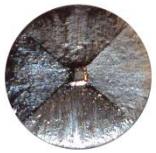
UNIVERSITY OF CAMBRIDGE



BSG

The successful incorporation of Ag into $YBa_2Cu_3O_7$ bulk superconductors

J. V. J. Congreve, Y. H. Shi, A. R. Dennis, J. H. Durrell and D. A. Cardwell

EUCAS, September 17-21, 2017

Overview

- Motivation
- Growth of YBCO-Ag
- Growth rate
- Microstructure and Composition
- Trapped field
- Conclusions

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Motivation for incorporation of Ag

- Mechanical properties limit achievable superconducting properties
- Ag improves the fracture toughness and bending strength without negatively affecting superconducting properties
- YBCO, GdBCO-Ag and SmBCO-Ag successfully batch processed
- Reduction in peritectic temperature affects initial decomposition, diffusion, interface kinetics & growth rate

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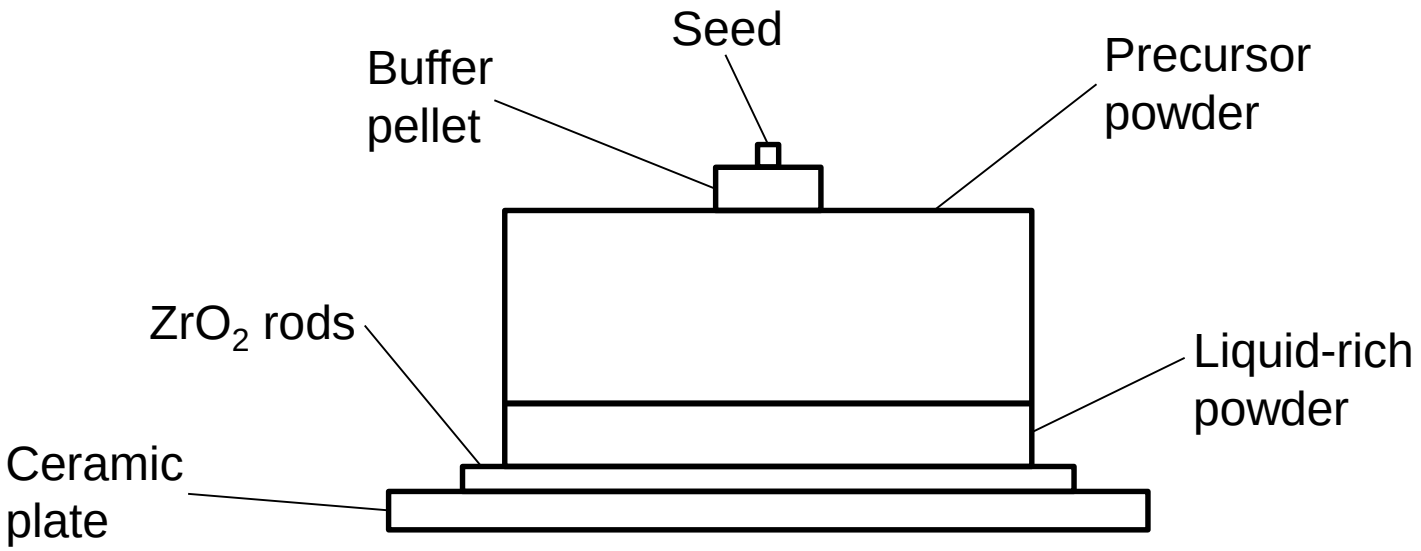
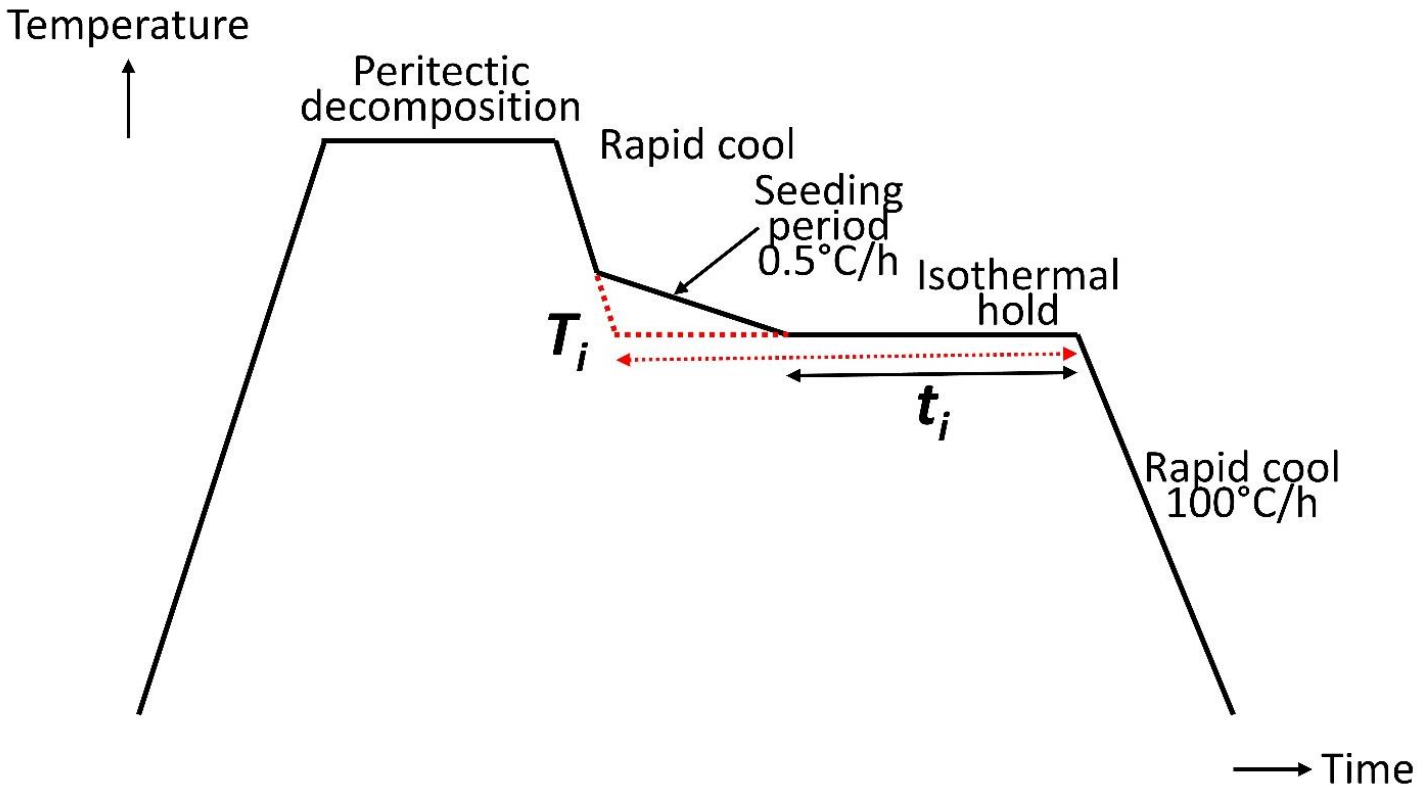
Growth

