Coated Conductor Cylinders

Summary of multilayer STO/YBCO results:

- We have now extended our previous feasibility tests to the case of six superconducting layers each ~ 400nm thick, separated by intervening strontium titanate layers ~130nm thick.
- The in-plane and out-of-plane texture actually improves as the number of layers increases.
- There are some pores and outgrowths observed by XTEM, but there is no evidence of layer interdiffusion. STEM results, not shown here, support this conclusion using linescans.
- Tc remains stable at around 90K. There is some evidence of degradation of ΔTc as the number of layers increases – the effect on Jc is not yet known. (next task!!)

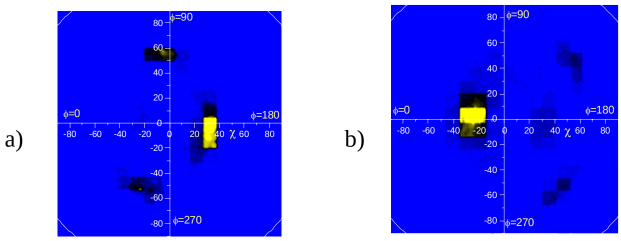

Fig 1 : EMGO 7 – 2μm ISD on glass. a) the (111) pole figure and b) the (100) pole figure. For both pole figures, the sample was oriented such that the growth vector was in the diffraction plane with ϕ=0. Intensity is plotted in a logarithmic scale.

These pole figures show the characteristic 23° tilt of the MgO (00l) pole in the direction of the growth vector.

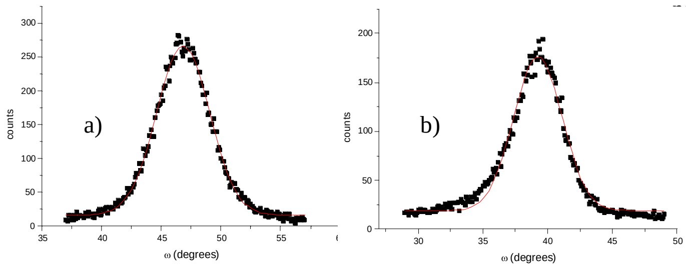

Fig 2 : EMGO7 – a) (400) rocking curve with FWHM of 4.5 degrees and b) (311) rocking curve with FWHM of 3.8 degrees.

For each reflection the rocking curves were obtained with the diffraction plane perpendicular to the growth vector.

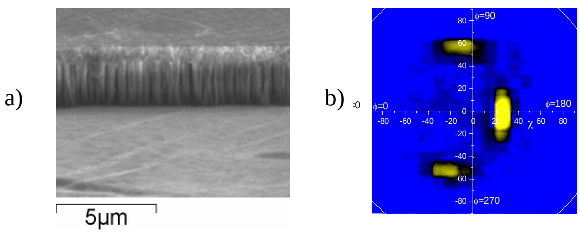

Fig 3 : a) EMGO 34 – 2μm ISD + 1μm homoepitaxial layer on 310 Stainless. b) (111) pole figure taken with sample oriented such that the growth vector was in the diffraction plane with ϕ=0. Intensity is plotted in a logarithmic scale. This shows the characteristic 23° tilt of the MgO (00l) pole in the direction of the growth vector. The apparent large breadth in the phi direction is due to the detector being vertical slit – reducing the resolution in this circumferential direction.

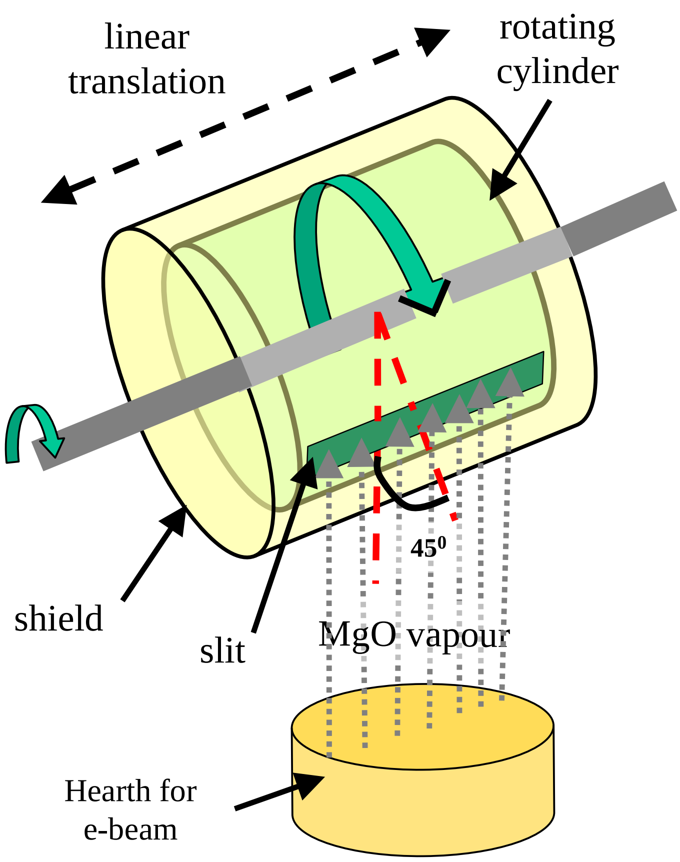

Fig 4 : Schematic for textured coating of rotating cylinder using e-beam evaporation of MgO.

Whilst the multilayer feasibility results to date have been carried out on RABiTS substrates, it is of course necessary to develop a texturing method for the 3-C's cylinders. Of the various possible techniques, we have chosen a variant of the Inclined Substrate Deposition (ISD) technique using e-beam evaporation of MgO(4).

To gain experience of the process and the key parameters we first carried out depositions on glass substrates. Good texture properties were obtained for the heteroepitaxial layers as shown in Figs 1 and 2 (left). The process seems to be remarkably tolerant to changes in parameters – for example we have varied the deposition rate from 5 to 20 nm/s without noticeable change in the morphology and texture of the structure up to 2 microns thick.

The columnar structure produced by this room temperature process is very friable and is neither dense nor smooth enough to ensure the subsequent deposition of a good HTS layer. As has been reported by other groups, it is therefore necessary to deposit a homoepitaxial layer in addition, at temperatures of the order of 500 C, in order to produce a smooth, dense and stable structure on which to grow the HTS layer. We chose a stainless steel (310) substrate for this demonstration since it has to survive these temperatures and of course it is an option for the cylindrical geometry too. The overall structure is shown in Fig 3a), and the corresponding pole figure is shown in Fig 3b). The latter shows that the cap layer is copying the texture of the ISD layer successfully.

We are now working on an adaptation of this ISD process to the cylindrical geometry, as shown schematically in Fig. 5 above. Given that we have the advantage, in principle, of an enormously high power density in the multilayer coils (because of there being no "repeating substrate"), the MgO ISD technique with its lower costs and relative simplicity looks very promising. A suitable HTS process for this geometry is also under development in order to produce the first 3-C's demonstrator – which is likely to be configured as an inductive fault current limiter.