Substrates and optical coatings for 157 nm applications

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157 nm radiation of F_2-excimer laser is considered to be one of the promising exposure tools for the 70 nm node in further integrated circuit production. /1/, /2/ Similar to the general concept at 248 nm and 193nm, a 157 nm lithographic tool will probably consist of the following components:
157 nm lithography laser, beam delivery system, beam forming unit and projection optics, which all together form a closed, purged beam-line.

Due to material properties and expected higher optical losses, the projection optics will probably be a catadioptric one /3/, although all reflective designs have also be proposed for projection purposes /4/. Generally, different types of high effective optical coatings are required for 157 nm applications: high reflectors (HR) and antireflection coatings (AR) for different angles of incidence.

Fluoride single layers and multi-layer optical coatings for use in the vacuum ultra-violet spectral region, especially at 157 nm have been deposited by a conventional vacuum processes. The optical properties have been studied to evaluated limiting factors on their performance. Additional to coatings, surface and bulk properties of CaF_2 substrates have been investigated and first results on the influence of roughness and surface contamination on the transmittance are presented.
For dielectric mirrors, reflectance values of 95%–96% at near normal incidence have been measured at 157nm for conventional deposited QWOT-mirror coatings. For both side AR-coated CaF_2, a residual reflectance well below 1% and a high transmittance have been obtained. The optical performance of these multi-layer coatings is limited by absorption (intrinsic, impurities) and by scattering losses due to the morphological and crystalline structure of the fluoride films. Further investigations and optimisation of technology are necessary to improve the optical performance of the layer systems.

References

/1/ M. Rothschild, "Photolithography at wavelengths below 200 nm", Proc. SPIE 3274, pp.222-228, 1998

/2/ T.M. Bloomstein, M.W. Horn, M. Rothschild, R.R. Kunz, S.T. Palmacci, R.B. Goodman, "Lithography with 157 nm lasers", J.Vac.Sci.Technol. B15 (1997), 6, p.2112-2116

/3/ J.H. Bruning, "Optical lithography – thirty years and three orders of magnitude", Proc. SPIE 3051 (1997), 14-27

/4/ D.R. Shafer, "Projection lithography system and method using all-reflective optical elements", US – patent 5.686.728 publ.11/11/97

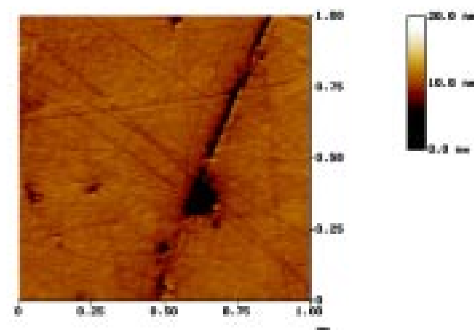

Fig. 1:
Normal polished CaF_2 substrate

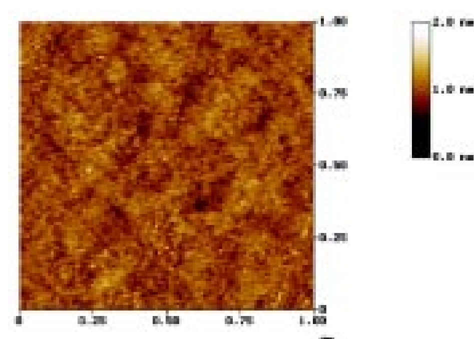

Fig. 2:
Super-polished CaF_2 substrate

AFM scans of a normal polished and a super-polished CaF_2 surface. Note the different height scale. Super-polished samples show a better smoothness and a very low defect density.