Crack pattern in bacterial drop

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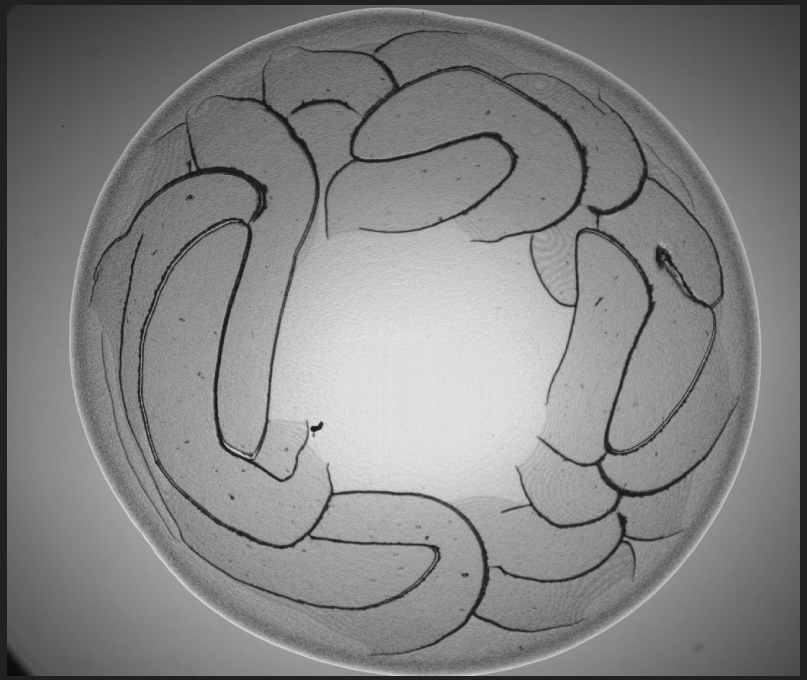
Big picture

- Practical
  - Biofilm formation
- Fundamental
  - Mechanical instability
  - Role of activity
  - Pattern formation

