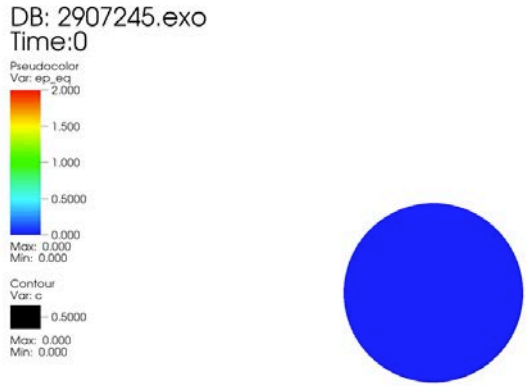
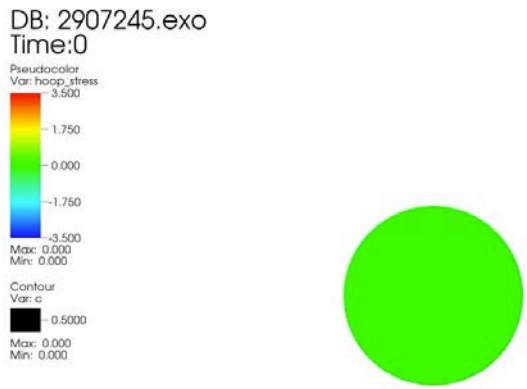
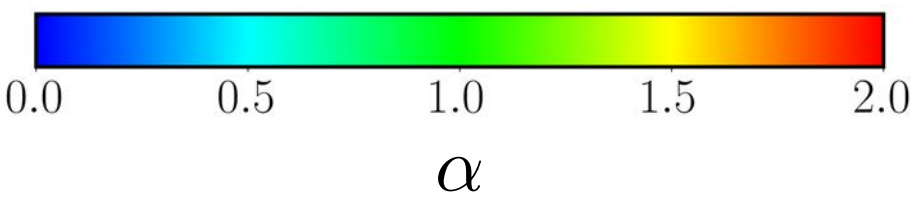
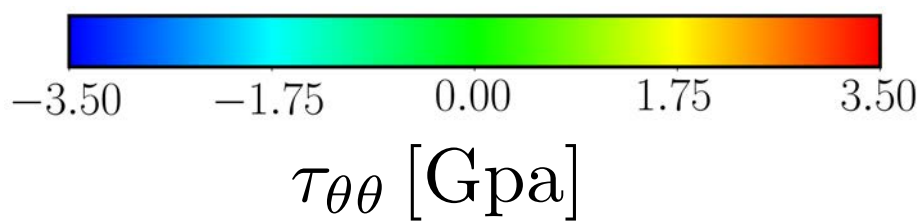
2D Simulation $\sigma_y = 3\,\mathrm{Gpa}$

