XPS for evaluation of dopant distribution in YBCO thin films

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Introduction

Crystalline nanoparticles are used as active pinning centres in $YBa_2Cu_3O_{7-\delta}$ (YBCO) thin films in order to improve the critical current density (J_c). Precursor solutions are deposited via chemical solution deposition on $LaZrO_3$ or $LaAlO_3$ substrates followed by a calcination and sintering process. During this process nanoparticles are either pushed to the YBCO surface, sink to the substrate interface or, as preferred, are homogeneously distributed throughout the superconducting film. XPS sputterprofiling was used to establish this distribution throughout the thin film.

Results and Discussion

YBCO thin films of 400 till 800 nm are doped with different kinds of nanoparticles. The behaviour of these nanoparticles during the thermal process depends on their surface chemistry, size, growth rate and the YBCO precursor solution. For evaluation, films were sputtered with an Ar^+ ion gun. After consecutive sputter cycles an area of 250 × 1000 μm^2 was analysed (VG Surface Science Instruments).

The step size was chosen after calibration versus a Ta_2O_5–reference thin film. Relative sputterrate of YBCO versus Ta_2O_5 could be determined as 2.67 (st dev 0.71) for calcined samples and 0.79 (st dev 0.15) for fully sintered films, fig. 1.

The atomic composition after every sputter cycle is estimated using Casa XPS soft-ware. For visual representation of nanoparticle distribution the molar percentage of dopant versus yttrium concentration showed to be a useful tool.

As such, distinction between homogeneous distribution, accumulation at the interface or at the sample surface could be distinguished.

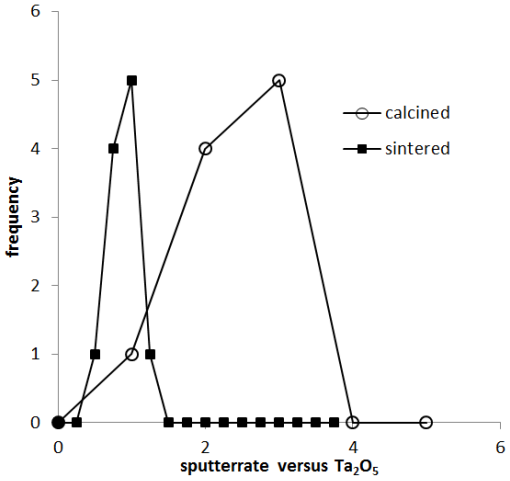

Fig. 1: Histogram of YBCO sputterrate versus Ta_2O_5

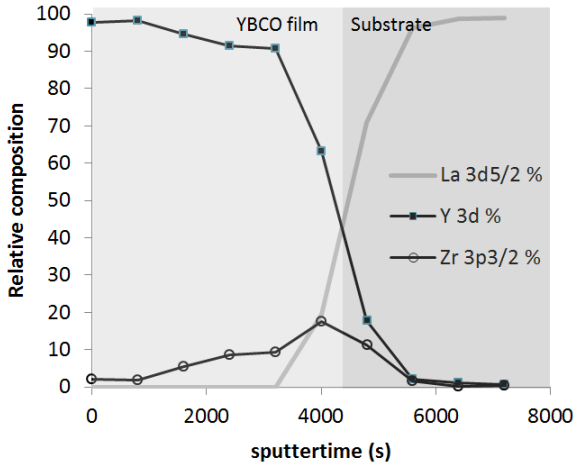

Fig. 2: La, Zr, La relative composition with increase of Zr concentration at the interface

Conclusions

It is demonstrated that XPS sputter profiling can be used for the study of nanoparticle distribution in thin films.

References

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