DTU Library

Analysis of Key Factors Controlling Sintering of Dense and Porous CGO Bi-layers

Tadesse Molla, Tesfaye; Frandsen, Henrik Lund; Esposito, Vincenzo; Bjørk, Rasmus; Foghmoes, Søren Preben Vagn; Olevsky, Eugene; Pryds, Nini

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

Analysis of Key Factors Controlling Sintering of Dense and Porous CGO Bi-layers

Tesfaye Molla, Henrik Frandsen*, Vincenzo Esposito*, Rasmus Bjørk*, Søren Foghmoes* ,Eugene Olevsky**, Nini Pryds**

**Technical University of Denmark, Risø National Laboratory for Sustainable Energy, Frederiksborgvej 399,P.O.Box 49,Building 779,4000 Roskilde,Denamrk*

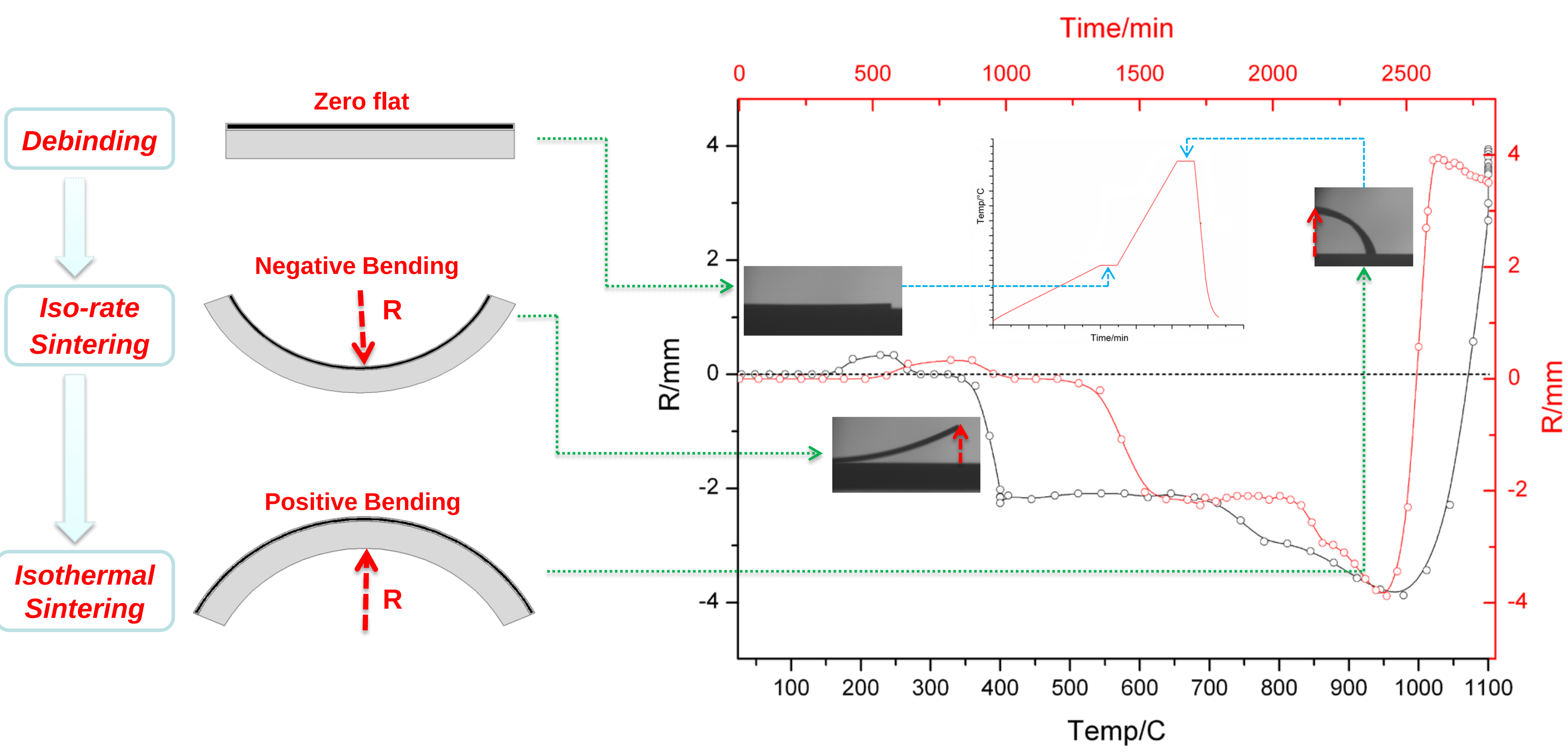
***San Diego State University, Department of Mechanical Engineering,5500 Campanile Dr.,San Diego,CA 92182-1323,USA*

