DICTRA® SIMULATIONS OF SIGMA PHASE FORMATION IN DUPLEX STAINLESS STEELS

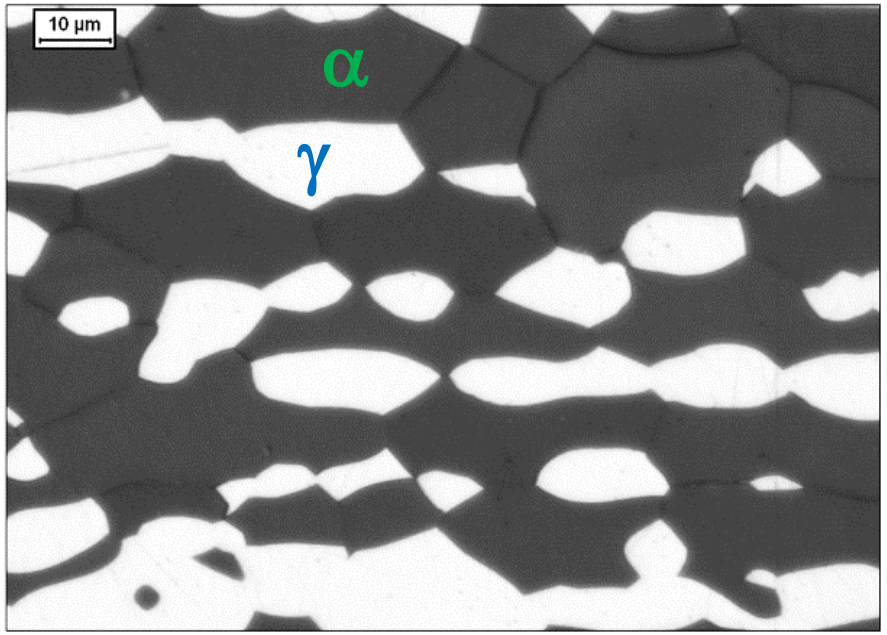
G. D. R. Chbane,
RODRIGO MAGNABOSCO

Introduction

Duplex Stainless Steels (DSS)

Equal amounts of ferrite (α, BCC) and austenite (γ, FCC)

Corrosion resistance, mechanical strength, toughness



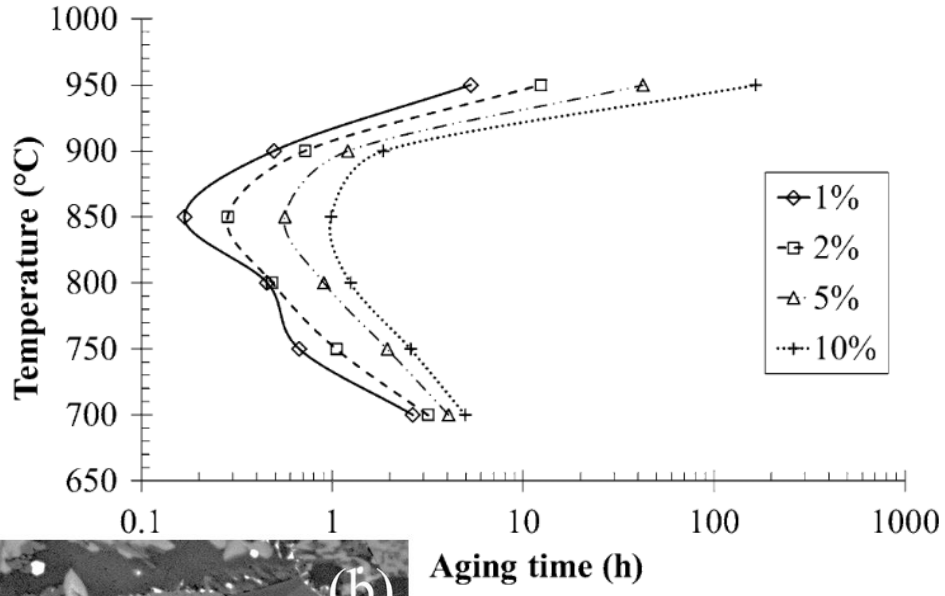
D. C. dos Santos, R. Magnabosco, C. Moura-Neto, Influence of sigma phase formation on pitting corrosion of an aged UNS S31803 duplex stainless steel. Corrosion, v. 69, p. 900-911, 2013.

