Emerging Device Technology > **Thick Film Ferroelectric Phase Shifters**

Ferroelectric materials are of interest because there dielectric permittivity changes when a bias voltage is applied. Both thin film materials (~1mm thick) and thick film materials (~50mm thick) are of interest for different types of device and different microwave systems. This change in permittivity allows phase shifters and tunable filters to be constructed, and here we discuss some phase shifters made out of thick film.

One use of phase shifters is in phased array antennas, and the purpose of this particular work is to develop them at about 30GHz to be used in an adaptive antenna for local area communication systems.

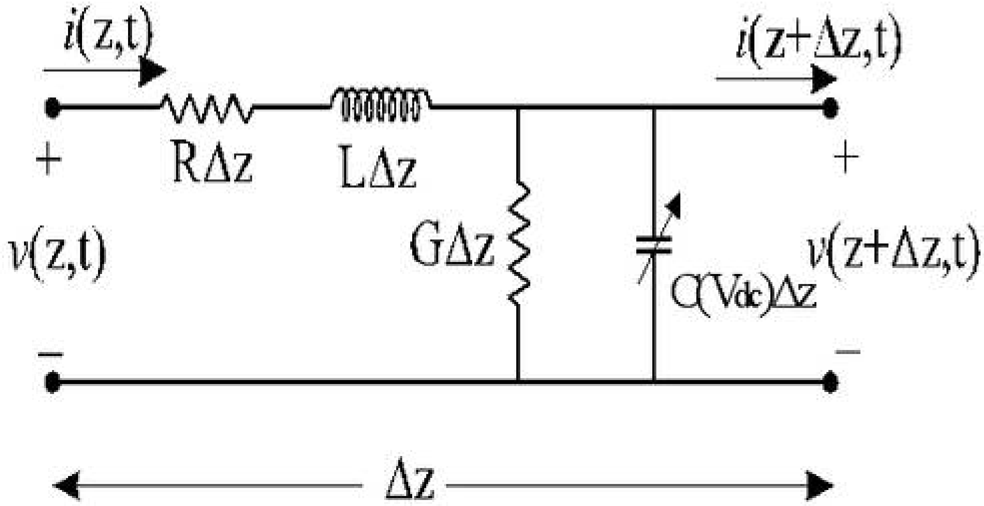

Figure 1 The basic equivalent circuit of a small section of transmission line.

Figure 1 shows the general principle of how a ferroelectric material can be included into a transmission line. The figure is an equivalent circuit for a short section of transmission line; the ferroelectric material allows a change in capacitance if a bias voltage is applied. This change in capacitance gives a change in velocity of the electromagnetic wave on the transmission line which in turn gives a phase change.

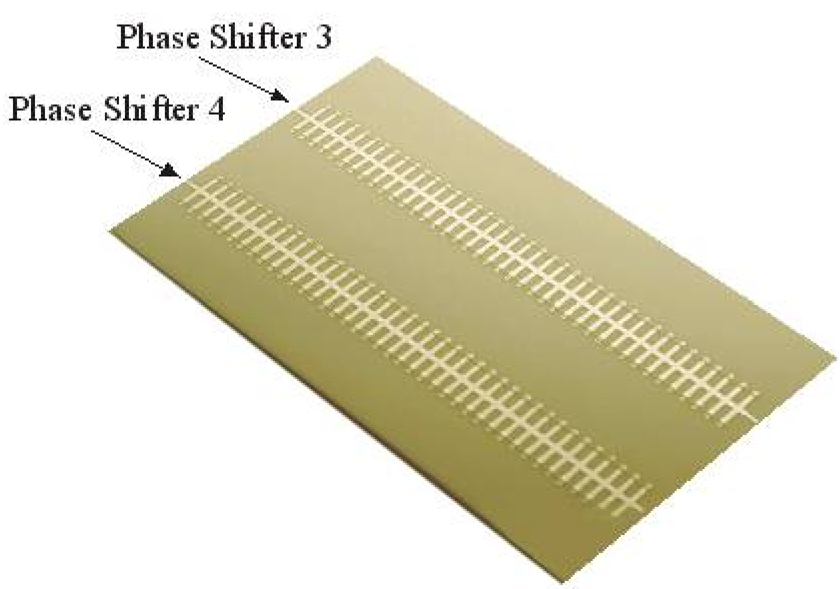

Figure 2. Two ferroelectric thick film phase shifters. The total length is about 4cm.

Figure 2 shows two phase shifters, they consist of a microstrip line along the long length with a number of discreet ferroelectric capacitors at regular intervals. The special design allows not only a change in the phase with an applied voltage, but also the device acts as a bandstop filter. Figure 3 shows the phase response of one of the devices. The lines show the change in phase between the application of 50V and 100V to the ferroelectric capacitors. The noise at the edges of the graph are where the bandstop filter is highly attenuating and the phase cannot be accurately measured.