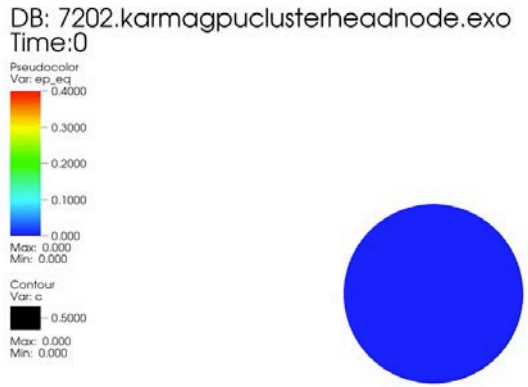


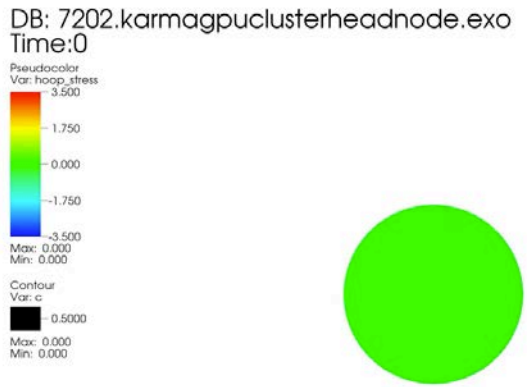


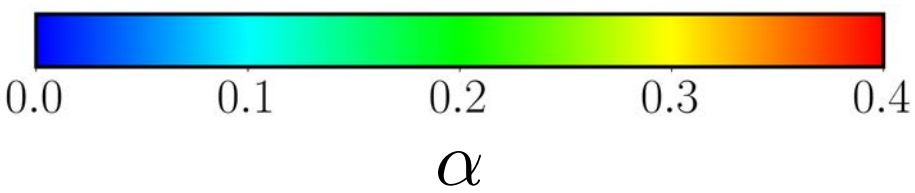


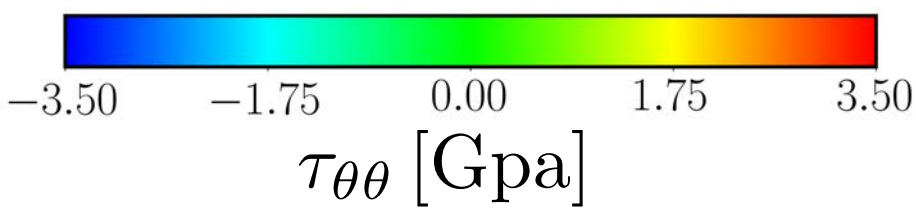


2D Simulation $\sigma_y = 5\,\mathrm{Gpa}$









Size Effect

Griffith $\frac{\tau_c^2}{E} a^n \sim G_c a^{n-1}$

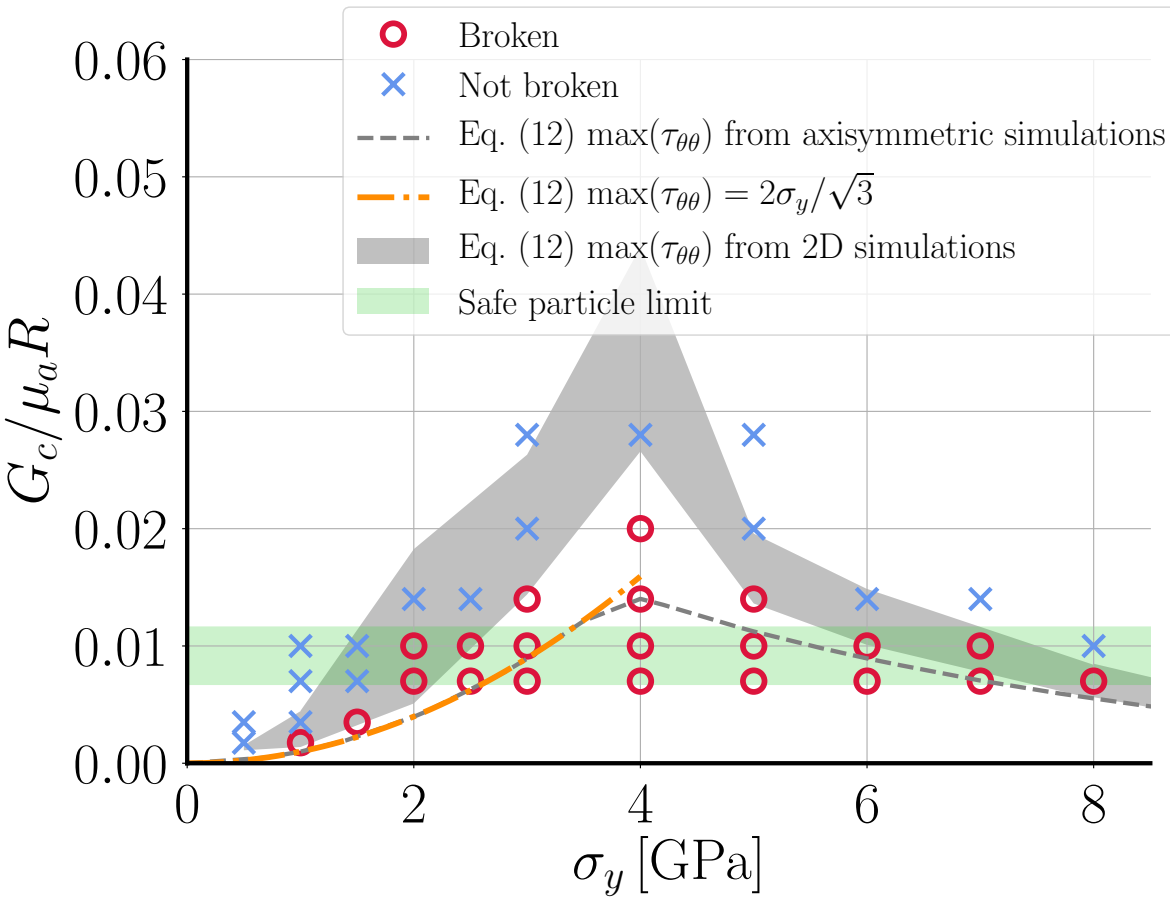
Pham & Marigo $\frac{\tau_c^2}{E} \sim \frac{G_c}{\xi}$