Introduction

Undesirable formation of Cr- and Mo- rich phases between 650 – 950 °C

- **Sigma phase**
- Chi phase
- Cr_2N

D.C. dos Santos, R. Magnabosco. Kinetic Study to Predict Sigma Phase Formation in Duplex Stainless Steels. Metall. Mat. Trans. A (2016) 47: 1554. doi:10.1007/s11661-016-3323-z



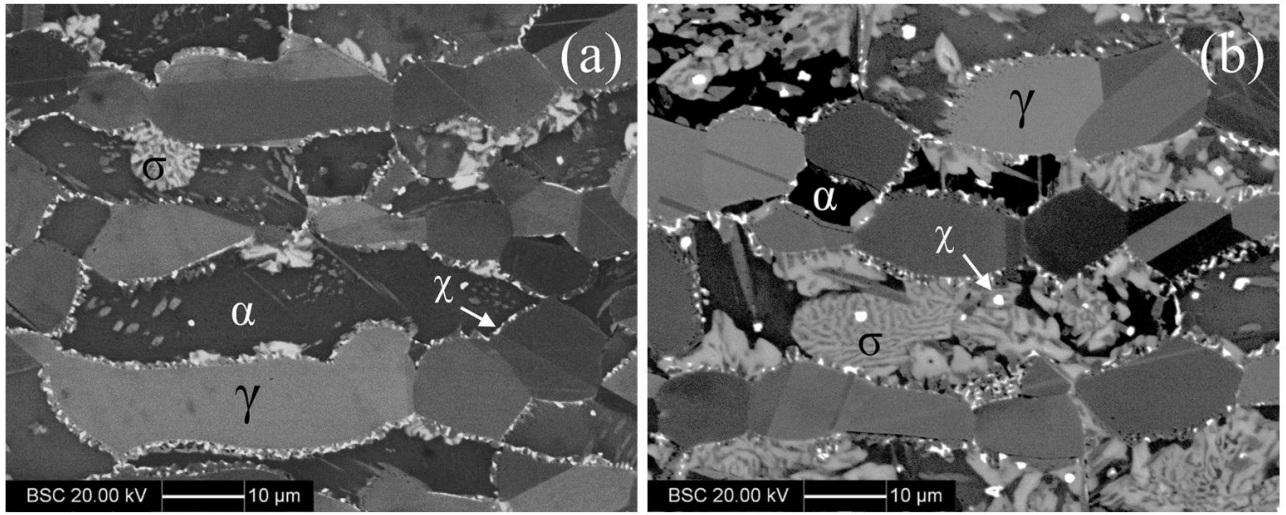
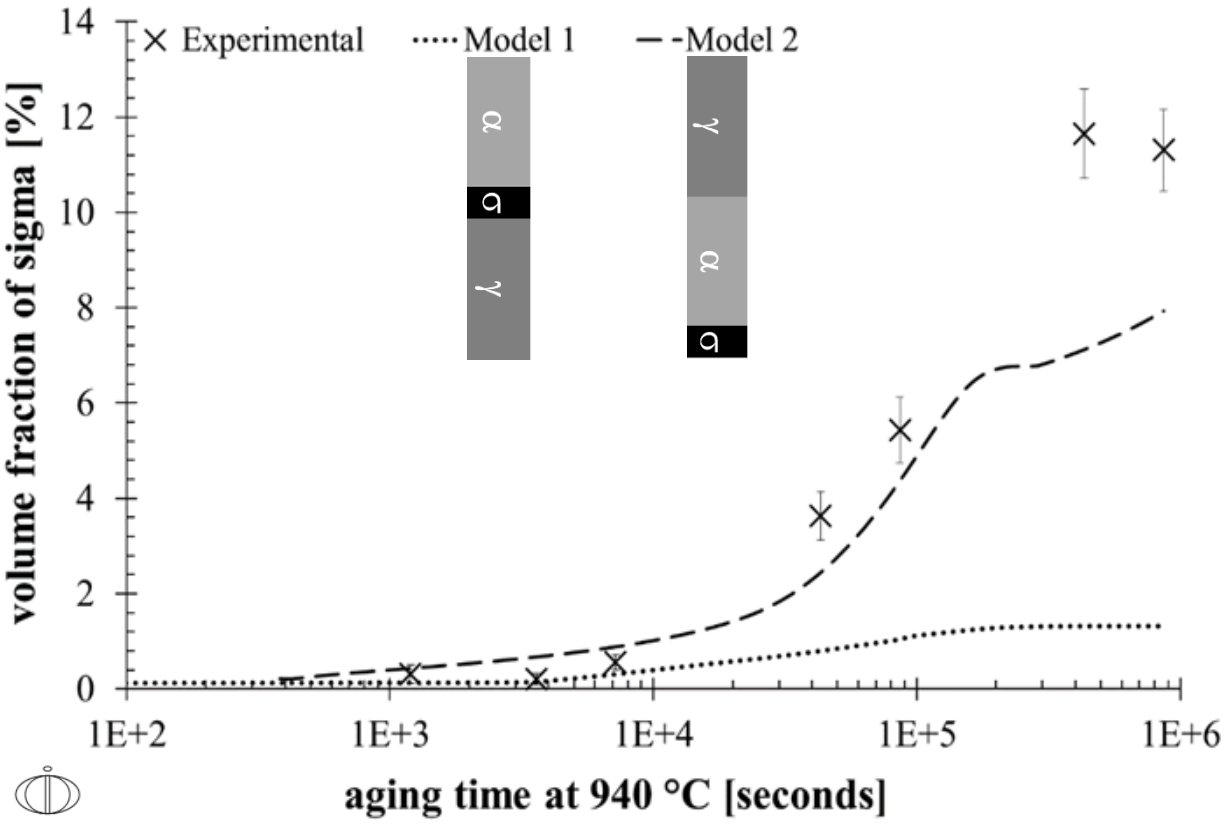


Fig. 13—Microstructural evolution of UNS S31803 duplex stainless steel aged at 973 K (700 °C) for: (*a*) 4 h (*b*) 12 h.