Contact : ttmo@risoe.dtu.dk

Risø DTU
National Laboratory for Sustainable Energy

Problem and Objective

- ***Difference in shrinkage rate often lead to shape distortion, warping or crack formation.***
- ***Need for optimizing processing parameters to avoid such defects.***



The aim is therefore to develop methods for predicting distortion and understand the shape stability during sintering of layered composites through modeling and experiments .
Model (Isothermal regime) -The kinetics of shrinkage and shape distortion
- Evolutions of porosity and thickness reduction in each layer

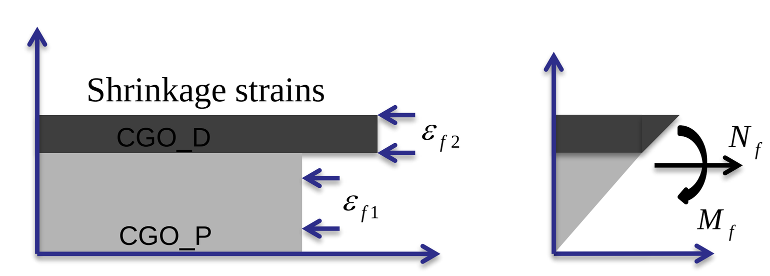
Model Features

Stress Developments

- **Continuum theory of sintering :** *SOVS*

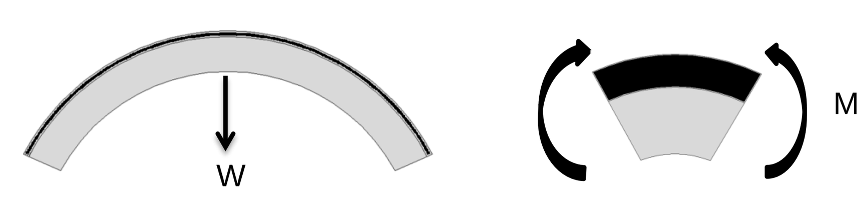
$$\sigma_{ij} = 2\eta_0 \left[\varphi \dot{\varepsilon}_{ij} + \left(\psi - \frac{1}{3}\varphi \right) \dot{e} \delta_{ij} \right] + P_L \delta_{ij}$$

1. ***Differential shrinkage rate -*** *biaxial stress*



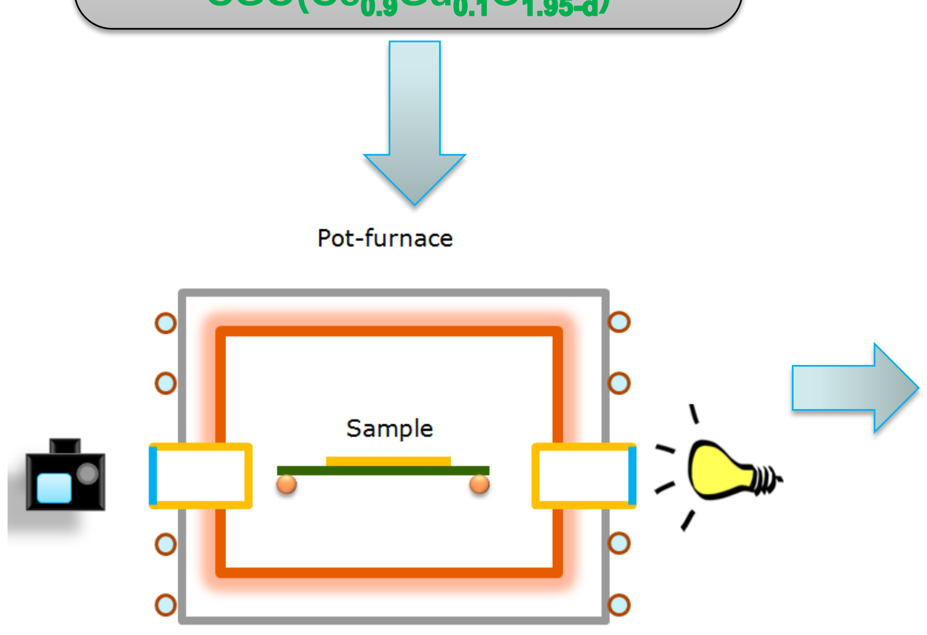
- *Viscous analogy of classical laminate theories*

