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Electrically controlled holographic varied line-spacing grating based on polymer dispersed liquid crystal

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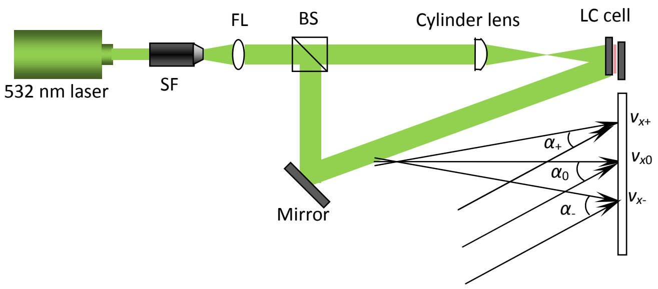

Experimental setup for fabricating varied line-spacing (VLS) H-PDLC.

Abstract: With the development of laser manufacturing technology, people can fabricate VLS plane gratings by holographic lithography. Compared with traditional gratings, the light incident on different positions of the VLS grating can diffract light with different angles, which leads to astigmatism and focusing effect. The application of VLS plane gratings reduces the number of optical elements inside the instrument and improves the resolution of the instrument. It is widely used in vacuum ultraviolet, soft X ray, optical fiber communication, sensor and many other fields.

The fabrication of VLS plane gratings has been reported mainly by mechanical scribing and holographic lithography. Adjacent lattice spacing in VLS grating is always in nanometer scale. It is difficult to use the ruling machine to make grating and to guarantee the accuracy in the actual operation process. Holographic lithography use photosensitive material to record spherical wave or non-spherical wave interference that can form varied distance of interference fringes and further fabricate VLS spherical or plane gratings. It has the advantages of simple operation, low cost, and easy to control the line-space, which is a common method to fabricate VLS grating. The holographic polymer dispersed liquid crystal (H-PDLC), as a new photoelectric information functional device, has high diffraction efficiency, fast response, and simple preparation. Its electric-optic characteristics have been greatly improved.

In this paper, H-PDLC material is used as a photosensitive material to record VLS interference pattern. The grating not only has advantages of ordinary VLS grating but also has electric-optic characteristics of H-PDLC. First, VLS interference pattern is generated through interference between cylindrical wave and plane wave. Second, the PDLC material is produced and put into the interference field for exposure. During polymerization, the prepolymer absorbs intense optical energy and polymerizes at the bright region, while the liquid crystal molecules are forced to diffuse from the bright region to the dark region, which forms the periodic alternating LC-rich region and polymer-rich region, corresponding to the interference optical pattern. Characteristics such as spatial frequency, diffraction and electric-optic, are analyzed by experiments. The results show that the trend and range of grating period match well with the theoretical formula. The relationship between diffraction efficiency and exposure intensity, as well as time is studied. The grating diffraction efficiency can be achieved up more than 70% with spatial frequency from 530 mm^{-1} to 650 mm^{-1}. In addition, the grating has good electrically controlled property. The threshold voltage is 2.4 V/μm, and the rise time and fall time are 300 μs and 750 μs, respectively.

Keywords: liquid crystals; holographic gratings; electric control; varied line-spacing; optical devices

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