Introduction

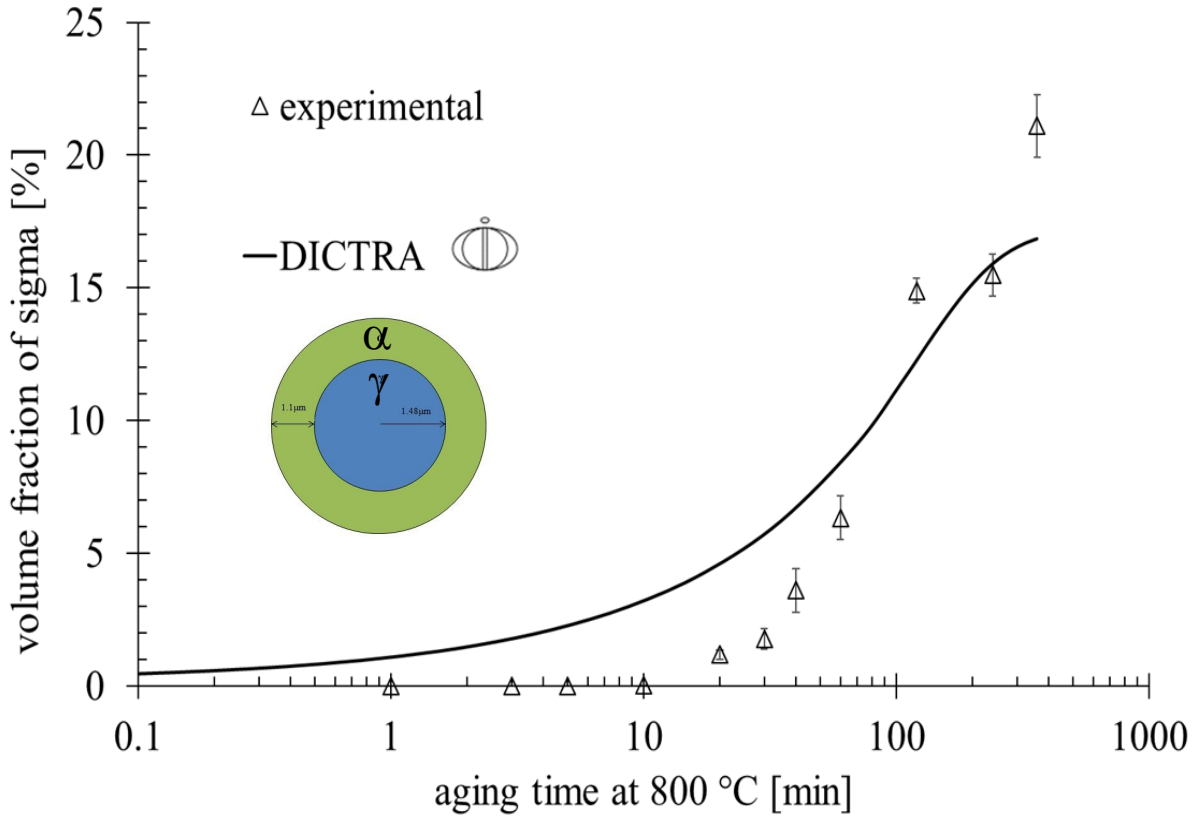
L. C. Morais, R. Magnabosco. Experimental investigations and DICTRA® simulation of sigma phase formation in a duplex stainless steel. CALPHAD, v. 58, p. 214-218, 2017.

