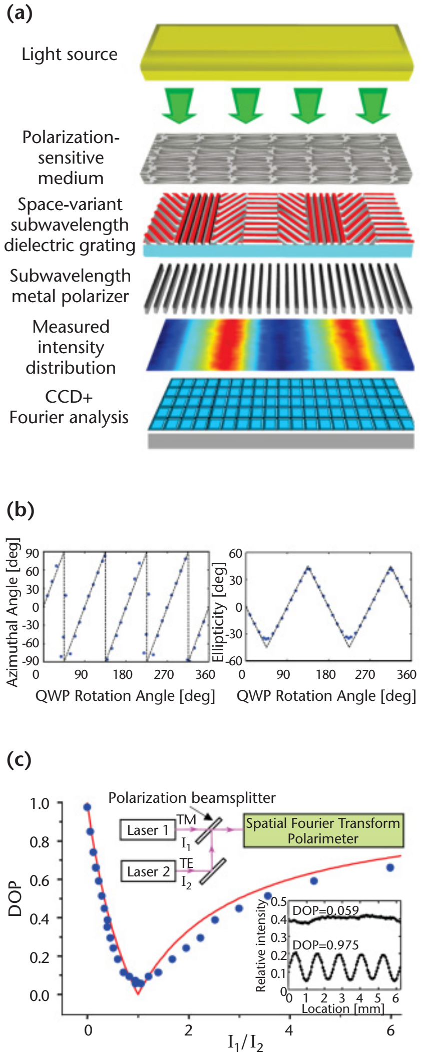

Figure 1. (a) Schematic presentation of near-field spatial Fourier-transform polarimetry based on a discrete space-variant subwavelength dielectric grating followed by a subwavelength metal polarizer. Also shown, the measured intensity distribution captured in a single camera frame when the fast axis of the rotating QWP was at angle 20 deg. (We used a CO_2 laser that emitted linearly polarized light and replaced the polarization-sensitive medium with a rotating QWP). (b) Measured (circles) and predicted results (solid curves) values for azimuthal and ellipticity angles as a function of orientation of the QWP. (c) Calculated (solid curve) and measured (circles) DOP as a function of the intensity ratio of the two independent lasers having orthogonal linear polarization states, as used in the setup depicted in the top inset. The bottom inset shows calculated (solid curves) and measured (circles) intensity cross sections for two extremes, $I_1 = I_2$ (DOP=0.059) and $I_2 = 0$ (DOP=0.975).

POLARIZATION

Spatial Fourier-Transform Polarimetry By Use of Space-Variant Subwavelength Gratings

Erez Hasman, Gabriel Biener, Vladimir Kleiner and Avi Niv

Polarization measurement has been widely used for a range of applications such as ellipsometry, bio-imaging, imaging polarimetry and optical communications. A commonly used method is measuring the time-dependent signal once the beam is transmitted through a photoelastic modulator or a rotating quarter-wave plate (QWP) followed by an analyzer. The polarization state of the beam can be derived by Fourier analysis of the detected signal. This method, however, requires a sequence of consecutive measurements, thus making it impractical for real-time polarization measurement in an application such as adaptive polarization-mode dispersion compensation in optical communications. Moreover, it involves either mechanically or electronically active elements, resulting in a complicated, cumbersome device, not suitable for on-chip integrated applications.

We developed a novel method for real-time polarization measurement by use of a discrete space-variant subwavelength dielectric grating (DSG).[1] DSGs are considered wave plates with constant retardation and space-variant fast axes. The grating is formed by discrete orientation of the local subwavelength grooves. The complete polarization analysis of the incident beam is determined by spatial Fourier transform of the near-field intensity distribution transmitted through the discrete subwavelength dielectric grating followed by a subwavelength metal polarizer. Unlike other methods based on Fourier analysis, no active elements are required to determine the polarization state of an incident beam. Our method is suitable for real-time applications and can be used in compact configurations. It is possible to integrate our polarimeter on a two-dimensional detector array for lab-on-chip applications to achieve a high-throughput, low-cost commercial polarimeter for biosensing.

The concept of near-field polarimetry based on subwavelength gratings is presented in Fig.1(a). We realized gratings for CO_2 laser radiation at a wavelength of 10.6 μm on a GaAs substrate using advanced photolithographic and etching techniques. We demonstrated experimentally the capability of our method to measure the polarization state for fully and partially polarized light [Fig.1(b-c)]. To demonstrate the use of a DSG for polarimetry of partially polarized beams, two independent CO_2 lasers of orthogonal linear polarization states were combined by use of the setup depicted in the inset at the top of Fig. 1(c). Figure 1(c) shows the measured and the predicted degree of polarization (DOP) as a function of the intensity ratio of the lasers. This experiment shows the ability to obtain all four Stokes parameters simultaneously, thereby emphasizing the good agreement between prediction and measurement for partially polarized light.

Recently we demonstrated a novel method for formation of a complete depolarizer based on a polarization-state scrambling procedure over the space domain.[2] This element can be achieved by use of cascaded, computer-generated, space-variant subwavelength dielectric gratings. Our spatial polarization-state scramblers are compact, passive components suitable for use with real-time applications and monochromatic laser radiation. These components are essential for removing undesired polarization sensitivity in optical systems. We also exploited space-variant subwavelength gratings to demonstrate polarization Talbot self-imaging, Pancharatnam-Berry phase optical elements[3,4] and formation of vectorial fields.[5]

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Erez Hasman (mehasman@tx.technion.ac.il), Gabriel Biener, Vladimir Kleiner and Avi Niv are with the Optical Engineering Laboratory, Faculty of Mechanical Engineering, Technion-Israel Institute of Technology, Haifa.