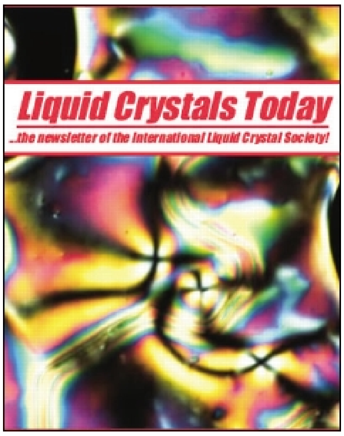

Liquid Crystals Today
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713681230

A liquid crystal microwave wavelength selector

Fuzi Yang[a]; J. R. Sambles[a]
[a] Thin Film Photonics Group, School of Physics, University of Exeter, Exeter, EX4 4QL, UK,

Online publication date: 03 December 2010

To cite this Article Yang, Fuzi and Sambles, J. R.(2002) 'A liquid crystal microwave wavelength selector', Liquid Crystals Today, 11: 4, 1 — 2
To link to this Article: DOI: 10.1080/14645180210000069238
URL: http://dx.doi.org/10.1080/14645180210000069238

LIQUID CRYSTALS TODAY, 2002, VOL. 11, NO. 4, 1–2

Taylor & Francis
Taylor & Francis Group

A liquid crystal microwave wavelength selector

FUZI YANG and J. R. SAMBLES
Thin Film Photonics Group, School of Physics, University of Exeter, Exeter, EX4 4QL, UK

Many thermotropic liquid crystals have a high optical birefringence. While this has been used extensively in low voltage driven liquid crystal displays it has yet to be significantly exploited with microwaves, even though the birefringence extends into this frequency range.

A few microwave modulation devices involving waveguide or microstrip-line structures, which use the large dielectric anisotropy of LC materials, have been reported. However, possibly through a perceived lack of suitable geometries for use of thin films of liquid crystal in the microwave wavelength range, few practicable devices have been developed.

Recently, however, a range of experiments and theoretical models have been presented which show strongly enhanced transmission of electromagnetic radiation through thin, periodic metallic samples containing very narrow slits. Surface waves in the slits may set up coupled standing waves resulting in resonant field enhancements within the slits and strong transmission. We have now developed this idea one stage further by filling the slits with liquid crystal, which leads to a voltage-controlled wavelength selector at microwave frequencies.

The geometry utilised is shown in figure 1, where a very deep zero-order transmission metallic grating is built by stacking 55 strips of aluminium with mylar spacers at each end. The crucial thickness of the mylar-spaced gaps is only 75.0 μm, which may be readily filled with a relatively small amount of liquid crystal. To facilitate alignment of the liquid crystal, the aluminium slats are individually coated with a polyimide film, which is rubbed along the short axis direction of the slats to provide homogeneous alignment of the liquid crystal molecules. These coated aluminium slats are then stacked as the above array and capillary filled with E7 nematic. Alternate slats are connected to an ac voltage source of 1 kHz, allowing the application of the same voltage across every gap.

Figure 2 shows the frequency- and voltage-dependent resonant transmission peaks for the sample with voltages varying from 0.0 to 7.0 V (running up the curves). This type of sample, for which there is no diffraction, can be described as a pseudo, or 'metal-filled' Fabry–Perot, the two highly reflecting surfaces being the front and back surfaces of the aluminium slats.

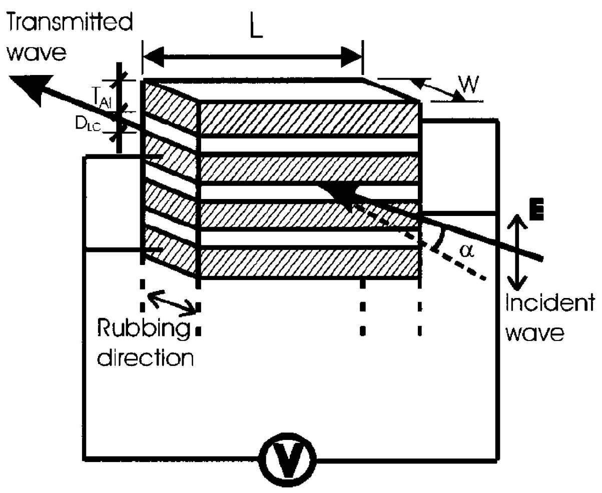

Figure 1. Sample geometry.

