Structural Integrity and Reliability of Advanced Materials obtained through additive Manufacturing

SIRAMM

H2020-WIDESPREAD-2018

1st Winter School on
Trends on Additive Manufacturing for Engineering Applications
24-28 January 2021

Presentation of the research topics of the PhD programme

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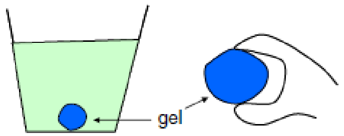
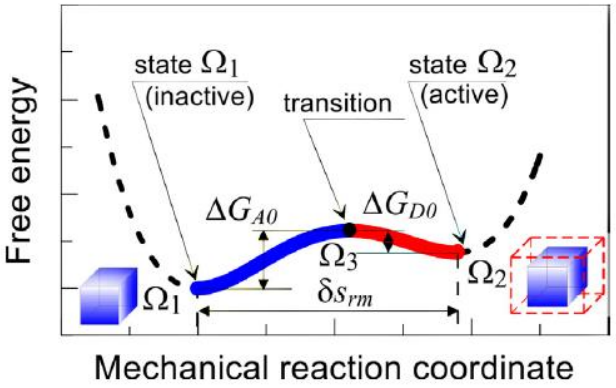
Research topics

1) Theoretical and numerical modelling of responsive polymers

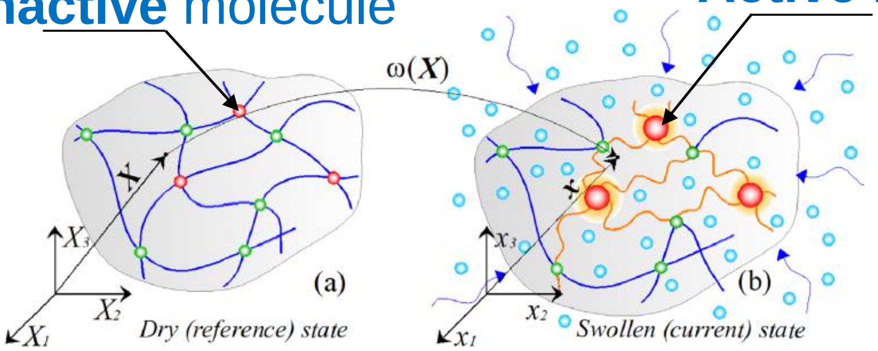
- Swelling mechanism in smart polymers responsive to **mechano-chemical** stimuli