Striking results

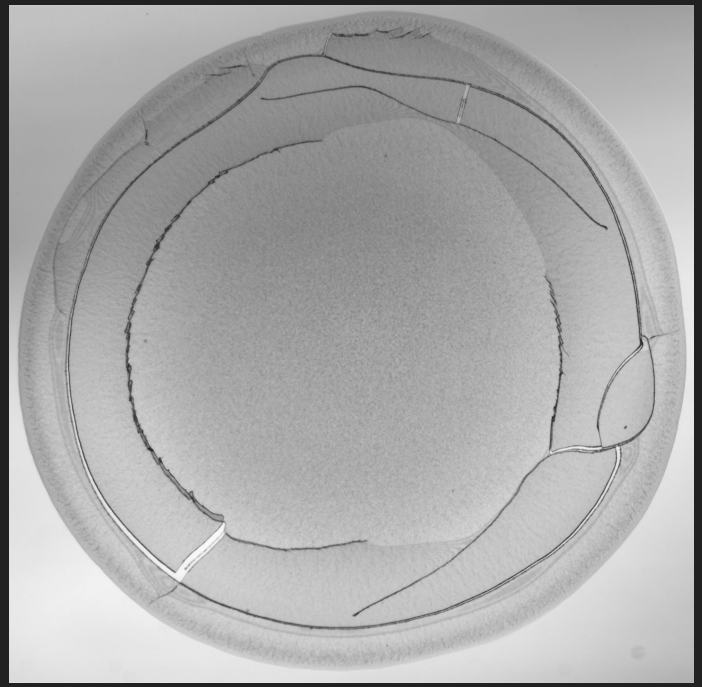


PR in water, 95n0, Glass substrate

RP in water, 116n0, Glass substrate

PR: light controlled E. coli; RP: tumbler E. coli

Striking results

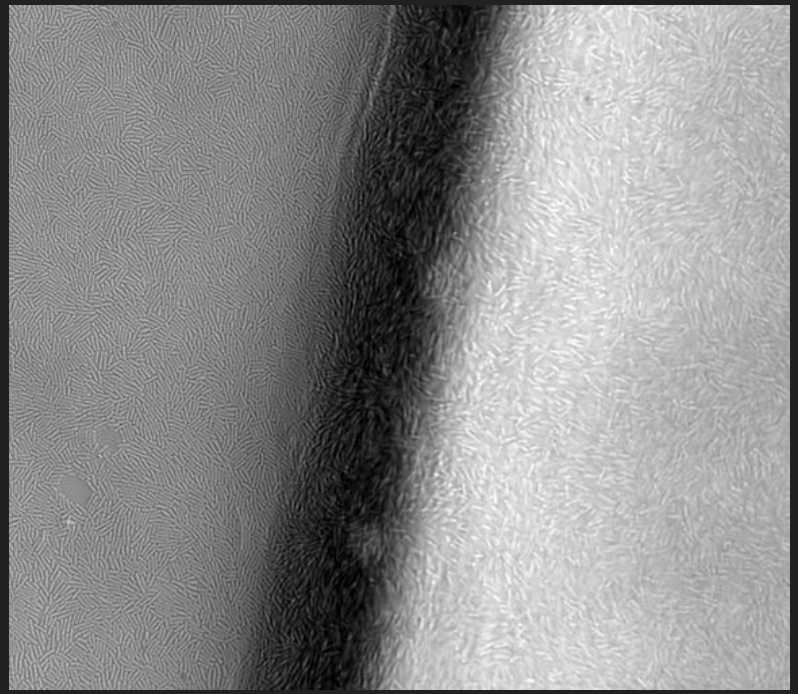


PR in TW5*, 95n0, Glass substrate

xxx

TW5: tween 20, 5e-6 v/v

Striking results



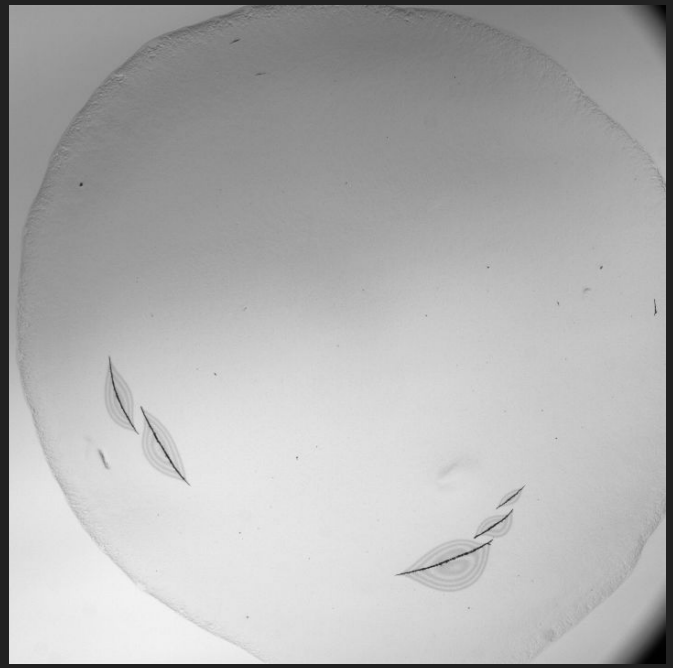
PR in TW5*, uk n0, thin film
2D micro-structure

xxx

TW5: tween 20, 5e-6 v/v

Tasks

1. Control experiment using dead bacteria and passive ellipsoids



Dead* in water, 135 n0, 4 ul, glass

Drop of dead bacteria suspensions show much less cracks compared to those of swimmers and tumblers.

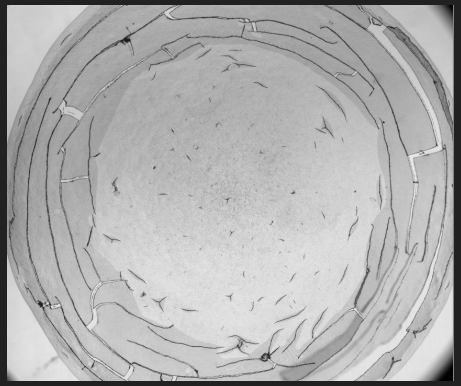
We don’t understand whyyy dead bacteria show different crack patterns from tumblers. Potential explanations: aggregation, ...

Tests:
1. passive ellipsoids
2. dead and tumbler

*Dead: 100 C for 10 min

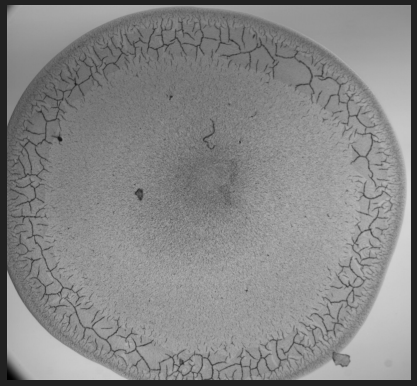
Tasks

2. Inconsistent patterns (of RP suspensions) at similar conditions



RP in water, 119n0, 4 ul, glass

RP in water, 116n0, 2.5 ul, glass



RP in water, 128n0, 2.5 ul, glass

We have seen 3 types of crack patterns. Which is right?