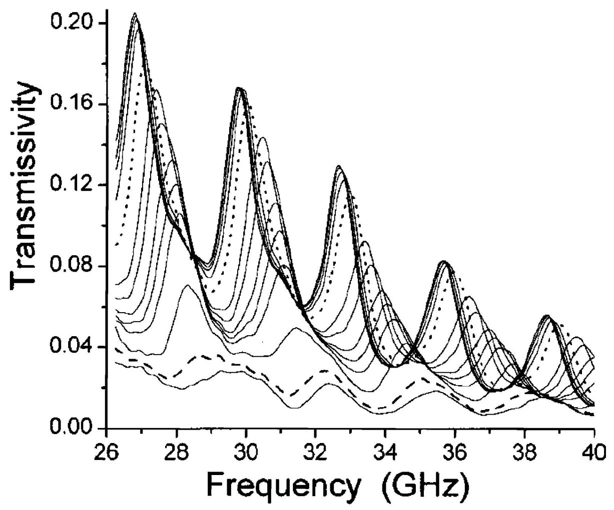

Figure 2. Transmission data as a function of frequency and applied voltage for microwaves polarized perpendicular to the grating slats.

Liquid Crystals Today ISSN 1464-5181 online © 2002 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/1464518021000069238

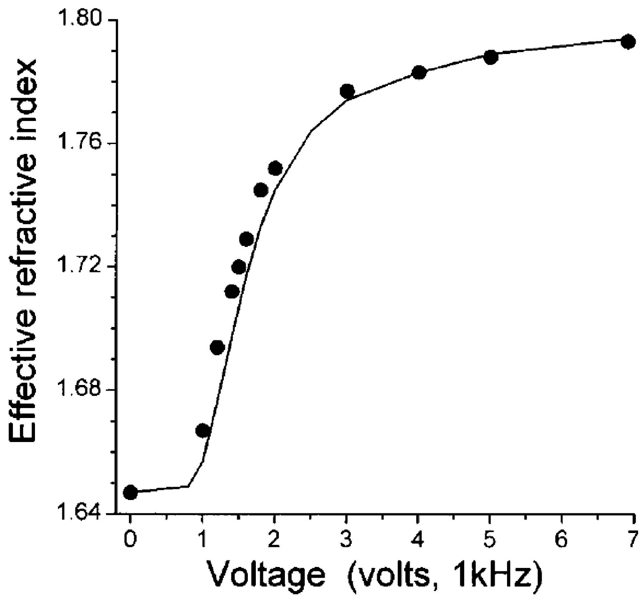

Figure 3. Variation of the effective index as a function of the applied voltage.

One mode step in frequency is encompassed by changing the voltage from 0.0 to 7.0 V. The most rapid movement of the modes occurs between 1.0 V (dashed curve in figure 2) and 3.0 V (dotted curve in figure 2). The effective microwave refractive index as a function of voltage is shown in figure 3 as solid circles. From figure 3 we see a fast change of index with voltage between 1.0 and 3.0 V, after which it appears to saturate. This is simply because at these voltages the LC director is almost completely homeotropically aligned throughout each cavity.

In conclusion, a low-voltage-controlled, liquid-crystal-based wavelength selector for the microwave frequency range of 26.5–40.0 GHz has been realised. This comprises a zero-order metal slat grating structure in which the thin inter-slat cavities are filled with nematic liquid crystal. In these cavities coupled surface waves are excited which, for certain incident wavelengths, set up standing waves. These wavelengths are selectively transmitted. By varying the voltage applied to the slats, these resonant transmission frequencies may be adjusted. Serious exploitation of such devices will need less absorbing liquid crystals specifically designed for microwave work.