At present, various types of X-ray optical multilayers, particularly Göbel-Mirrors for Cu Kα- and Mo Kα- radiation are prepared for analytical applications in diffractometry, TXRF and for individual research.

Pulsed Laser Deposition of X-Ray Optical Multilayers

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Since the end of the eighties Pulsed Laser Deposition (PLD) has been
developed into a practicable deposition method for multilayer synthesis in
addition to other established techniques like e-beam evaporation and sputter
deposition. Advantages of PLD are particular film growth conditions like particle
energies in the range of some eV up to 1 keV, high degrees of ionization, high
particle flux and deposition rates per pulse. These features are determined
essentially by the ablation parameters laser wavelength, laser pulse energy, laser
pulse repetition rate and laser pulse length. Due to these particular properties of
the condensing particle fluxes generated by pulsed laser ablation, the layer
growth regime proceeds in zone IV of GUENTHER’s structure zone model [1]. For
that reason amorphous or nanocrystalline film structures are achieved by means
of PLD at room temperature.

The multilayer PLD process is characterized by alternating pulsed laser
ablation of predicted spacer and absorber material targets under UHV conditions.
Layer-by-layer growth regime, film synthesis at low substrate temperatures, high
particle flux due to pulsed deposition, vapor phase condensation far from thermal
equilibrium and UHV-clean operation conditions are features of this process.

The results are a precise adjustment of average layer thickness as well as
smoothest interfaces over the entire layer stack without any increase of roughness
during the deposition process.

Even so, PLD has been established as a deposition method for X-ray optical
multilayers in only a few labs nowadays. One reason is, that PLD is usually restricted
to the deposition of small areas, due to the highly directional nature of the
process. Furthermore an extensive effort is essential to realize an automated PLD
process. High reproducibility and long term stability have to be guaranteed for
multilayer deposition on large area substrates.

To realize high quality X-ray optical multilayer stacks on large areas a double-
beam PLD-source was created and integrated into a commercial 4 MBE system
at the Fraunhofer-IWS. Optimization of ablation conditions and film growth regime,
resp., for various kinds of homogeneous thin films and multilayer systems has been
realized by a reproducible variation of pulse energy and repetition rate of each of
the two Nd:YAG-lasers. In addition the lasers can be independently controlled by
a predetermined pulse delay. Thus plasma parameters of two plumes generated
from locally separated origins can be influenced by the pulse delay of the
Nd:YAG-lasers, too. Further developments are focused on the coating of 6
substrates also in combination with magnetron sputter deposition.

Efficiency of the technology is demonstrated by typical X-ray reflectometry
and high resolution TEM results acquired from Ni/C, W/C, C/C, Mo/Si and at B₁₄C-
based multilayers. Advantages and limitations of PLD method are discussed, too.