- 9 samples successfully partially grown by liquid-phase enriched TSMG



Growth of YBCO-Ag by CCIH

- Continuous cooling and isothermal hold (CCIH) technique



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Growth Rate of YBCO-Ag

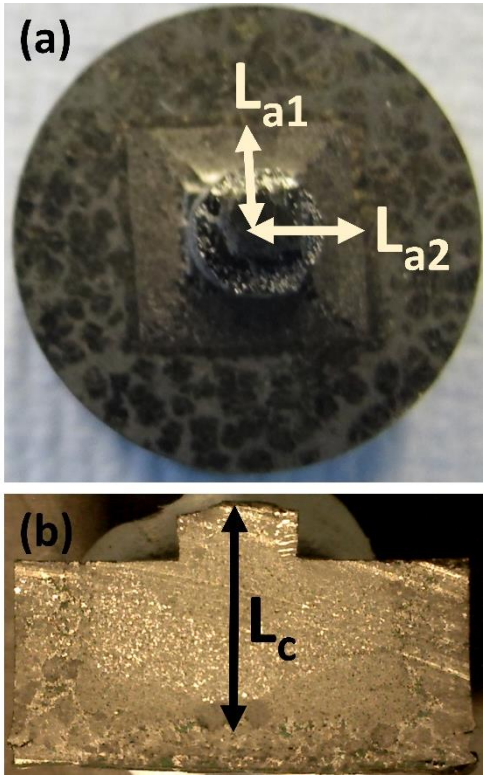
- Isothermal holding:

$$G = \alpha(\Delta T)^{\beta}$$

(Endo, Chauhan et al. 1996, Zhai, Shi et al. 2014, Shi, Babu et al. 2007)