Fe, Cr, Ni, Mo and N, TCFE8-MOB2



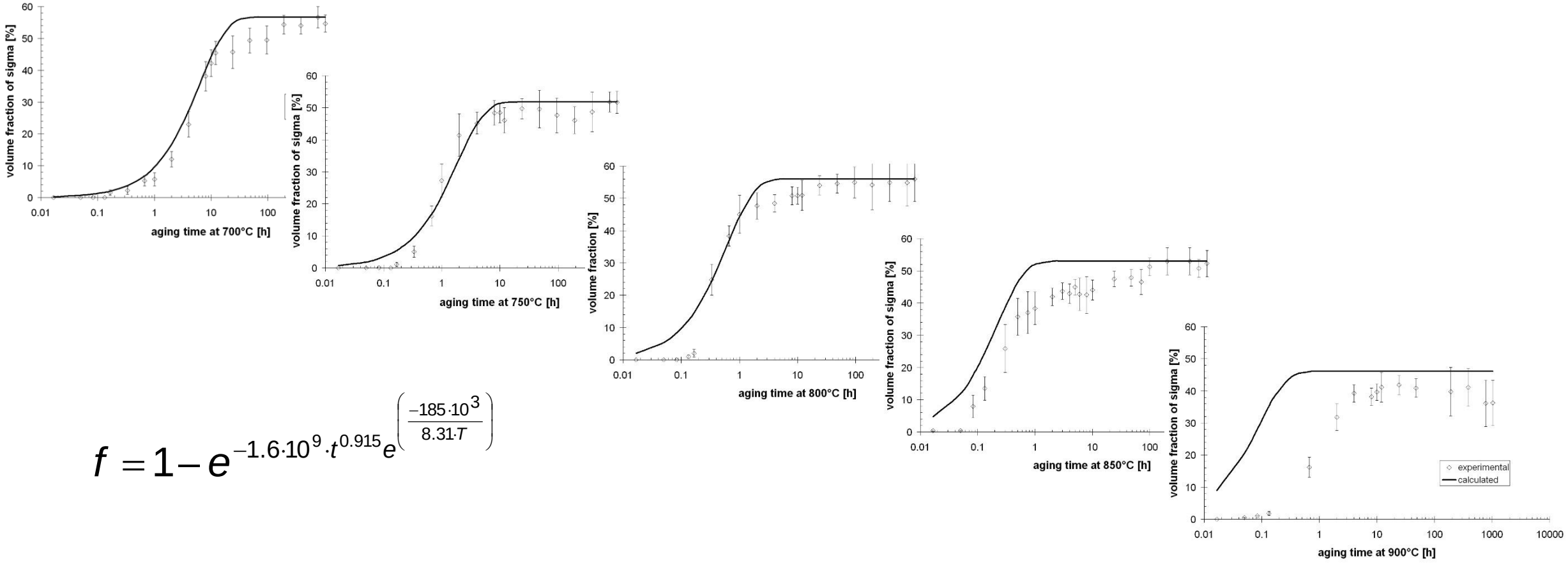
R. Magnabosco et al. Use of composition profiles near sigma phase for assessment of localized corrosion resistance in a duplex stainless steel. CALPHAD, v. 64, p. 126-130, 2019.

Fe, Cr, Ni, Mn ***without N***, TCFE8-MOBFE3



Objectives

This paper evaluated the possibility of assess the volume fraction of sigma phase formed during isothermal aging through DICTRA® simulations, comparing them to experimental data previously published.

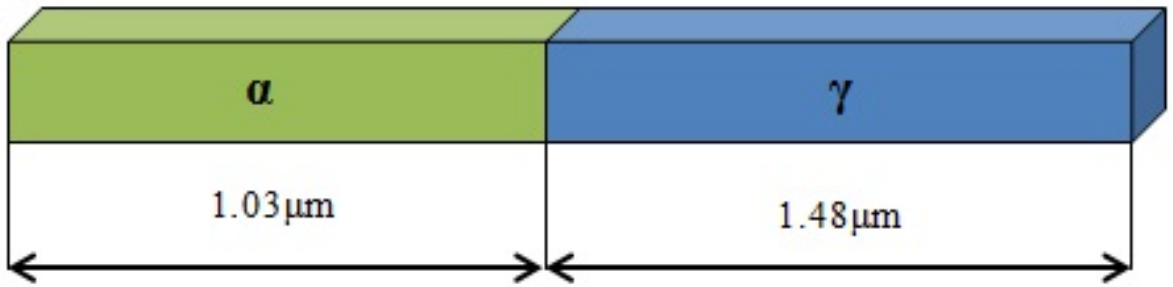


$$f = 1 - e^{-1.6\cdot 10^{9}\cdot t^{0.915} e^{\left(\frac{-185\cdot 10^{3}}{8.31\cdot T}\right)}}$$

R. Magnabosco. Kinetics of sigma phase formation in a Duplex Stainless Steel. Materials Research, v. 12, p. 321-327, 2009.

