ≈ 0.5

Deposition: large area PLD



Experimental setup of LA-PLD

An advanced large area PLD technique is used to deposit C-single layers and C/C-multilayers showing X-ray optical quality. C-single layers of different material densities show high reflectance both in the hard and in the soft X-ray regime. X-ray optical multilayer showing both high resolution and high reflectivity can be fabricated using only one material ⇨ Carbon. Thermal stability up to 600 °C was observed for a C/C- multilayer, at 800 °C a formation of SiC was found. C-single und C/C-multilayers show interesting applications as high power X-ray optics and high resolution multilayers.

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