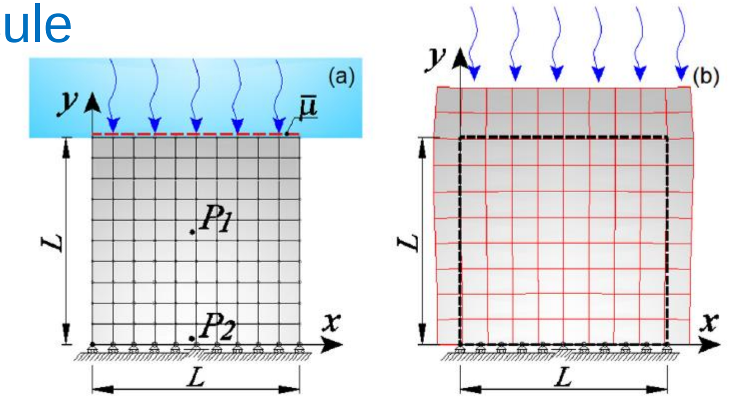




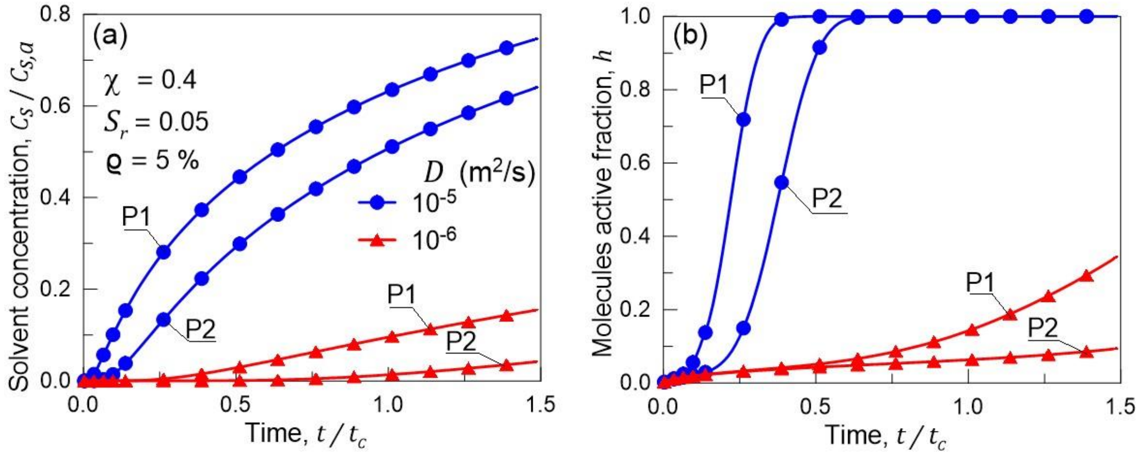
Inactive molecule

Active molecule

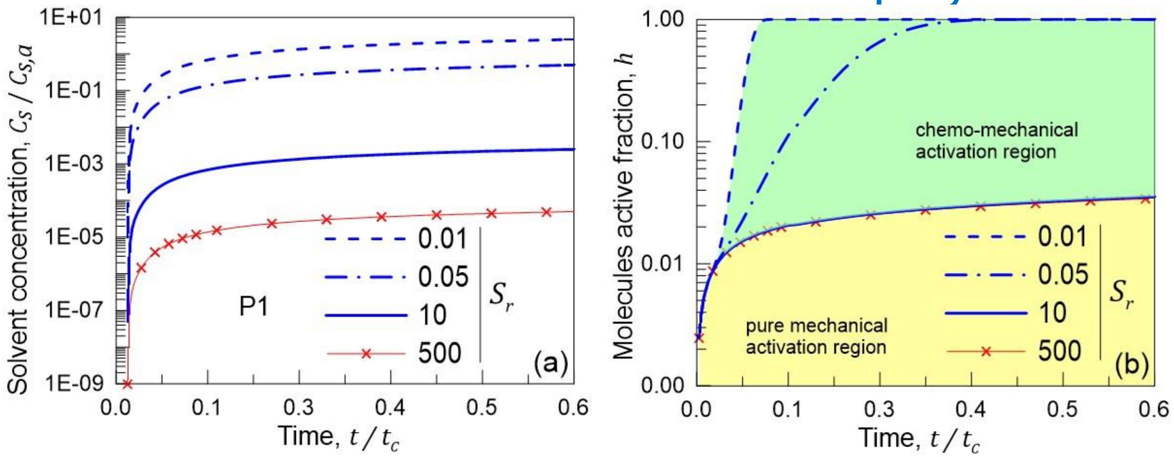




Effect of diffusion on the molecules activation



Chemo-mechanical interplay



Brighenti R. & Cosma M. P.,(2020). Swelling mechanism in smart polymers responsive to mechano-chemical stimuli. **Journal of the Mechanics and Physics of Solids.**