- Some growth in continuously cooled region:

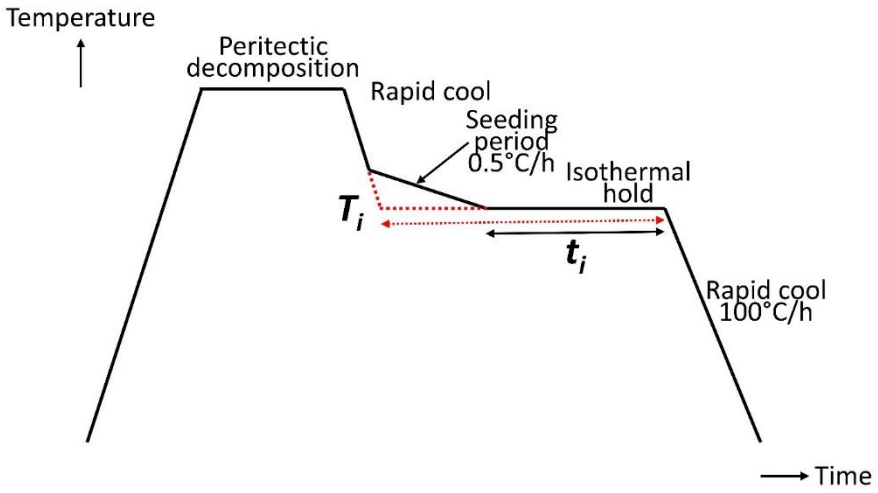
$$G = \frac{dL}{dt}$$



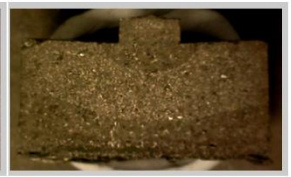
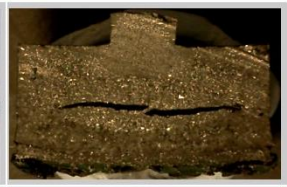
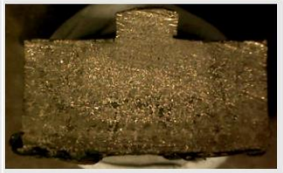
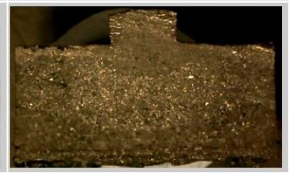
Growth Length

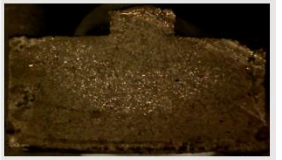
- $L = \int_{t_{start}}^{t_{end\ of\ continuous\ cool}} G_{continuous\ cool}\ dt + G_{isothermal\ hold}\ t_{isothermal\ hold}$

- $L = \int_{t_{start}}^{t_{end\ of\ continuous\ cool}} \alpha(-0.5t)^{\beta}\ dt + \alpha(\Delta T)^{\beta}\ t_{isothermal\ hold}$

