

## Superconducting Metamaterial Devices

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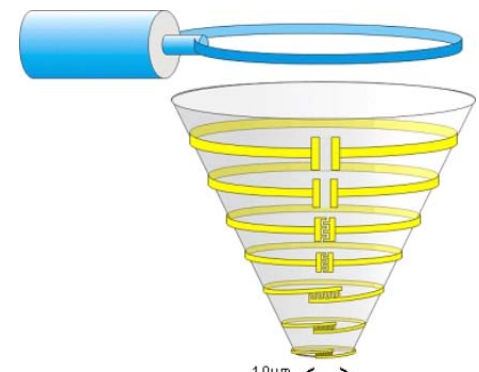
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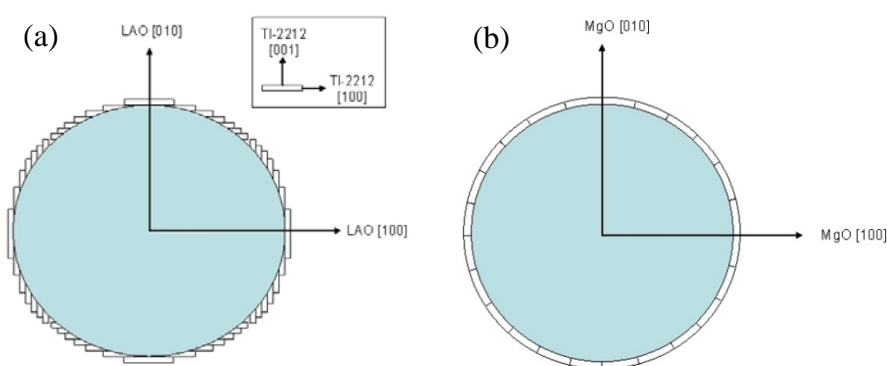
### Background on Metamaterials

Recent developments in the field of magnetic metamaterials have shown that coupled split-ring resonator (SRR) structures can manipulate magnetic fields, provided the feature size is smaller than the wavelength of the electromagnetic radiation. Stacks of copper/dielectric SRR structures can be used as high Q filters or as waveguides in near field imaging applications. High Temperature Superconductors (HTS) have the potential to perform better than conventional conductors in many metamaterial devices, but producing HTS films with low surface resistance ( $R_s$ ) values on *curved* dielectric substrates as required for these applications, has not been previously attempted and has many inherent difficulties.



Schematic of a superconducting probe for an NMR microscope

### Tl<sub>2</sub>Ba<sub>2</sub>CaCu<sub>2</sub>O<sub>7</sub> Growth on Dielectric Cylinders



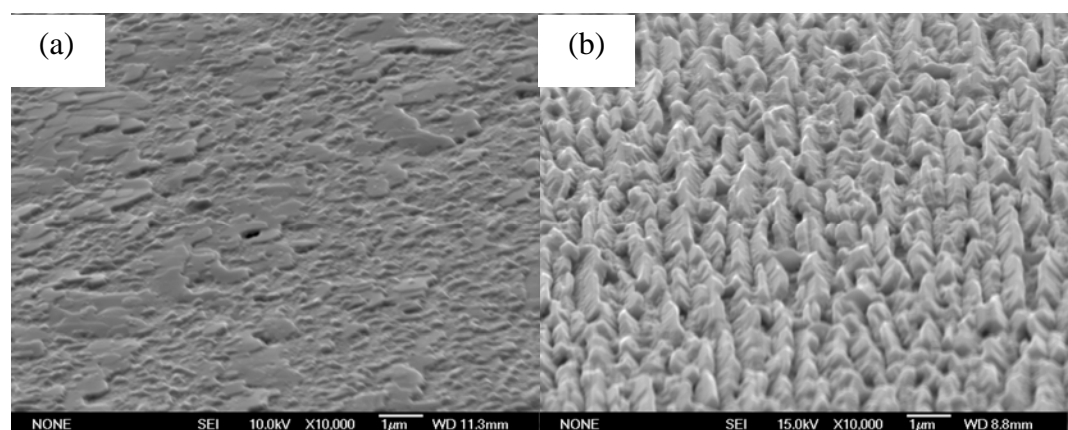
Schematic diagrams showing how Tl-2212 films grow on (a) LaAlO<sub>3</sub> and (b) MgO cylindrical substrates.

Tl-2212 films have been found to have a strong tendency to grow on LaAlO<sub>3</sub> cylinders with the c-axis aligned with the pseudocubic [100] axis of the LaAlO<sub>3</sub>.

In contrast, the lattice mismatch of Tl-2212 with MgO is much higher, resulting in kinetically favoured growth with the c-axis normal to the film surface. The in-plane alignment is random.

The SEM micrographs show the differences in film morphology in films grown on LaAlO<sub>3</sub> cylinders at positions where the angle with LaAlO<sub>3</sub> [100] is (a) close to 0°, and (b) close to 45°.

On MgO cylinders the films have a flat, plate-like morphology as in figure (a) at all positions around the cylinder.



### Conclusions and Further Work

MgO is a good potential substrate material for the growth of curved HTS films with low  $R_s$  values. Further investigation of Tl-2212 growth on vicinal MgO substrates will be carried out to develop strategies for substrate preparation to maximize the in-plane alignment (and hence minimize the  $R_s$  value) of the Tl-2212 film. In addition, progress is underway in the development of systems to measure  $R_s$  values and to pattern SRR devices in the cylindrical superconducting films.