Research topics

1) Theoretical and numerical modelling of responsive polymers

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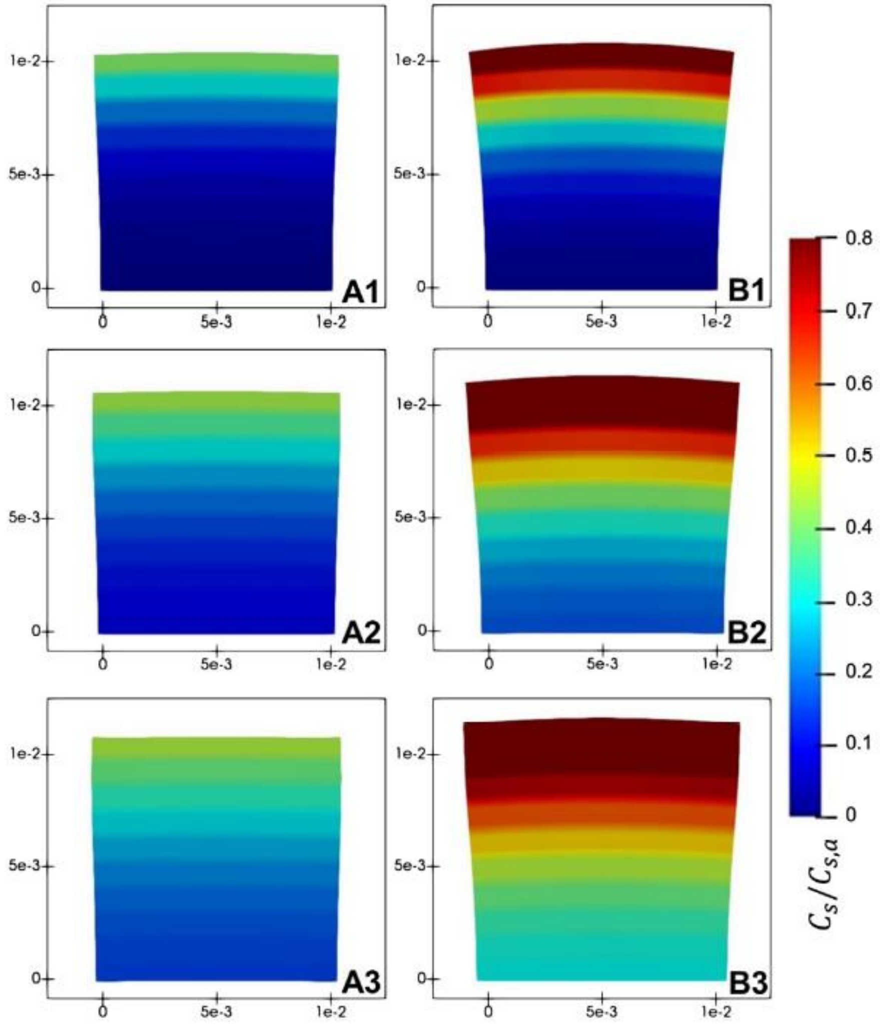
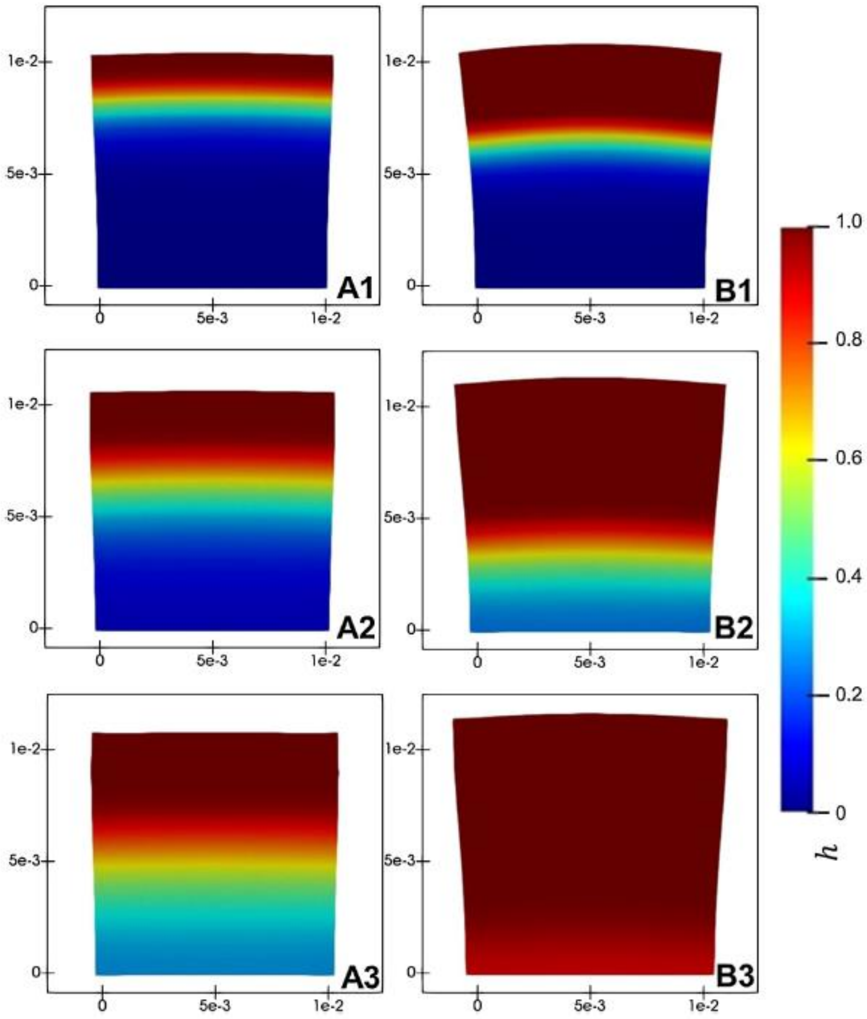


