Effects of energetic particles during growth of short period Pt/Mg X-ray multilayer mirrors

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Abstract

Short-period Pt/Mg multilayers have been grown using high vacuum DC magnetron sputtering. The multilayers are intended as mirrors for λ=1.7 nm wavelength (Fe XVII emission line), and were designed with a multilayer period Λ~8.52 Å and a layer thickness ratio Γ~0.5, i.e. $d_{Pt}=d_{Mg}$=4.26 Å.

In addition to the strict requirement of flat and abrupt interfaces, an exact multilayer period is also required for coherent reflectivity and maximal reflectance. In DC magnetron sputtering it can be expected that the energetic particles present in the plasma process will have large effects on the surface of the growing film. These effects are influencing, not only the interface quality, but also the layer thicknesses. In the present work, large non-linearities in the deposition rate of Mg were evident, see Figure 1. The deposition rate varied from 0.19 Å/s for d_{Mg}<7 Å to 0.50 Å/s for d_{Mg}>100 Å, i.e. by ~270%, having large implications when growing multilayers with accurate layer thicknesses.

The non-linear behaviour is explained by resputtering of the growing film by highly energetic backscattered neutrals from the Pt-target in combination with the sputter yield amplification (SYA) effect [1]. The sputter yield amplification effect is present during growth of multilayers where there is a large mass-contrast between constituent layers. In the case of Pt/Mg multilayers it is necessary to account for this effect for periods smaller than ~150 Å, depending on the growth conditions.

In this work varying sputtering pressures (3-9 mTorr) and sputtering gases (Ar and Kr) have been used in order to study the effects of this un-intentional energetic particle irradiation. TRIM simulations combined with calculations of gas-phase collisions during the transport through the gas-filled chamber have been performed to obtain the number and energy distributions of energetic particles in the substrate vicinity. It is found that backscattered neutral Ar sputtering gas atoms have energies ranging up to about 200 eV at the sputtering conditions used. The experimental results are discussed and compared with dynamic simulations using the TRIM code.

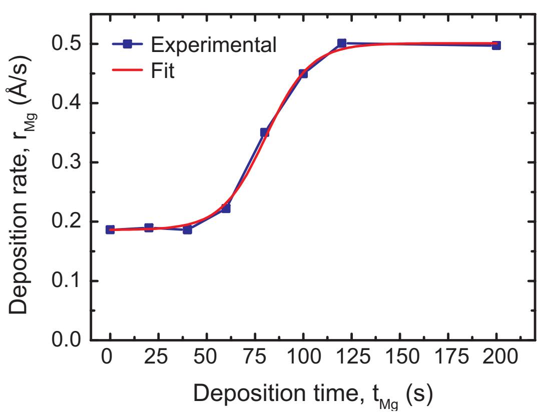

Figure 1. Deposition rate of Mg as a function of the deposition time.

References

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[1] Sören Berg, Ilia Katardijev, Resputtering effects during ion beam assisted deposition and the sputter yield amplification effect, *Surface and Coatings Technology* **84** (1996) 353-362