Computational modelling

Fe-22.2%Cr-5.7%Ni-2.98%Mo-0.16%N



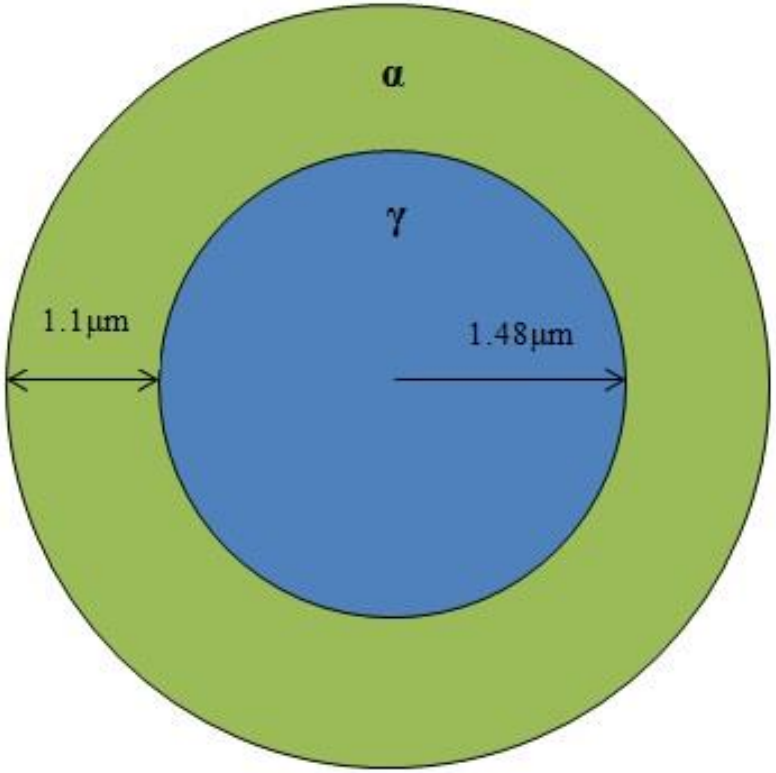
TCFE8

$f_\alpha = 0.409$

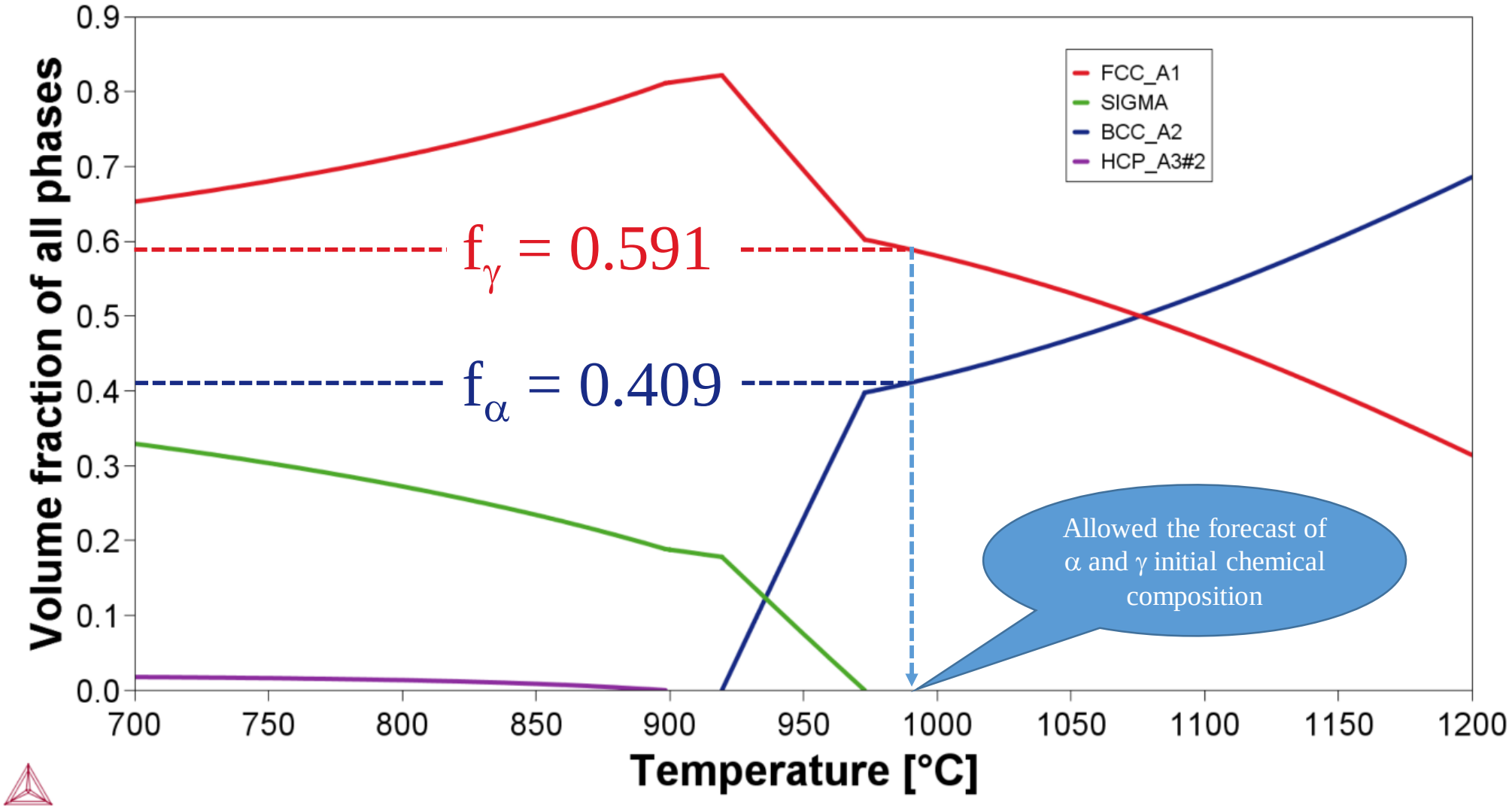