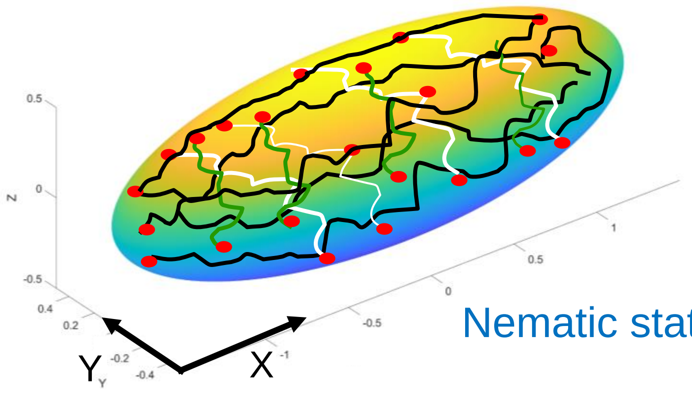


Brighenti R. & Cosma M. P.,(2020). Swelling mechanism in smart polymers responsive to mechano-chemical stimuli. **Journal of the Mechanics and Physics of Solids.**

Research topics

1) Theoretical and numerical modelling of responsive polymers

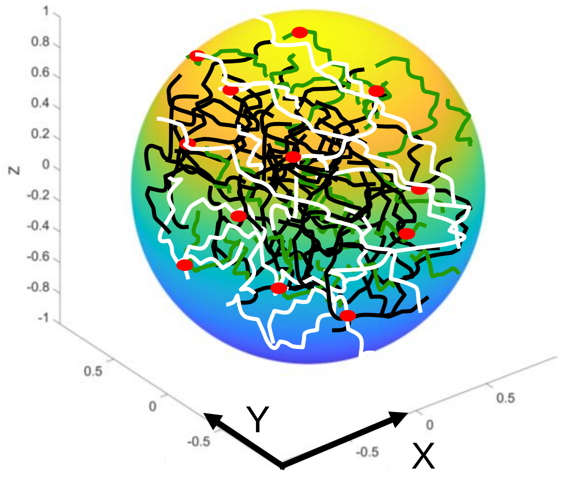
- Morphing of Liquid Crystal Elastomers (LCE)