Assumption! $\xi \sim R$

$$\frac{G_c}{\mu_a R} = \mathcal{C}\bar{\xi}(1-\nu)\left(\frac{\max(\tau_{\theta\theta})}{\mu_a}\right)^2$$

Pham, K. & Marigo, J.-J. From the onset of damage to rupture: construction of responses with damage localization for a general class of gradient damage models. Continuum Mech. Therm. 1–25 (2013).

Putting it All Together

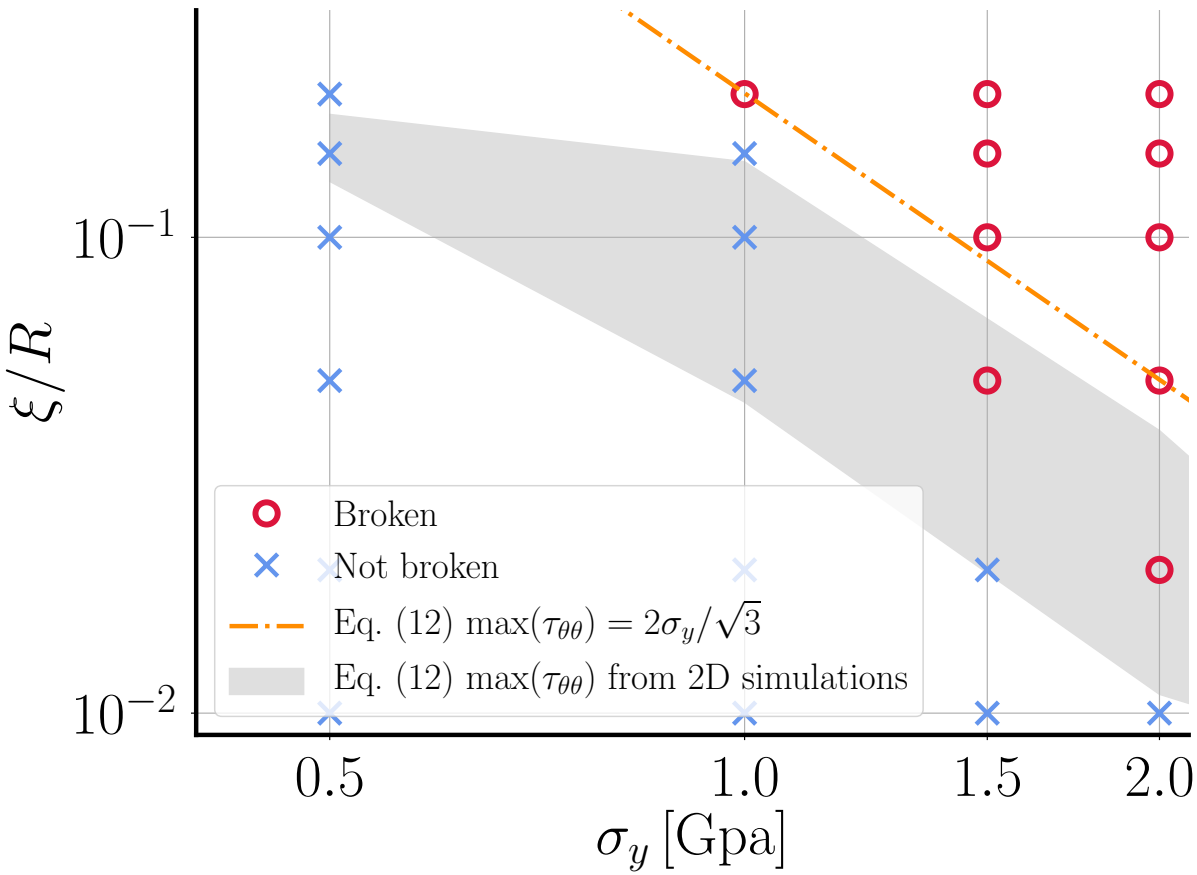


$$\frac{G_c}{\mu_a R} = \mathcal{C}\bar{\xi}(1-\nu)\left(\frac{\max(\tau_{\theta\theta})}{\mu_a}\right)^2$$

Zhao, K. et al. Concurrent reaction and plasticity during initial lithiation of crystalline silicon in lithium-ion batteries. J. Electrochem. Soc. 159, A238– A243 (2012).