$f_\gamma = 0.591$

MOBFE3

Fe-22.2%Cr-5.7%Ni-2.98%Mo
without N



Results and Discussion



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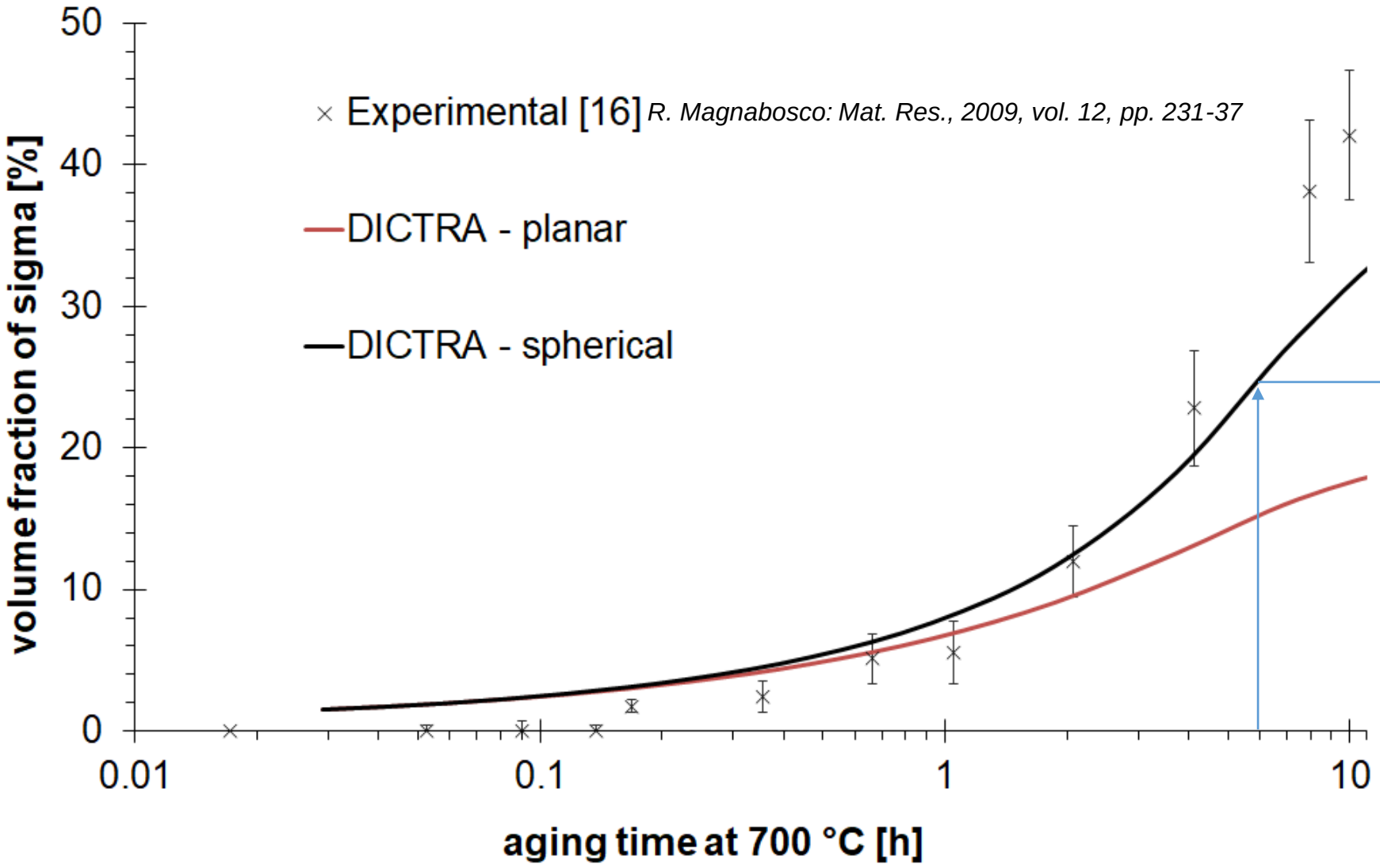

