Experimental results of the simultaneous measurement of spatially varying phase and polarization

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Overview

- A novel interferometric measurement method for the simultaneous measurement of any locally varying polarization and phase distribution was developed by combining phase and polarization shifting of the reference beam.
- The investigated methods are presented by showing experimental results of light distributions generated with special polarization objects.
- The measurement objects used on this poster are based on sub-wavelength gratings with locally variant orientation made from silicon nitride.
- For more theoretical description of the method, notation and used setup $\mapsto$ **Poster Nr.1**

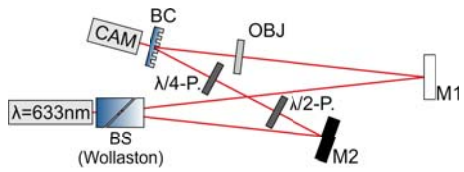
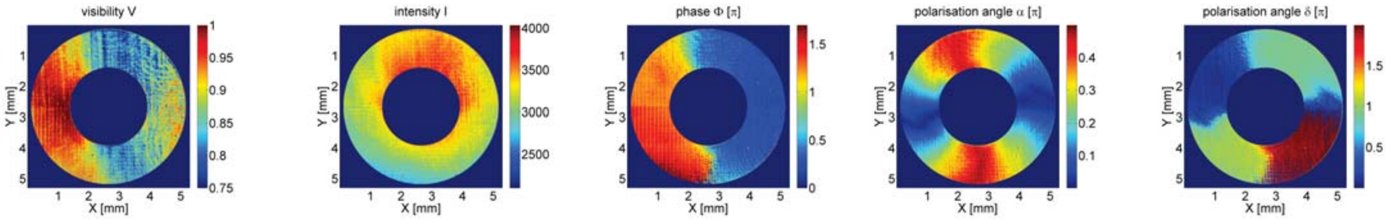


Fig. 1: *Sketch of used Mach-Zehnder interferometer*

Measurement results and discussion

All five unknown values of the radially polarized light distribution generated by a polarizing element, presented on this poster bellow, were measured with a 4/2/2 method (Fig.2-6). This method uses four phase steps $(\phi_i \in \{0; \pi/2; \pi; 3\pi/2\})$ for each of four polarisation states $(\Psi_i \in \{0; \pi\}; \chi_i \in \{-\pi/4; \pi/4\})$ of the reference wave.



- The measured polarisation angles α and δ represent the expected radial polarized light. These two values can be combined to one ellipse plot (Fig.7) for more comprehensible visualization of the measured polarisation.
- The measured phase distribution is the sum of the real object phase Φ^* and an additional phase step Φ_{pol} caused by the polarisation (For the explanation of the occurrence of Φ_{pol} see Fig. 8). The pure object phase with manually removed polarisation phase step is shown in Fig. 9.

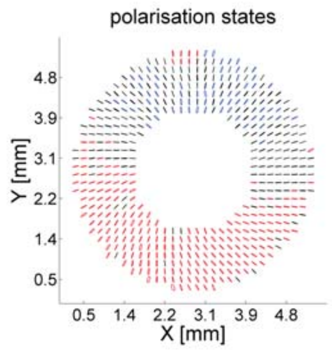


Fig. 7: *Visualization of the distribution of polarisation states. (red/blue ellipses $\mapsto$ right/left hand polarisation)*

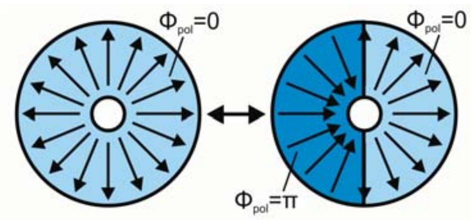


Fig. 8: *Because of the limited codomain of calculated $\alpha \in [0, \frac{\pi}{2}]$ not all polarisation states can be represented with this angle. All "'forbidden"' states caused an additional phase step of $\Phi_{pol} = \pi$.*

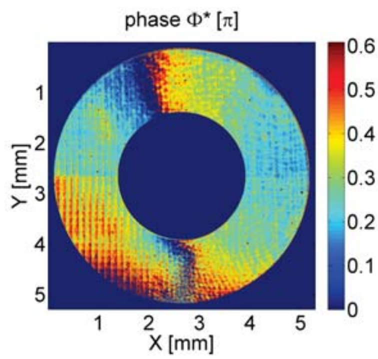


Fig. 9: *The object phase with manually removed additional phase step of π caused by polarisation.*

- Future research includes the improvement of the stability and precision of the setup and characterisation of the methods.
- Furthermore the decoding of the object phase and the additional phase term caused by polarisation must be solved.

Polarization elements made from Si3N4 sub-λ gratings

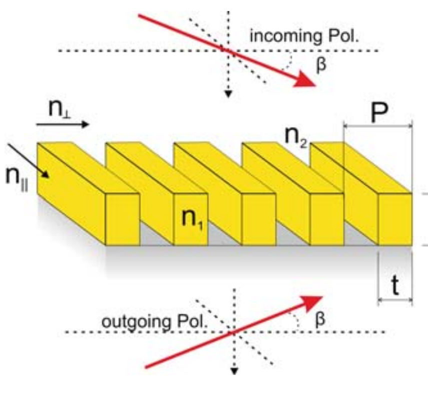


Fig. 10: *Sketch of local grating geometry*

- The form birefringence $(n_\perp \neq n_\parallel)$ of a dielectric material (Si_3N_4) is achieved by structuring the surface in the nm-range (binary grating).
- To avoid higher diffraction orders as the zeroth order the grating period must fulfill following equation: $P < \lambda/n_{Si_3N_4} \quad \mapsto P < \frac{633nm}{2.01} = 314nm$
- The geometry parameters (Fig. 10) of the grating are calculated with the effective medium theory: $n_\parallel = \sqrt{\frac{t}{P}n_1^2 + (1-\frac{t}{P})n_2^2} \quad n_\perp = \frac{n_1 n_2}{\sqrt{\frac{t}{P}n_2^2 + (1-\frac{t}{P})n_1^2}}$
- The phase retardation that has an effect on the incoming light is a function of the grating depth: $\Delta = \frac{2\pi}{\lambda}d(n_\parallel - n_\perp)$
- The final geometry parameters for structure with a local phase retardation of $\Delta = \pi$ (HWP) are: $P = 300nm;\ t = 120nm;\ d = 1050nm;$
- By choosing the correct local orientation of the gratings it is possible to fabricate e.g. a radial polarizer. The local orientation of a such space variant half wave plate is half of the azimuthal angle (Fig. 11).
- Fabrication: e-beam lithography & reactive ion etching

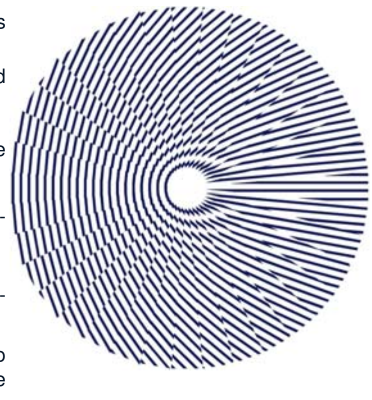


Fig. 11: *Sketch of global element pattern*

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