Zhao, K., Pharr, M., Hartle, L., Vlassak, J. J. & Suo, Z. Fracture and debonding in lithium-ion batteries with electrodes of hollow core–shell nanos- tructures. J. Power Sources 218, 6–14 (2012).

Process Zone Size



$$\frac{G_c}{\mu_a R} = \mathcal{C}\bar{\xi}(1-\nu)\left(\frac{\max(\tau_{\theta\theta})}{\mu_a}\right)^2$$

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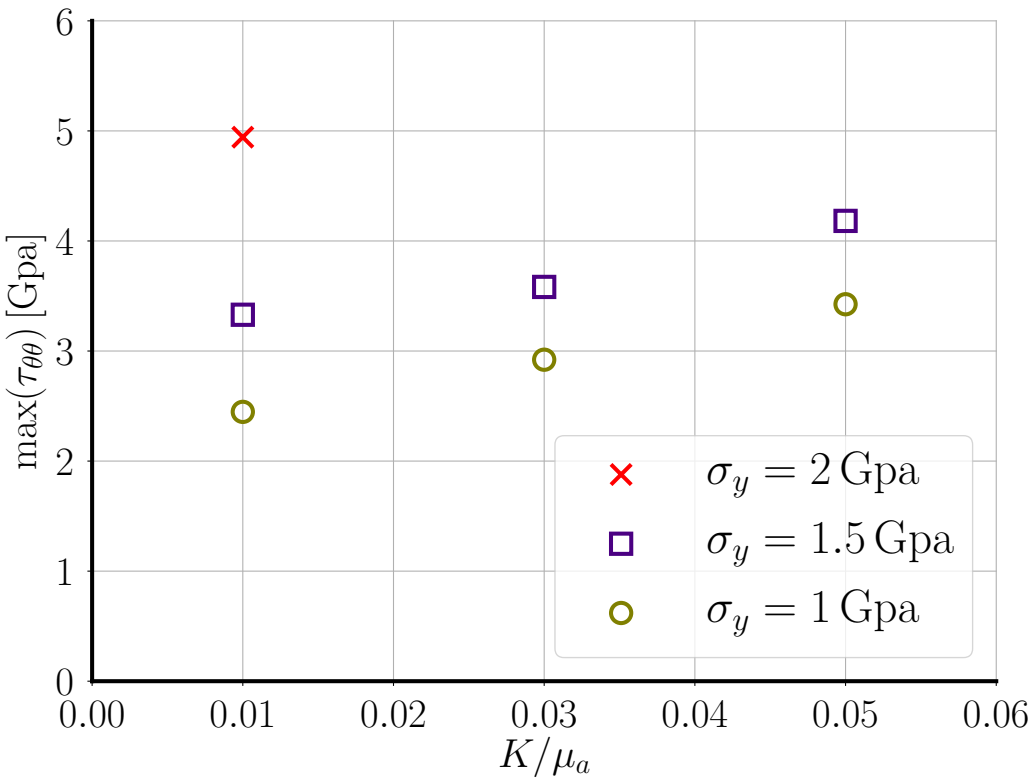
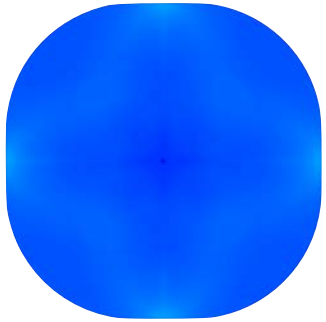
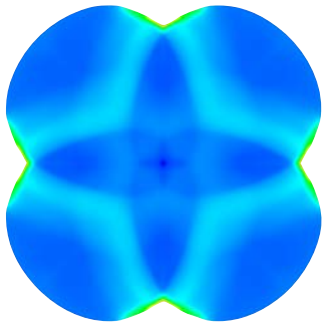
Hardening Effect



