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.

[1] Guenther, K.H., SPIE Vol. 1324 (1990)

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 B_4C-based multilayers. Advantages and limitations of PLD method are discussed, too.