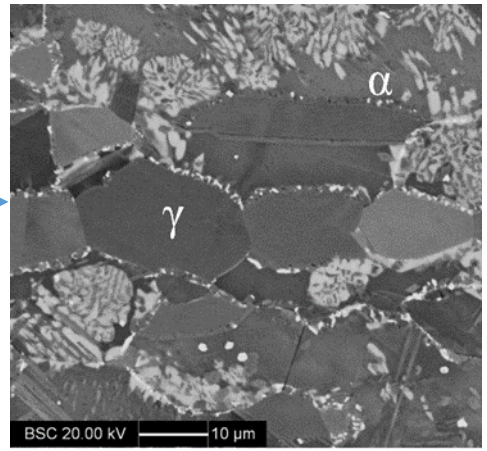

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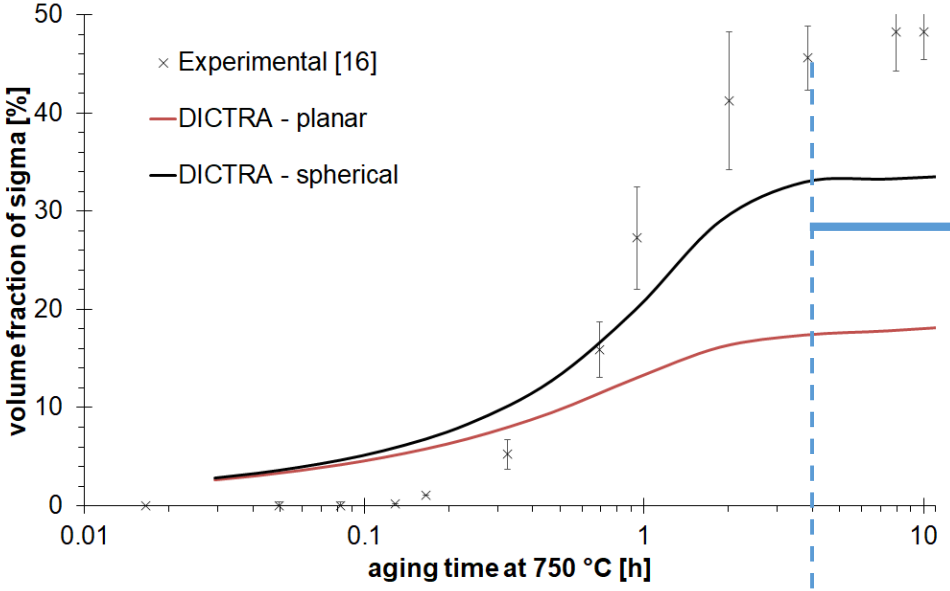

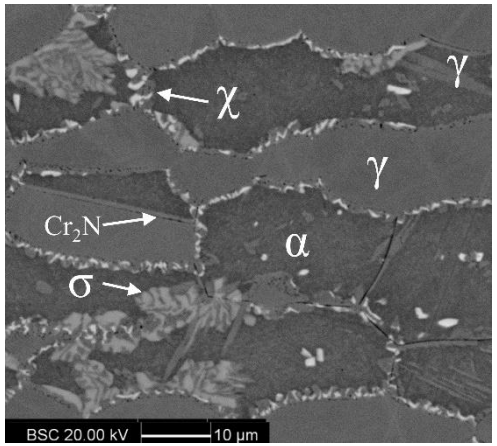

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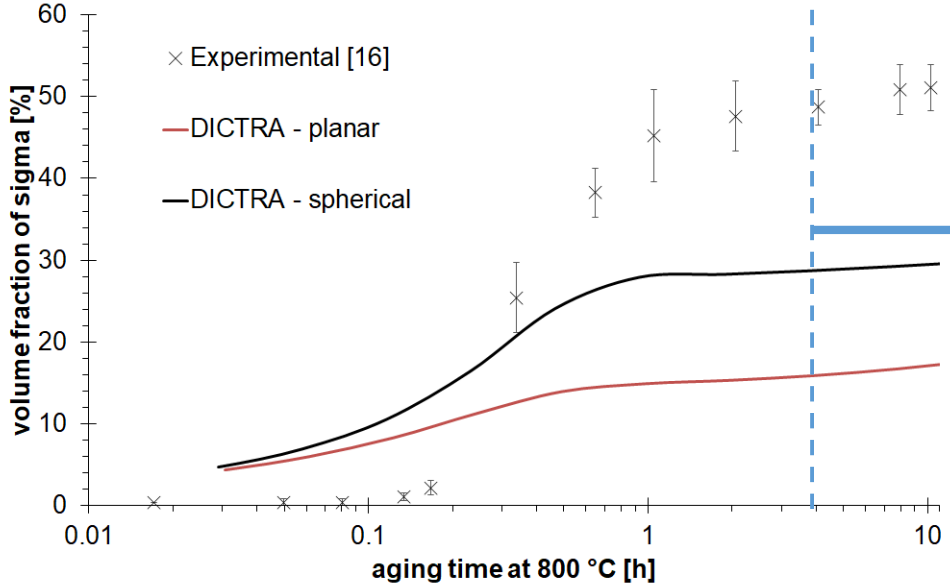
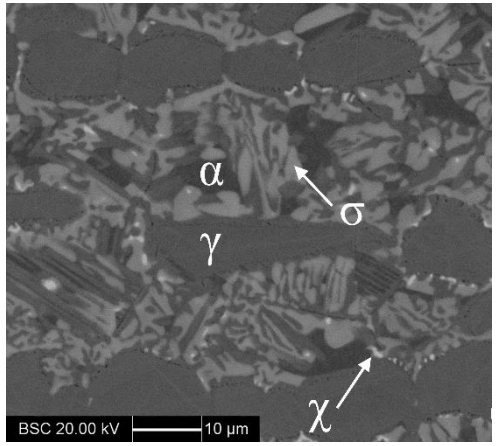
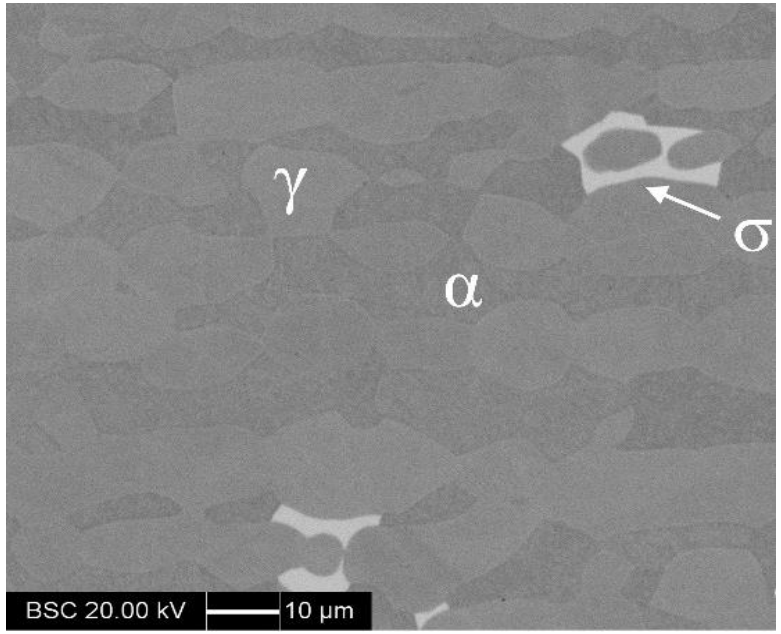