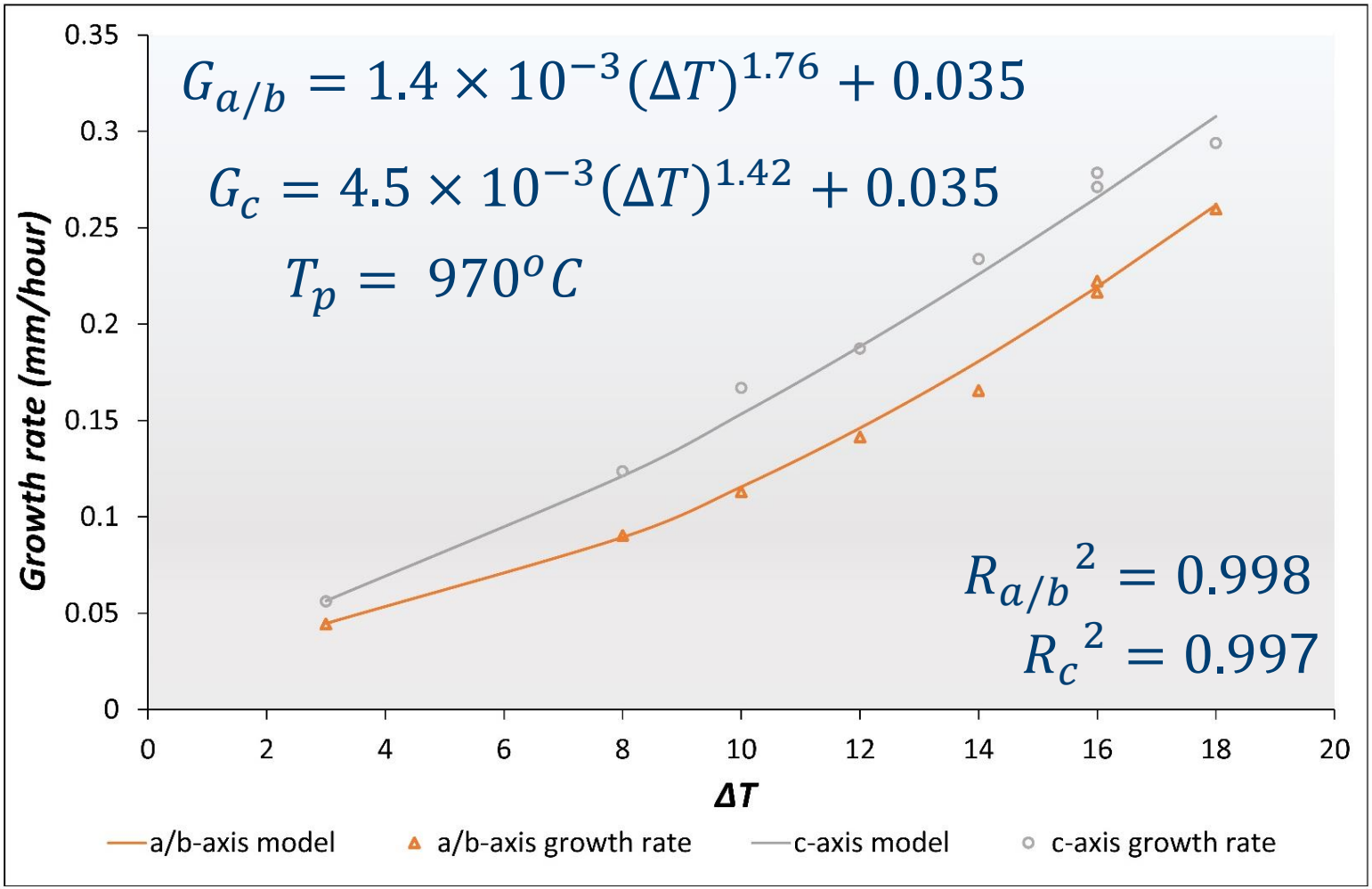


Samples

ΔT	t_i (hours)	Top of sample	Cross section of sample
0	10		
3	10		
8	10		
10	10		
12	8		

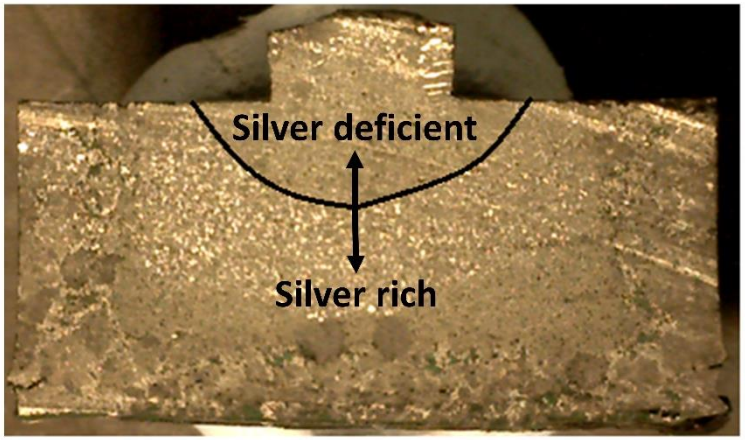
ΔT	t_i (hours)	Top of sample	Cross section of sample
14	6		
16	3		
16	2		
18	0.75		

