Liquid crystal beam steering components for display applications

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Real-time manipulation of a light beam, such as its direction of propagation or its divergence, is a crucial operation in a number of optical and photonic systems. In particular, there are important applications for displays such as laser scanners or autostereoscopic displays. Next to that, in the emerging field of lighting, beam manipulation also opens up new possibilities.

Traditional systems for beam deflection, based on the mechanical movement of mirrors, prisms and lenses, are usually too bulky and costly and lack flexibility and reliability. Other techniques for beam steering include the decentered micro lens technique and the positional or angular displacement of curved micro mirrors. Still, these techniques face limitations such as complicated device structures and fabrication processes and very small working dimensions [1-3].

Recently, beam steering devices based on liquid crystals have attracted new interest. Such components provide easy electrical modulation, have no moving parts, can be very compact and offer process compatibility with existing technology.

Here we present such an electrically controllable micro-optical component for light beam steering and light intensity distribution, consisting of standard nematic liquid crystal on polymer micro prisms and offering continuous beam angle modulation.

The polymer micro prism arrays are made using the soft embossing technique. First, a copy of the master mold is made in elastic polydimethylsiloxane. This mold is then used to replicate the structures in UV-curable resin.

The liquid crystal above the micro prisms is aligned in such a way that a change of refractive index is obtained when switching the liquid crystal and light can be deflected according to Snell's law.

The realized components have a quite low operation voltage (10Vrms). The obtainable steering angle with a 554 nm laser beam was found to be 3º. The components are also able to deflect collimated white light over an angle of about 2º with an efficiency of 32% [4].

In a variation of the above component, circular micro-prism structures have also been combined with liquid crystals to realize an electrically switchable polarization independent beam expander, consisting of two orthogonally oriented prism structures. A similar performance as for the linear devices was obtained.

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References

1. A. Tuantranont, V. M. Bright, J. Zhang, W. Zhang, J. A. Neff, and Y. C. Lee, *Sensors and Actuators A: Physical*, 91, 363 (2001).
2. Y. Sabry, D. Khalil, B. Saadany, T. Bourouina, *Proc. SPIE*, vol. 8616, p. 86160F (2013).
3. L. Bogaert, Y. Meuret, S. Roelandt, A. Avci, H. De Smet and H. Thienpont, *Optics Express*, vol. 18(25), p. 26092 (2010).
4. X. Shang, J.-Y. Tan, O. Willekens, J. De Smet, P. Joshi, D. Cuypers, E. Islamaj, J. Beeckman, K. Neyts, M. Vervaeke, H. Thienpont and H. De Smet, *IEEE Photonics J.*, 7(2) (2015)