Nematic state

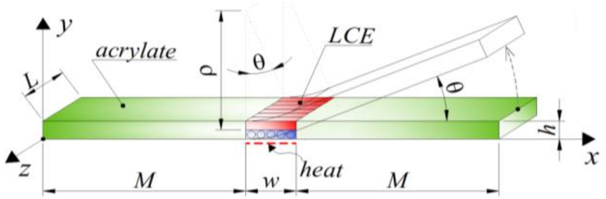
heat →

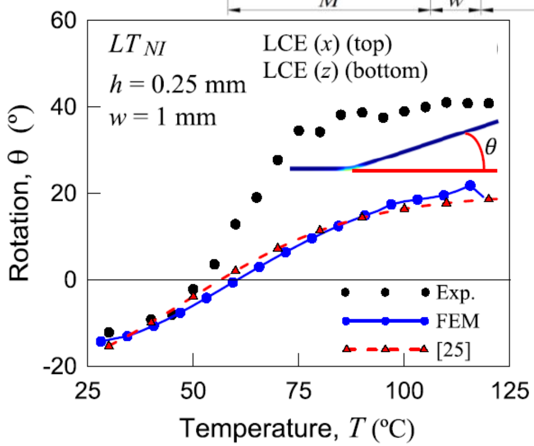
← cool



Isotropic state

Mesoscale effects



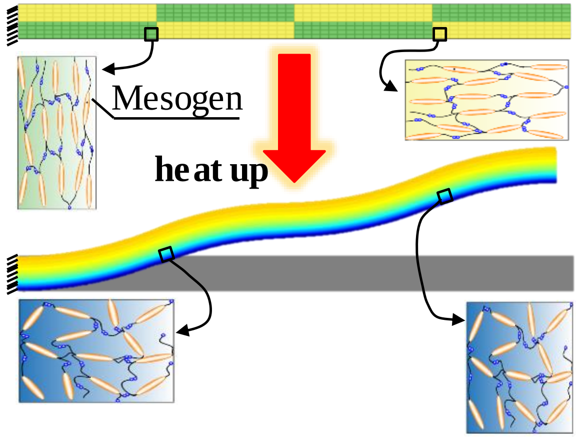


Collaboration:

- **Caltech (CA, USA)**
- **Harvard University (MA, USA)**

Brighenti, R., Connor, G., Cosma, M. P., et al.,(2020). A micromechanical-based model of stimulus responsive liquid crystal elastomers.
Submitted to **International Journal of Solid and Structures**

Strain detectable at the **macroscale** level



Cosma, M.P. & Brighenti, R., (2020). Morphing of architected liquid crystal elastomers.
Submitted to **Mechanics Research Communications**

Research topics

H2020-WIDESPREAD-2018, Project No. 857124

2) *Mechanical behaviour of polymers via 3D printing*

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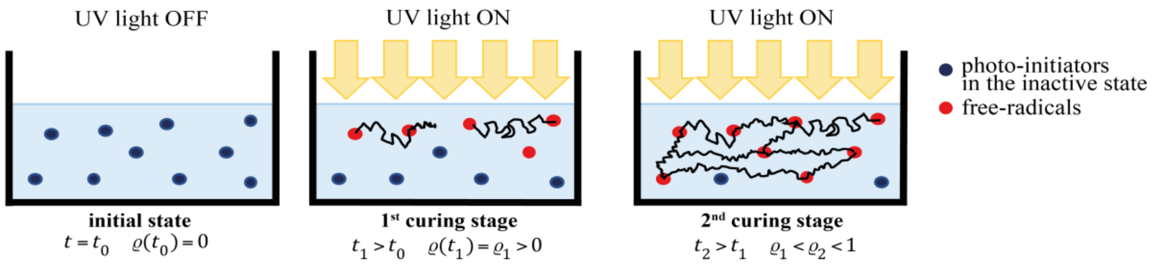
- Theoretical and numerical multiphysics model for Photopolimerization