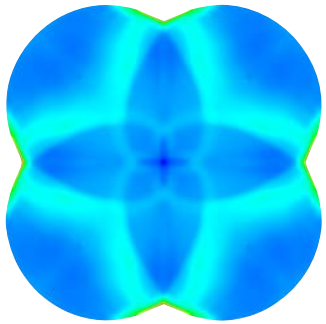
$K/\mu_a = 1$



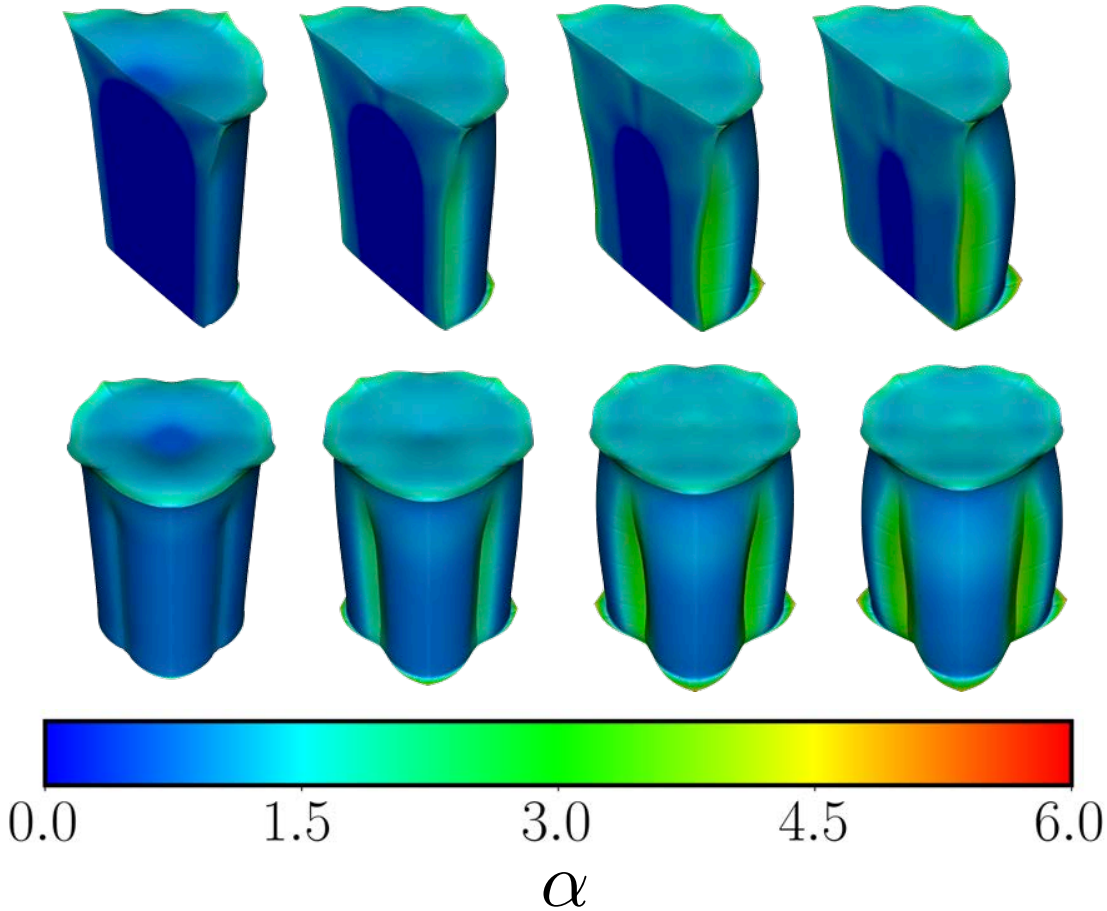
$K/\mu_a = 0.1$



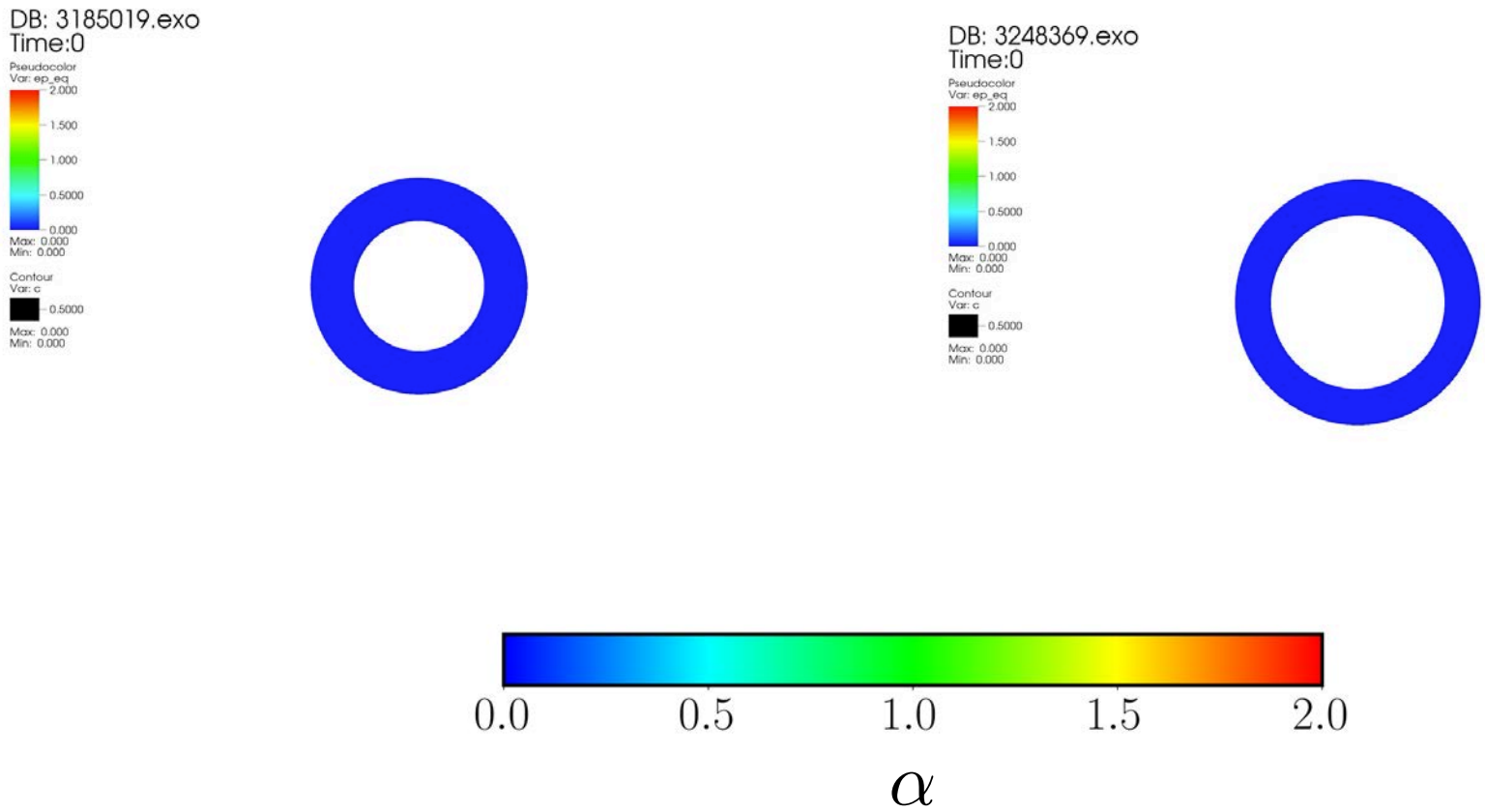
