Accurate modelling of liquid crystal based microwave devices

F.A. Fernandez[1], L. Seddon[1], R. James[1], S.E. Day[1], D. Mirshekar-Syahkal[2], S. Bulja[2], P. Deo[2]

1. *University College London, London, UK*
2. *University of Essex, Colchester, UK*

e-mail: a.fernandez@ucl.ac.uk

Mobile and wireless communication systems as well as radar systems require reconfigurable filters, tuneable and adaptive antennas, adaptive couplers, electronically controlled delay-lines, etc, in order to be flexible and operational under different communication standards and operational and environmental conditions. Also, for security reasons, lightweight field radios and radar systems are required to reconfigure and operate over different frequency bands in a short time span. Research have shown that liquid crystals are particularly attractive for these applications. As in the optical range, liquid crystals offer the possibility of large permittivity changes, controlled by low, externally applied voltages, so their incorporation as substrates in microwave devices can bring about many advantages into communication and radar devices and provide a low-cost alternative to adaptive and reconfigurable systems.

To take full advantage of these possibilities and design devices effectively, it is necessary to explore the possibilities offered by liquid crystals thoroughly, with a full characterisation of the materials at the frequencies and geometries involved. It is also important to develop accurate modelling techniques that can predict the behaviour of liquid crystal materials in complex device configurations and can take into account the full anisotropy and non-uniformity of its permittivity distribution in the modelling of the RF operation of the device. The liquid crystal properties can be controlled by changing the components in the mixtures, but in order to formulate the mixtures properly the properties must be measured over the relevant frequency ranges.

We have developed techniques that combine liquid crystal modelling, electromagnetic modelling and experimental measurements that allow the wide-band charcterisation of liquid crystal materials at microwave frequencies and for the analysis and design of complex liquid crystal based, reconfigurable and tuneable microwave devices.

These methods have been used to design and analyse microwave filters, resonators and phase shifters for phased antenna arrays.

The same modelling techniques can be applied in other frequency ranges including terahertz and optics.

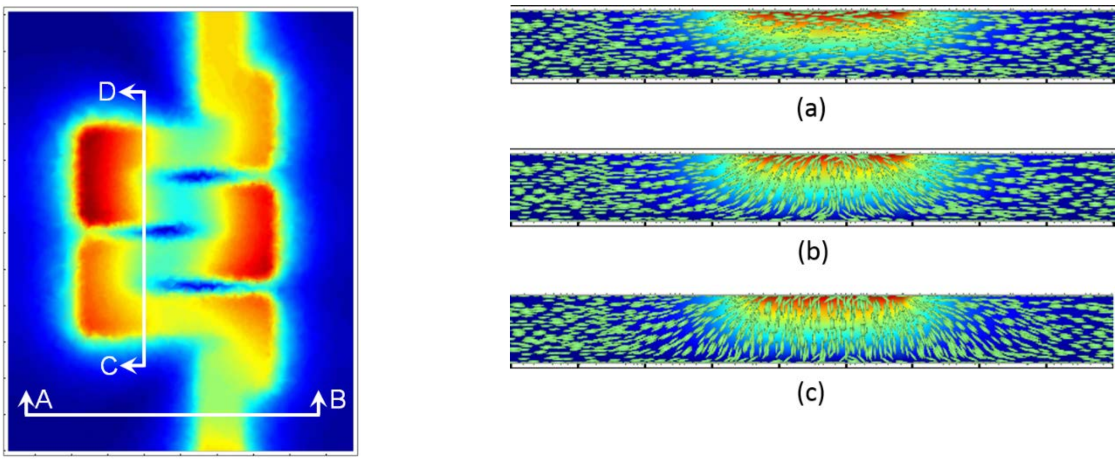

Figure 1. Field distribution in a meander-line phase shifter (left). Liquid crystal orientation in the cross-section A-B at three different voltages (right).

Acknowledgment: This work has been funded by the UK Engineering and Physical Sciences Research Council, EPSRC.