(1) Photo-initiators decomposition: $Ph_I \xrightarrow{\beta} 2R^\bullet$

(2) Initiation of a polymer chain: $R^\bullet + M \xrightarrow{k_p} P^\bullet$

(3) Propagation of a polymer chain: $P^\bullet + M \xrightarrow{k_p} P^\bullet$

(4) Termination: $P^\bullet + P^\bullet \xrightarrow{k_t} P_{dead}$, $P^\bullet + R^\bullet \xrightarrow{k_t} P_{dead}$

1) Light propagation

$$\boldsymbol{l}(\boldsymbol{X},t)\cdot\nabla_X I(\boldsymbol{X},t) = -A(\boldsymbol{X},t)\, I(\boldsymbol{X},t) \quad \text{for } \boldsymbol{X}\in\Omega_0$$

$$I(\boldsymbol{X},t) = I_0(\boldsymbol{X},t) \quad \text{for } \boldsymbol{X}\in\partial\Omega_0$$

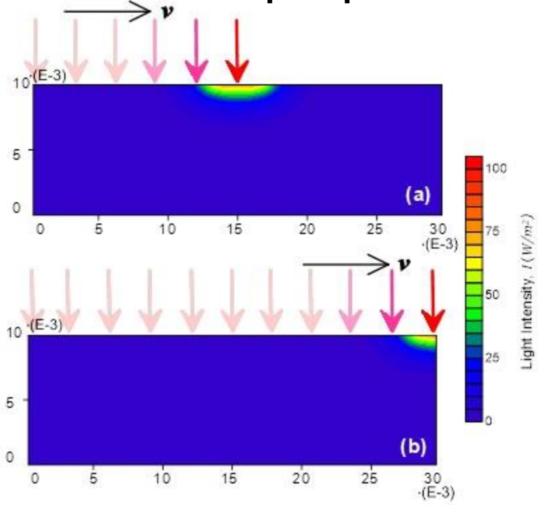
2) Kinetic of the chemical species evolution

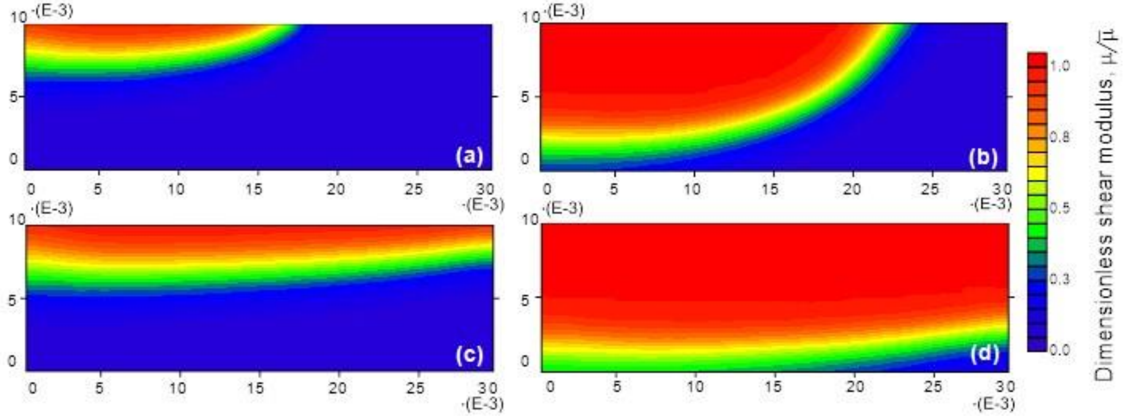
$$\varrho(\boldsymbol{X},t) = 1 - \frac{C_M(\boldsymbol{X},t)}{C_M(\boldsymbol{X},t=0)}$$

3) Mechanical properties

$$c_a(\boldsymbol{X},t) = \frac{\mu(\boldsymbol{X},t)}{k_B T} = \frac{\bar{\mu}}{k_B T}\cdot\exp[\alpha(\varrho(\boldsymbol{X},t)-1)]$$

✓ Mechanical properties evolution through the **simulation of the printing process**





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Thank you for your kind attention