$K/\mu_a = 0.01$



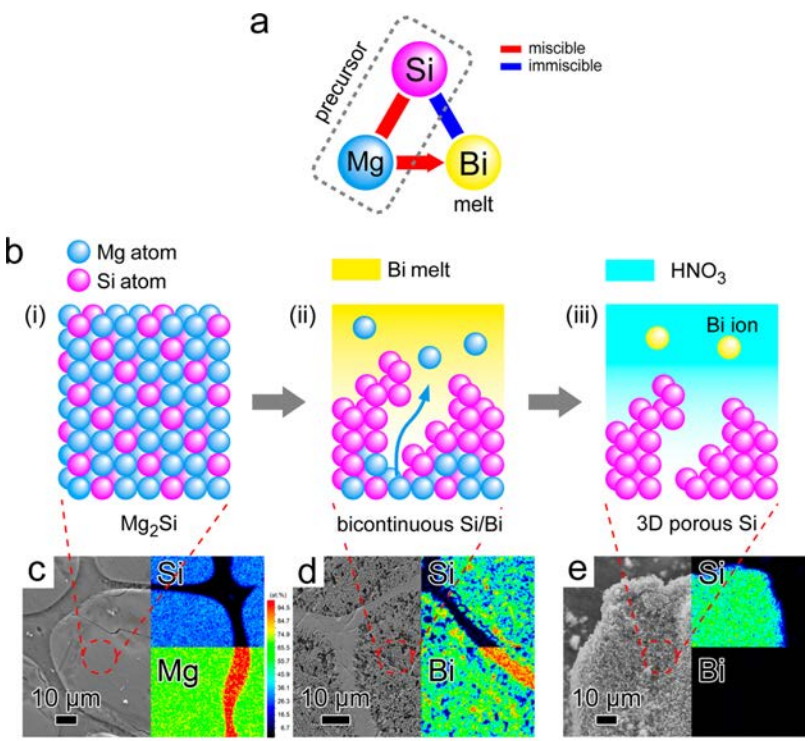
Going 3D

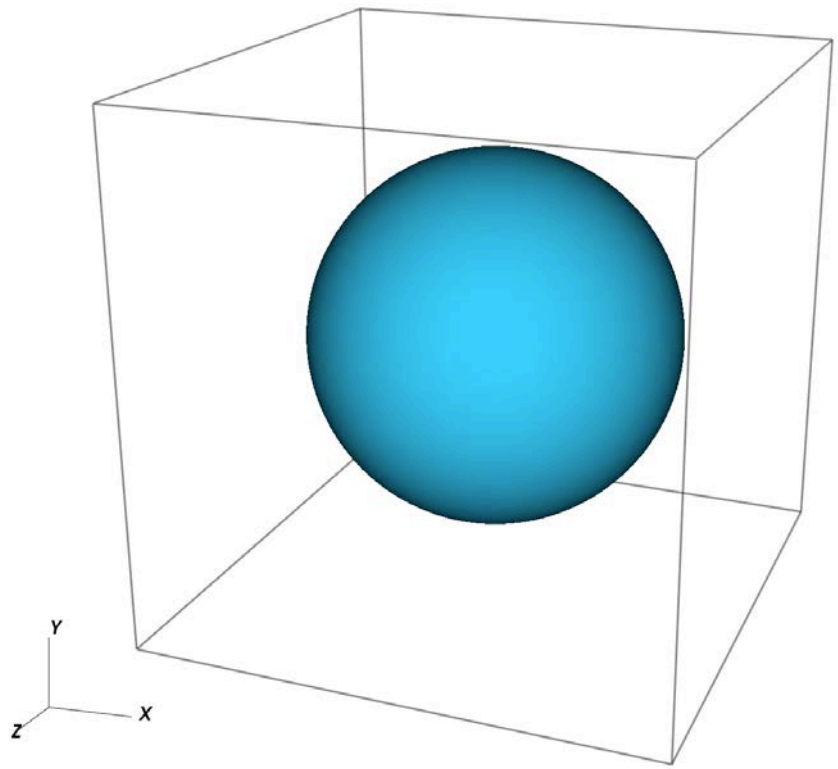


Hollow Cylinder



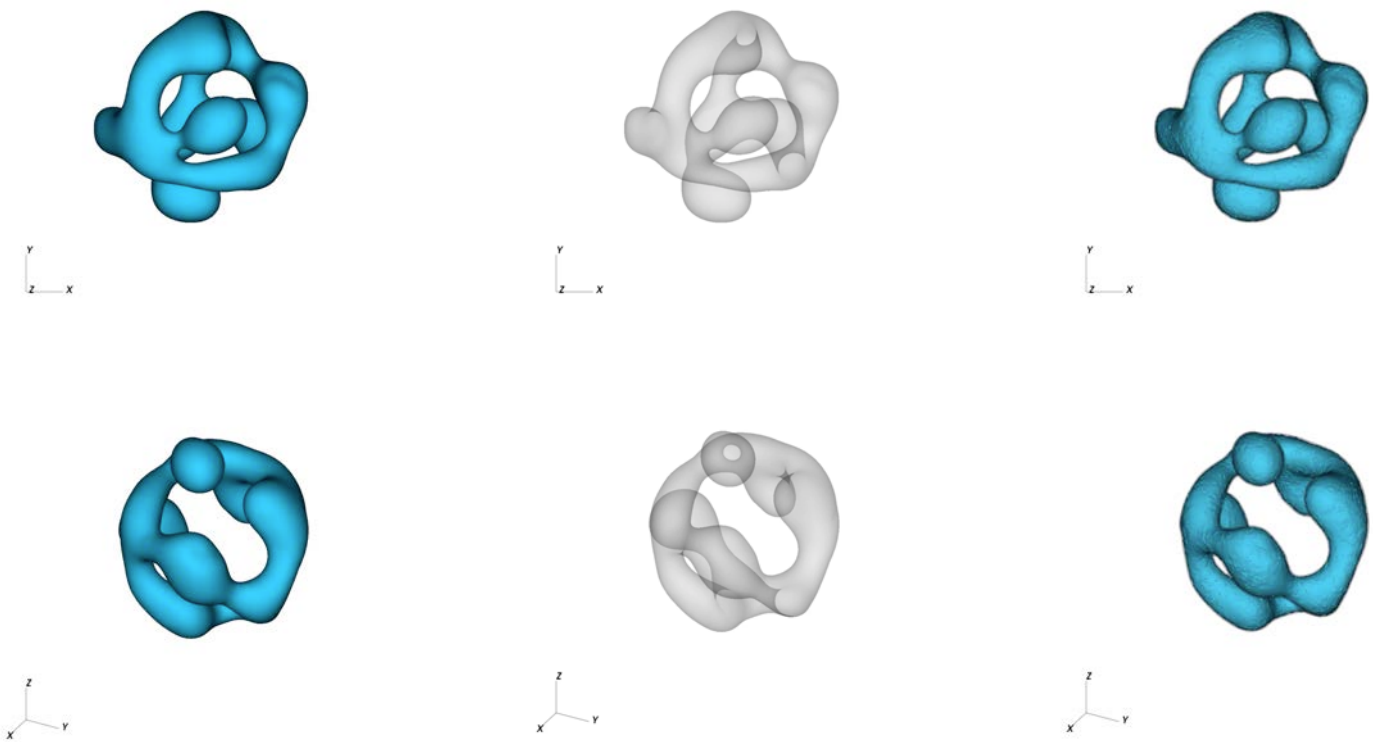
Dealloying of small particles





Li insertion in dealloyed geometry

$||u||$ α ψ



Thank you for your attention.

Open questions:

- Why does J_2 <u>work</u>?
- What does yield stress correspond to?
- What is the plasticity length scale?
- What are effects of plasticity (localization) on initiation?