[Emerging Device Technology](#) > **Microwave Microscopy**

The scanning evanescent microwave microscope is a microscope which works with microwaves instead of with light like a normal microscope. It is used to analyse the electrical properties of materials at frequencies of the order of 1 GHz over length scales of the order to one micron or less.

It has potential for use as a high-throughput characterisation tool in combinatorial synthesis and as a probe of the electromagnetic properties of ferroelectric, dielectric, ferromagnetic and conducting materials whenever issues of heterogeneity and spatial non-uniformity are present.

The sample is scanned closely beneath a tip through the end wall of a quarter-wavelength co-axial cavity. This provides imaging via the near-field with a spatial resolution orders of magnitude smaller than the wavelength of the microwave signal, hence the high spatial resolution.

Near-field imaging of materials with microwaves has been known for some time [1] but only in recent years, with the demand for wider characterisation of materials at frequencies of interest for communications applications, has the development of sensitive, resonator-based probes really taken off [2].

[1] RF Soohoo, J. Appl. Phys. 33 1276 (1962), M Tabib Azar, NS Shoemaker, S Harris, Meas. Sci. Techn. 4 583 (1993)
[2]DE Steinhauer, CP Vlahacos, FC Wellstood, SM AnlageC Canedy, R Ramesh, A Stanishevsky, J Melngailis Review of Scientific Instruments 71 2751 (2000): T Wei and XD Xiang, Appl, Phys. Lett. 68 3506 (1996)

Figure 1 shows a photograph of the microscope we have built in Birmingham.

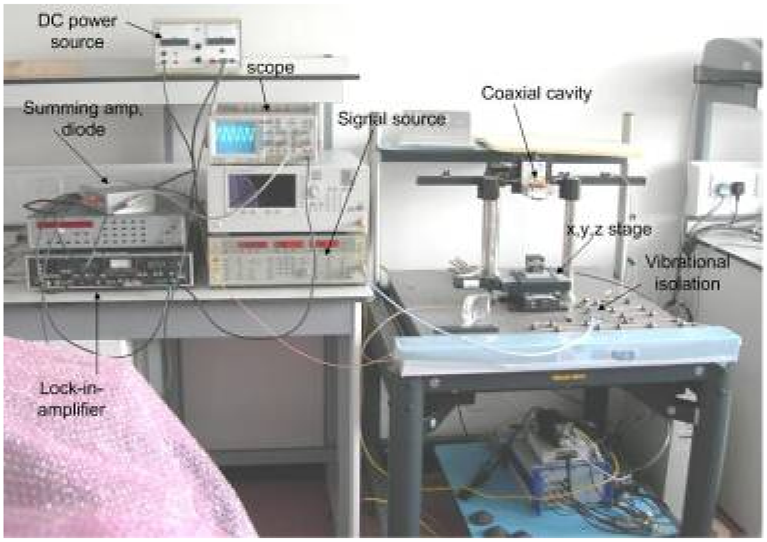

Figure 1: Photograph of the microwave microscope

We have developed a lock-in amplifier based technique for following the resonant frequency and loss of the cavity as the sample is scanned beneath the tip. The permittivity and loss tangent of dielectric and ferroelectric materials, for example, can be determined from the resonant frequency and loss by calibration against standard samples. A rapid, electronic feedback control circuit such is ideal for applications such as the screening of materials libraries produced by combinatorial synthesis. A schematic of the loop is shown in Figure 2.

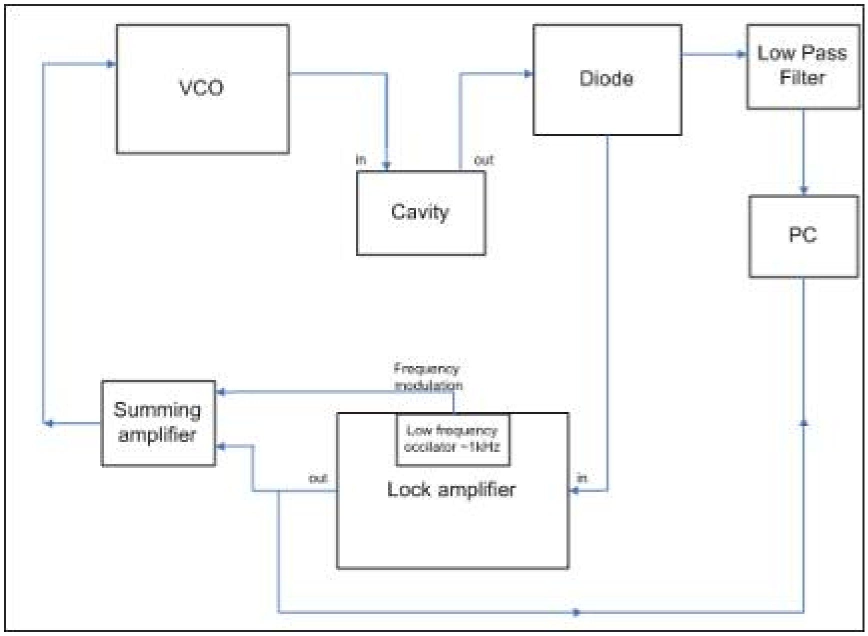

Figure 2: Schematic of the feedback loop. Microwave signal input to the cavity is modulated at 1 kHz. When the signal is centred on the resonant frequency of the cavity, the output power is modulated at 2 kHz.

