

Contents

Abstract	7
1 Introduction	9
1.1 Ellipsometers with Spatial Resolution in the Literature	11
2 Theory	15
2.1 Reflection of Polarized Light at Layered Interfaces	15
2.2 Ellipsometry	17
2.2.1 Interpretation of the Ellipsometric Angles Ψ and Δ	18
2.2.2 The Rotating-Analyzer Setup	19
2.2.3 Determination of n and d from the Ellipsometric Angles	23
2.2.4 Limitations of Ellipsometry	23
2.3 Microscopy	25
2.3.1 Fourier Description of Microscopy	26
2.3.2 Lateral Resolution of Microscopy	28
2.3.3 Oblique Illumination and Resolution	29
3 Experimental Setup	33
3.1 Ellipsometric Microscopy	33
3.2 Controlling the Incident Angle Q	37
3.3 Calibration of the Azimuthal Angles P , A and C	41
3.3.1 Calibration according to Aspnes	42
3.3.2 Calibration according to de Nijs	43
3.3.3 Influence of Component Optical Activity on the Calibration Methods	44
3.3.4 Calibration Results	45
4 Error Analysis	49
4.1 Influence of Stray Light	50
4.2 Errors due to Azimuthal Angle (P, A, C) Misalignment	51
4.3 Detector Nonlinearity	54
4.4 Image Persistence of the CCD Camera	55
4.5 Polarizer and Analyzer Imperfections	57
4.6 Influence of the Pinhole Size D	57

4.7	Influence of the Refractive Index of the Immersion Oil	60
4.8	Instrumental Polarization	62
5	Materials and Methods	67
5.1	Sample Preparation and Characterization	67
5.2	Computer Hardware	68
5.3	Software	69
5.4	Image Recording and Processing	70
5.5	More Image Processing: Selected Topics	72
5.5.1	Median Filter	73
5.5.2	Isotropic Gaussian Filter	73
6	Results and Discussion	77
6.1	Measurements on Silicon Substrates	77
6.1.1	Calibration of the Instrumental Polarization	79
6.1.2	Accuracy of Measurements at Silicon Substrates	82
6.2	Measurements on Glass Substrates I	92
6.2.1	Stray Light Correction Procedure	92
6.2.2	Measurements at Coated Cover Slides	95
6.3	Measurements on Glass Substrates II	98
6.3.1	Modified Setup	98
6.3.2	Results on Glass	102
6.3.3	Accuracy of Measurements at the Glass-Water Interface	104
6.4	Lateral Resolution	107
6.4.1	The Modulation Transfer Function MTF	110
6.4.2	Measuring the MTF: the Knife-Edge Method	112
6.4.3	The Influence of the Stray Light Pinhole on the Lateral Resolution	117
6.5	Height Sensitivity	118
7	Outlook	121
	Bibliography	126
	Important Symbols	132
	Danksagung	133