Growth Rate Model



Use of CCIH

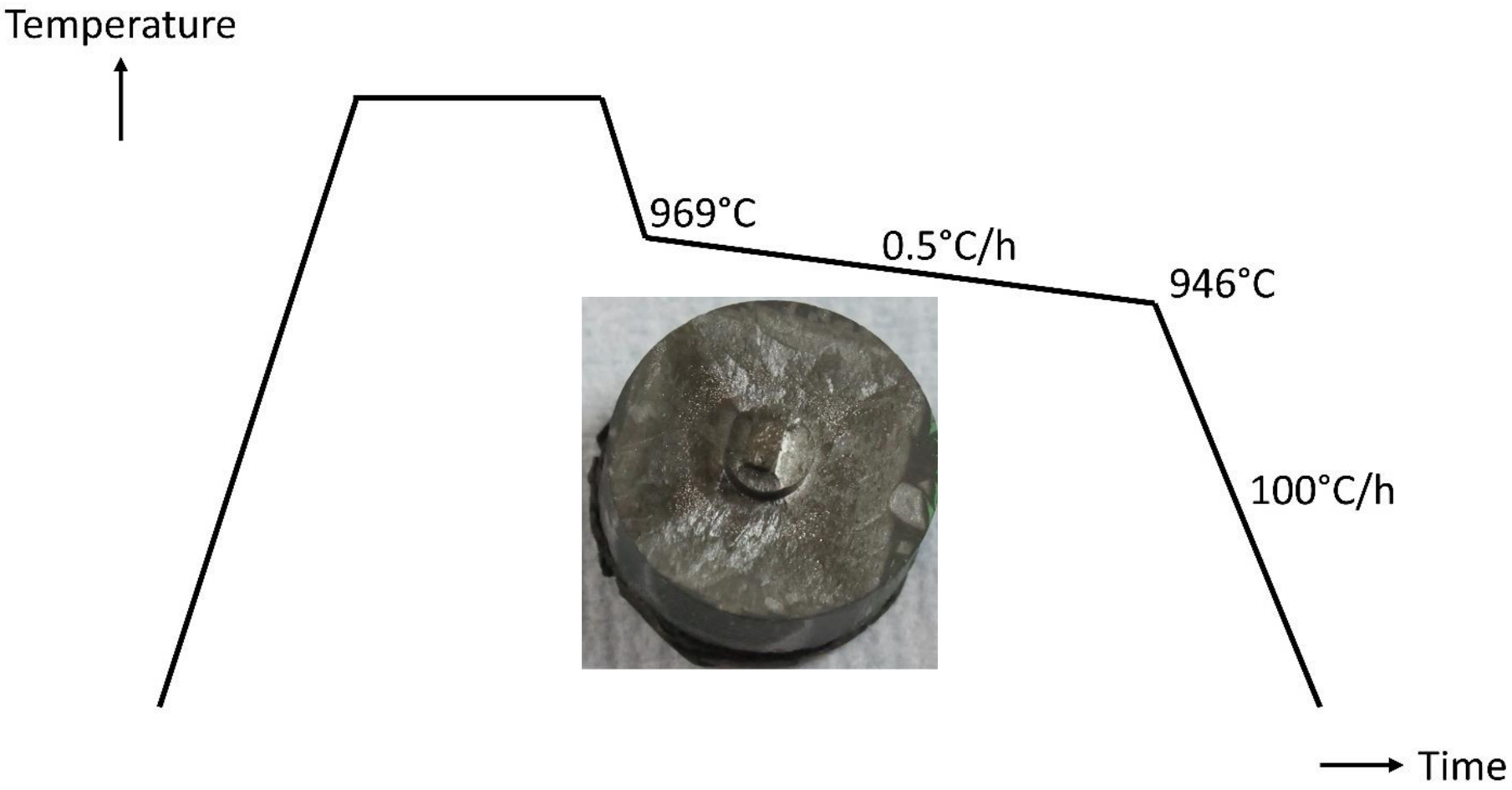
- Silver deficient region
- Offset in growth rate model