Modelling of the cavity using CST Microwave Studio is used to aid the design of new cavities, particularly the arrangements for shielding of the electromagnetic field where the tip protrudes through the endwall of the cavity. This assists in achieving high spatial resolution and high sensitivity to small changes in sample properties. Figure 3 shows an example of the output of the simulations.

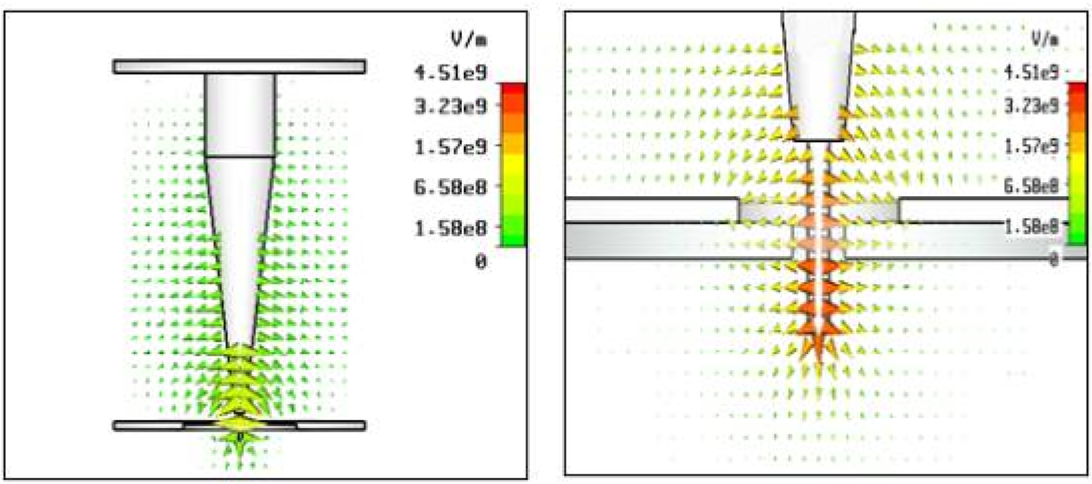

Figure 3: Simulation of the electric field around the tip attached to the centre conductor of the co-axial cavity and protruding through the endwall of the cavity.

We are applying the microscope to study of the ferroelectric materials used in microwave devices by other members of the research group. Figure 4 shows some images taken with the microwave microscope.

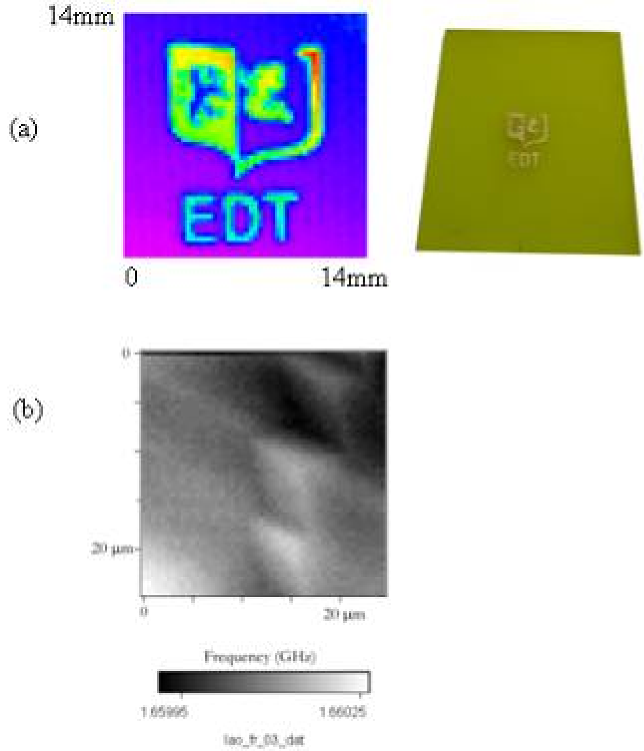

Figure 4: Images of (a) a patterned PCB (b) twins in a LaAlO3 single crystal