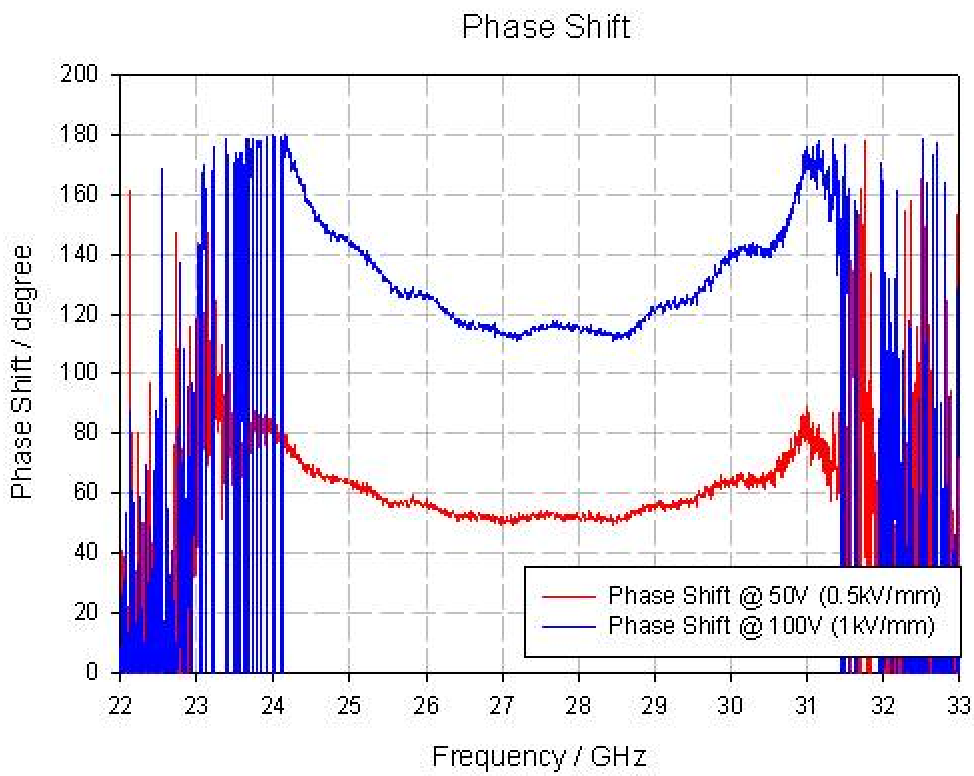

Figure 3 The phase response of the ferroelectric phase shifter.

The EDT group has made many phase shifter in collaboration with others, another example is shown in figure 4. In this case it is a microstrip hybrid with resonant circuits on two of the legs. These resonant circuits consist of an inductive line together with a ferroelectric capacitor allowing the phase to be altered with the application of a bias voltage.


Figure 4 Phase shifter based on hybrid coupler

An individual capacitor is shown in figure 5. Here the ferroelectric runs from the top of the picture to the bottom and is about 50 microns wide. The electrodes are connected to their ferroelectric by overlaying and underlying the conductor with the ferroelectric. A platinum electrode has to be used on the base of the ferroelectric as silver is not compatible with the processing of the ferroelectric during its processing; the silver is deposited last. These capacitors have now been well characterized at Birmingham and we are now able to use them in a number of other advanced microwave devices.

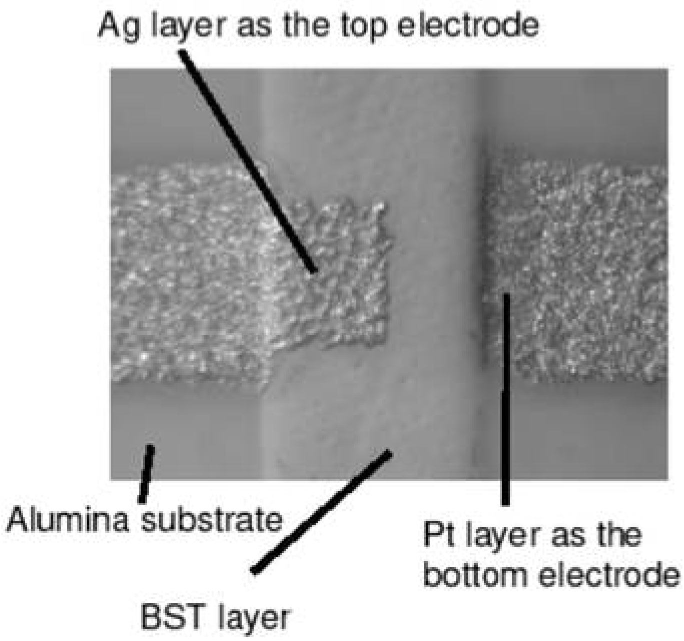

Figure 5. A ferroelectric capacitor; the Strontium Barium Titinate (SBT) runs from top to bottom with silver and platinum thick films forming the electrodes.

This work was done with a number of collaborators with the materials being made in the Materials Science department at Birmingham as well as Oulu university in Finland. In addition there was industrial collaboration with Filtronic Comtek, Ericsson and Temex and academic collaboration with the University of Chalmers in Sweden and the University of Lausanne in Switzerland. The project produced many more results that can be reported here.