$$G_{a/b} = 1.4 \times 10^{-3}(\Delta T)^{1.76} + 0.035$$

$$G_c = 4.5 \times 10^{-3}(\Delta T)^{1.42} + 0.035$$

Derivation of a heating profile



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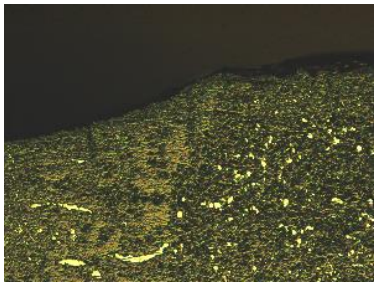
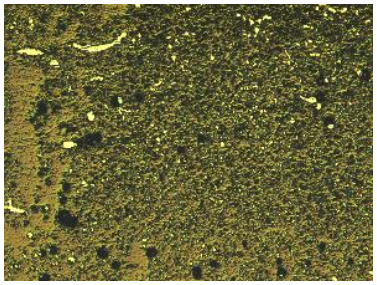
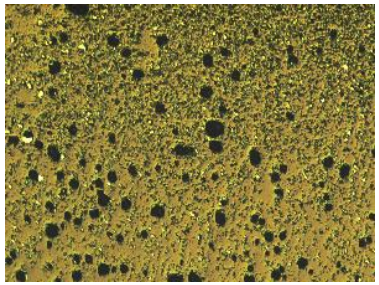
Microstructure in c-axis direction



