A classical model for depolarization by temporal and spatial decoherence

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A finite spectral resolution and/or an imperfectly collimated beam /and or an (areal) extended light source / and or an (areal) extended detector and/ or a sample with a varying thickness can produce depolarization in any ellipsometric or polarization measurement. Despite these experimental findings, there are to our knowledge no physical models published which trace the origin of depolarization back to the atomic properties. Therefore, in the talk I will explain crosspolarization - and subsequently depolarization by considering the ***common- not separable-*** effect between the light beam and the sample, described by **coherence length and coherence area**.
For inhomogeneous samples with dimensions smaller than the coherence area, the fields have to be added coherently. However, inner and non-planar boundaries give rise to evanescent fields in the vicinity of these boundaries. Parallel and perpendicular field components oscillate and decay differently in the vicinity of the boundaries, therefore cross- polarization (incident s- polarized light excites reflected p-polarized light and vice versa) occurs.[1] In inhomogeneous samples the Fresnel reflectances are not correct any more, these strictly rely on homogeneity (i.e. arbitrary shifts of the sample along any surface direction change the measurement).

However, in optics we never measure the electric fields, because our available detectors are much too slow, but we measure their ***statistical*** second moments. In homogeneous samples with thick transparent overlayers it turns out that depolarization arises through the temporal decoherence of photons, and the measured Müller matrix (MM) elements are given by a convolution of the spectral width of the light source and a sample property: the thickness of the transparent overlayer.

For inhomogeneous samples, when the sample sizes or structures are larger than the coherence area, then the different local polarization states in reflection coming from different materials have to be added incoherently- partially depolarized light results.[2] Also here the measured Müller matrix is given by a convolution of a light source property (i.e. the coherence area) and a sample property: the structure size). For both depolarization mechanisms mathematical models[3] will be presented, allowing to predict the polarization response, i.e. all MM elements for periodic structures, metamaterials and thick films.

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[1] J. -P. Perin, K. Hingerl, Appl. Surf. Sci. **421**, 738, (2017)
[2] The mathematical formulations- which will be largely avoided in the talk- are given through the coherency matrix / respectively the Stokes vectors, and decoherence shows up by the Cittert- Zernike theorem (M. Born & E. Wolf, *Principles of Optics*, chapter X.9).
[3] K. Hingerl, R. Ossikovski, Opt. Lett., **41**, 219, (2016)
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