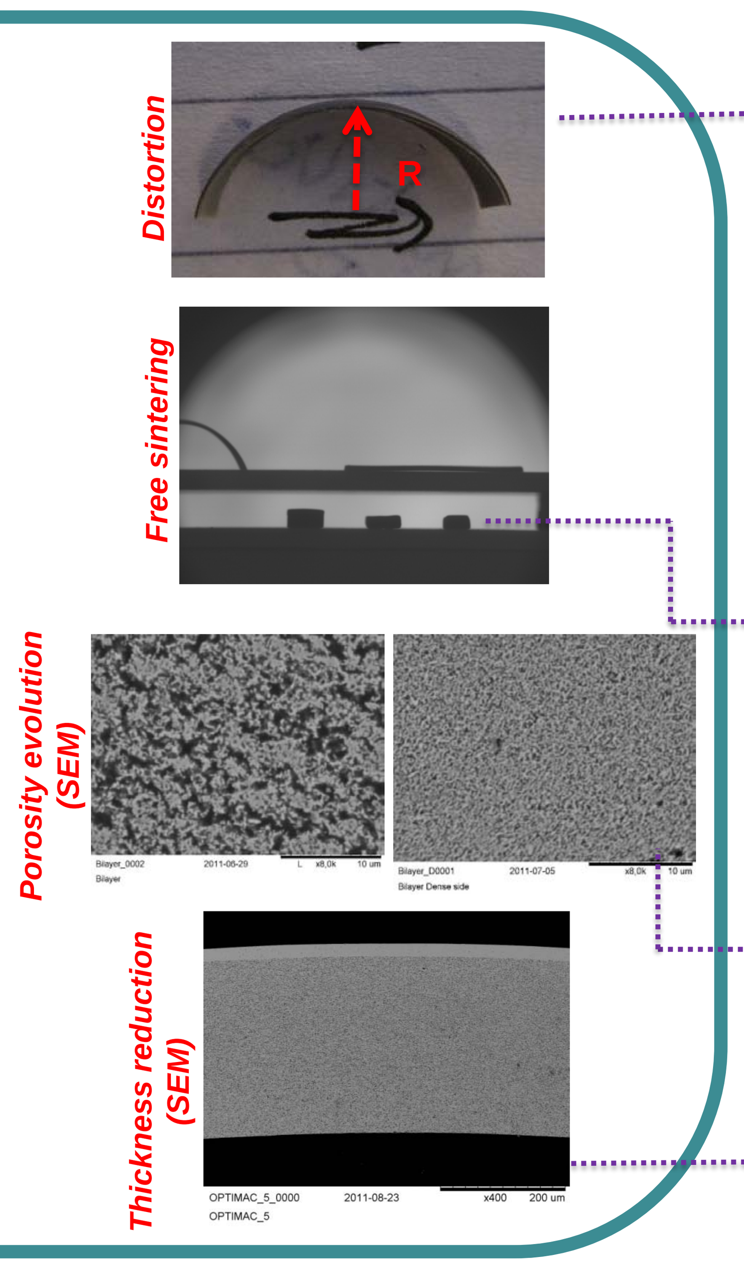
2. ***Creep due to own weight -*** *uniaxial stress*