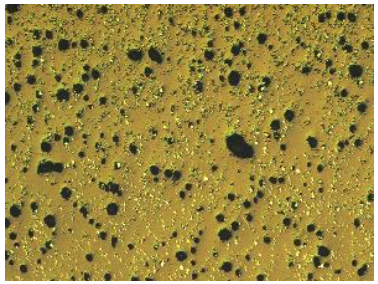
0 mm



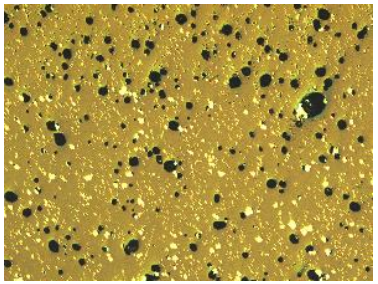
1 mm



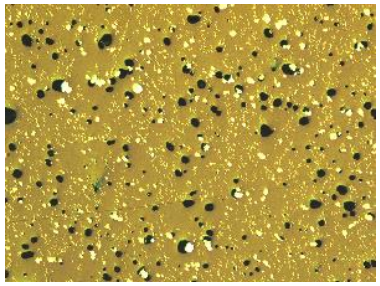
2 mm



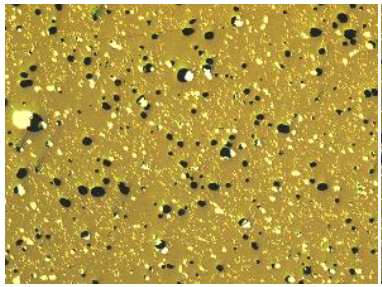
3 mm



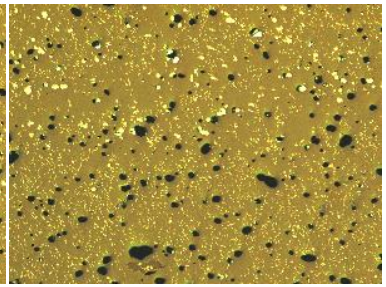
4 mm



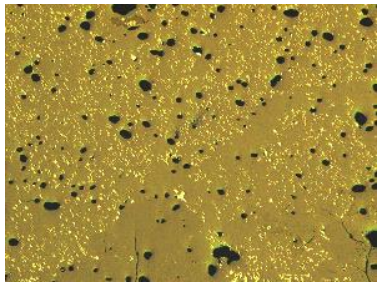
5 mm



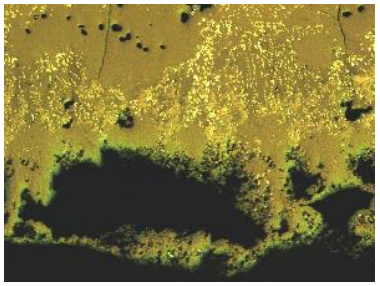
6 mm



7 mm

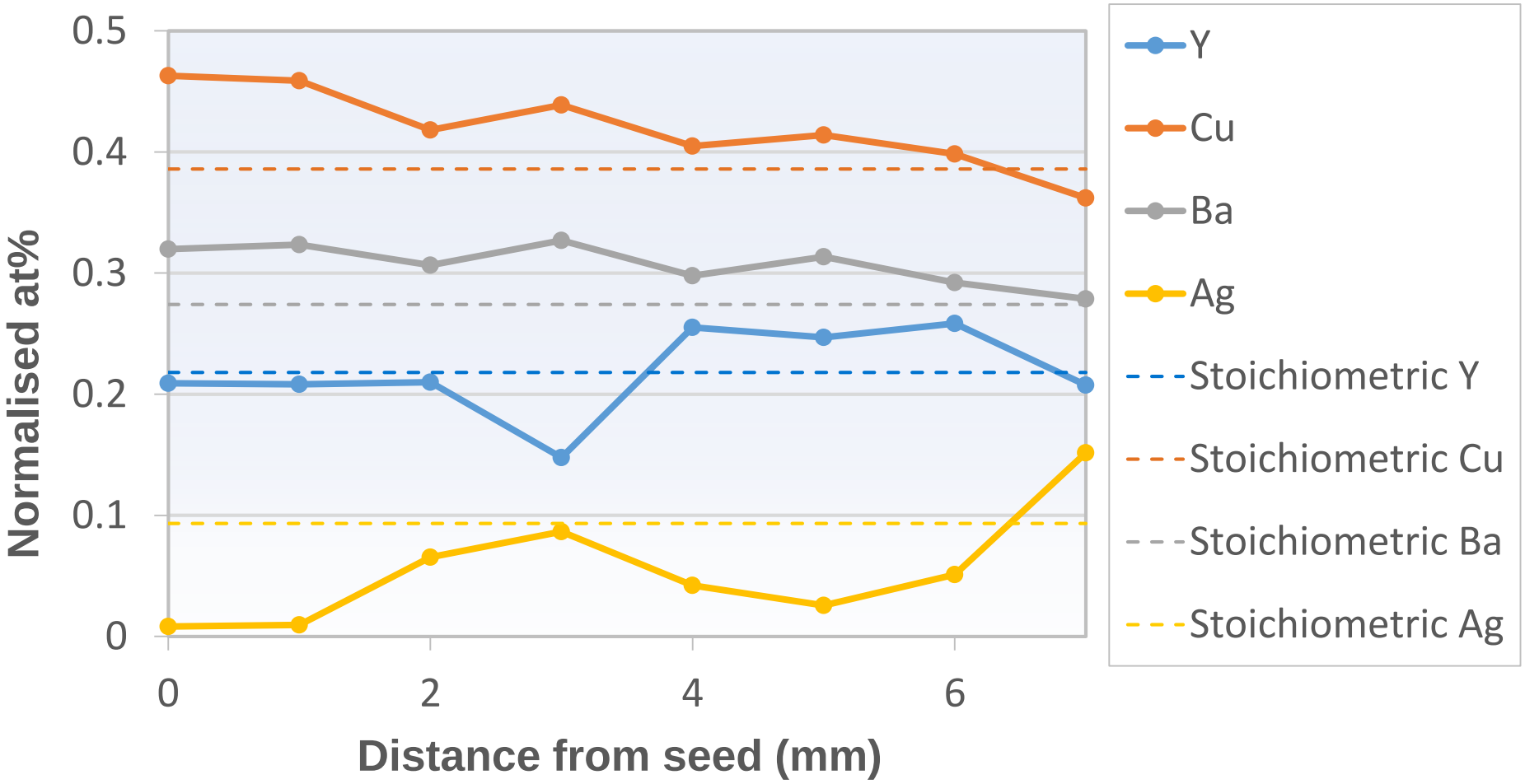


8 mm



9 mm

Composition in c-axis direction



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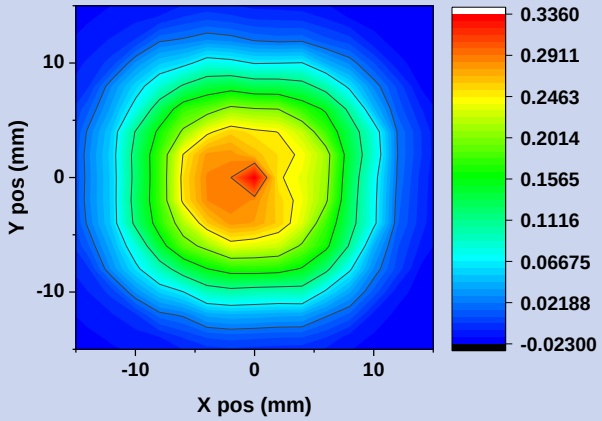
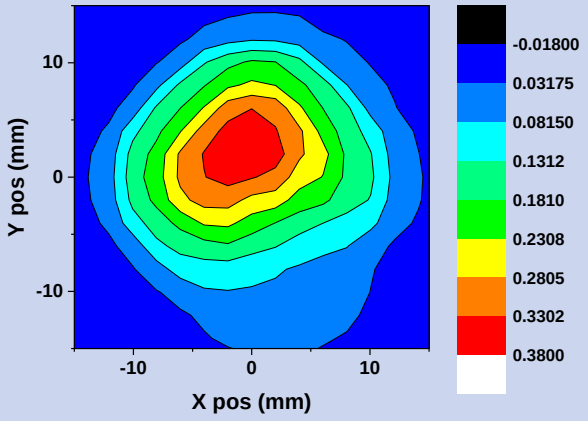
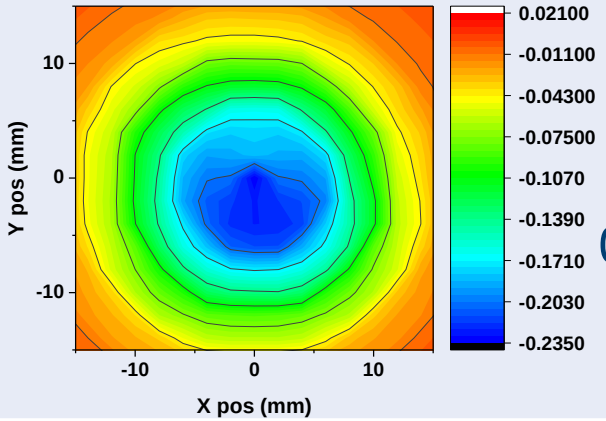