[16] R. Magnabosco: Mat. Res., 2009, vol. 12, pp. 231-37

Results and Discussion



4 h @ 900 °C

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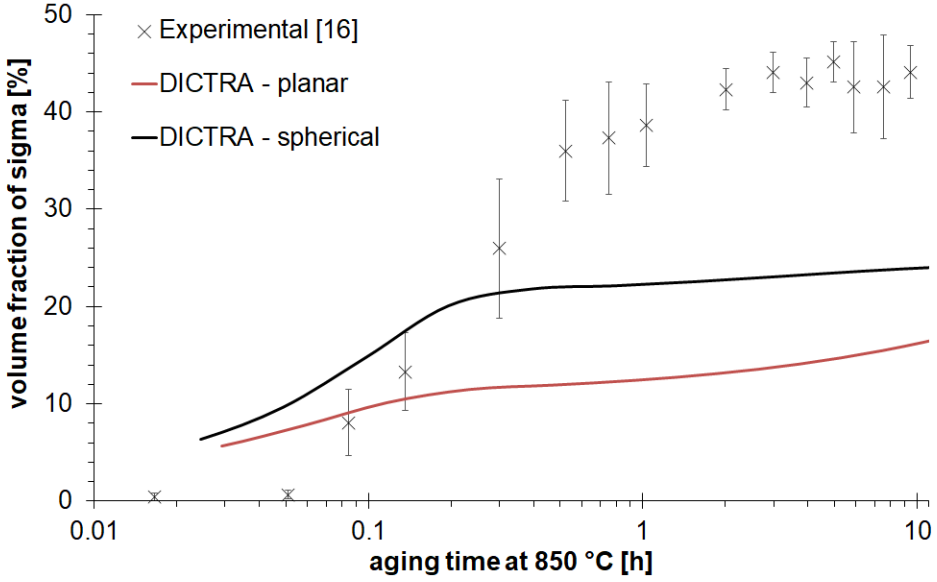

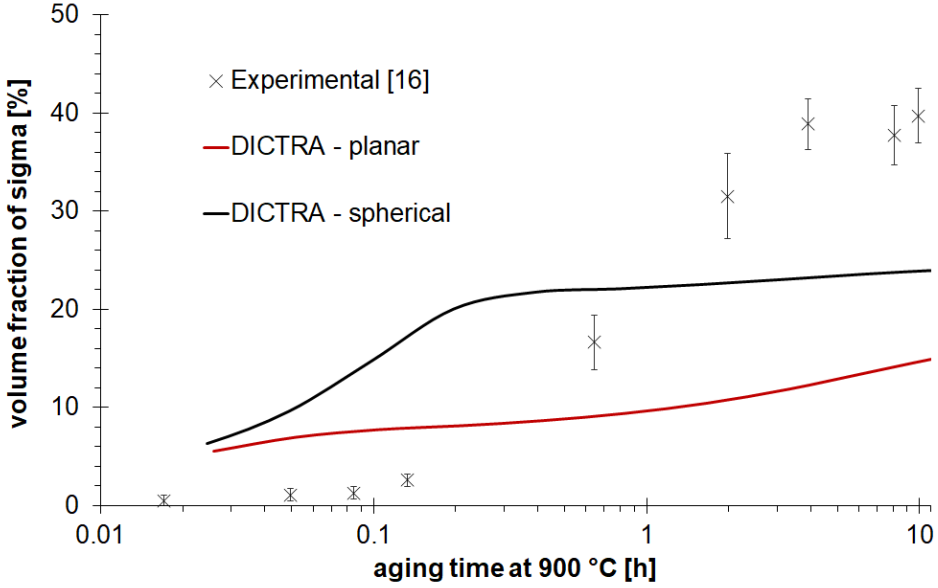

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Conclusions

- Better simulation model: spherical configuration with austenite in the centre, surrounded by ferrite, placing sigma as active phase between the two former phases with negligible thickness.

- Different aging temperatures lead to changes in sigma formation mechanisms, and the higher the tested temperature, the worst is the assessment of sigma volume fraction by DICTRA®.

Acknowledgements

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