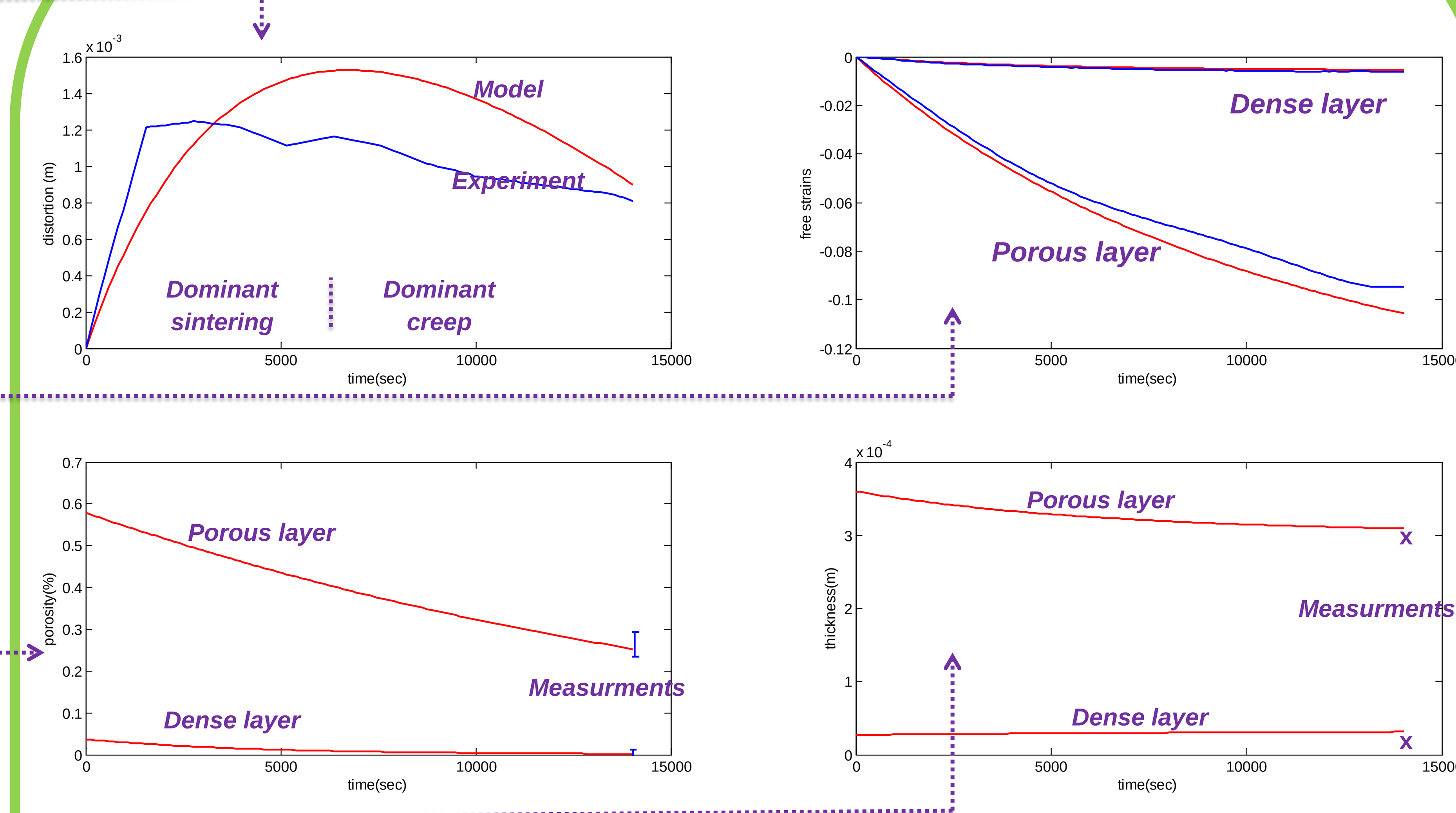
Experimental

Tape Casting + Lamination
Porous and dense layers of
CGO($Ce_{0.9}Gd_{0.1}O_{1.95-\delta}$)





Results



- **Initially rapid increment of distortion due to sintering followed by drop in curvature because of creep**
- **Rapid shrinkage in the porous layer**
- **Good agreements of model prediction and experiment in terms of porosity evolution and thickness reductions**

Conclusions

- **Shear viscosities and surface energies together with the average grain size of both layers are found to be the dominant factors controlling :**
  - **Distortion**
  - **Densification / porosity evolutions and Thickness reduction in each layer.**

Future work

- **Improvement of the model prediction capability**
- **Addition of biaxial state of stress for creep**
- **Finite element simulation of same problems**
- **More experiments**

Acknowledgment

- *The authors would like to thank the Danish Council for Independent Research Technology and Production Sciences (FTP) which is part of The Danish Agency for Science, Technology and Innovation (FI) (Project # 09-072888) for sponsoring the OPTIMAC research work."*