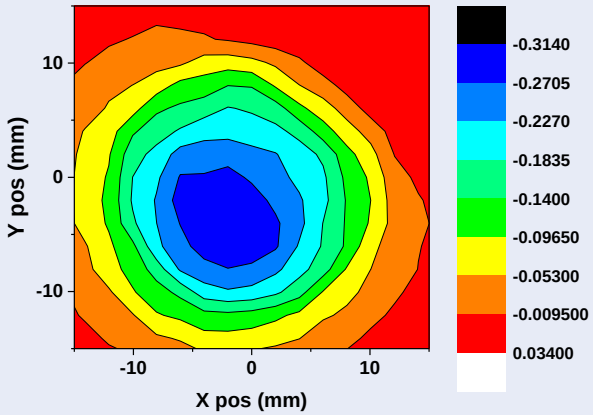
Trapped field

	YBCO-Ag	YBCO
Top	 Max 0.643 T	 Max 0.652 T
Base	 Max 0.366 T	 Max 0.440 T

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Conclusions

- Growth rate of YBCO-Ag has been studied in detail using the new CCIH technique
- A model for the growth rate of YBCO-Ag in both the a/b- and c-axis direction has been developed
- This growth rate model has enabled a heating profile to be developed to successfully grow single grains upto 30 mm in diameter
- We are now able to grow large single grains of YBCO-Ag which exhibit uniform trapped fields