Tests:
1. repeat many times, until we make sure the results are reproducible.
2. concentration gradient.

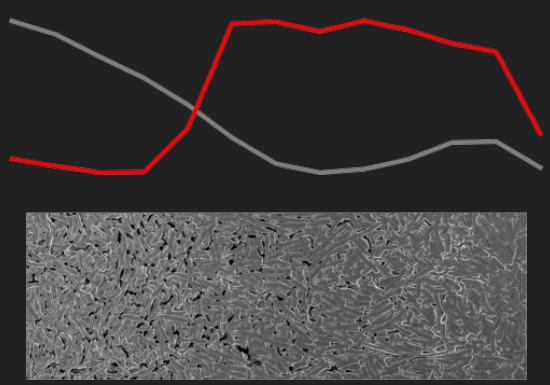
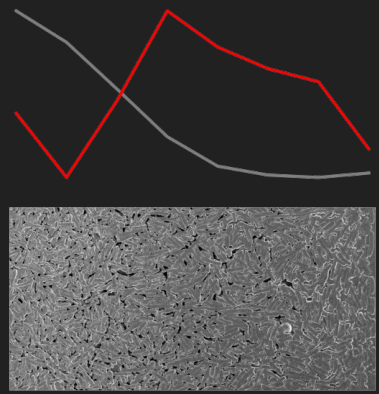
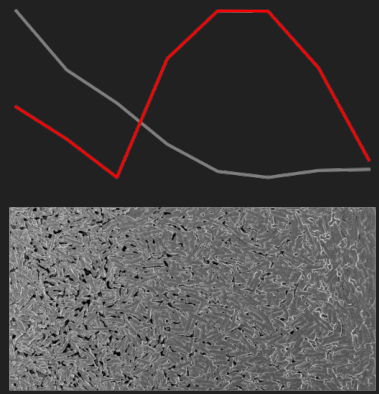
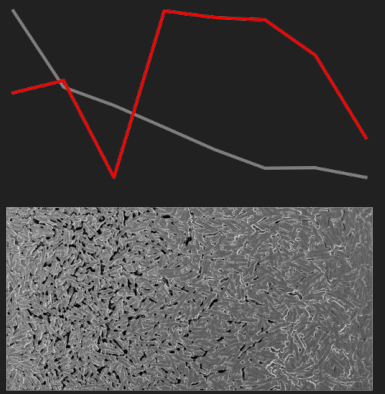
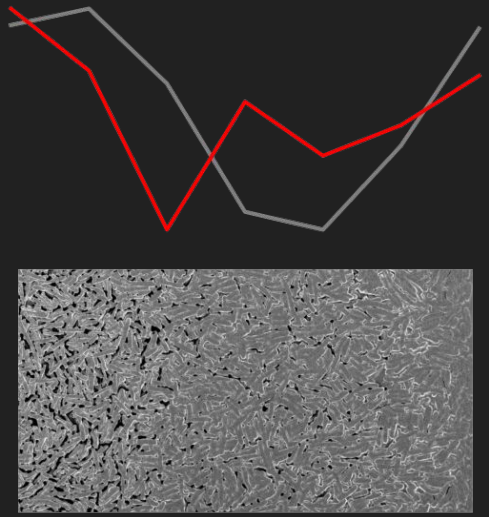
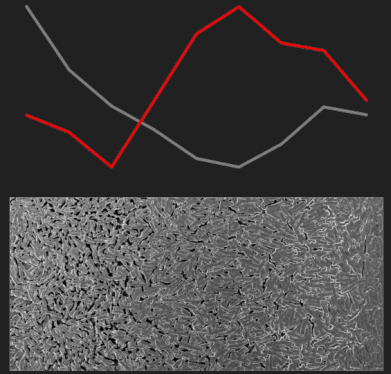
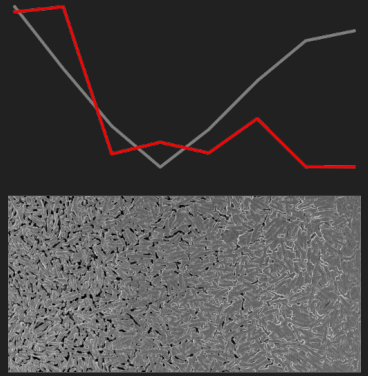
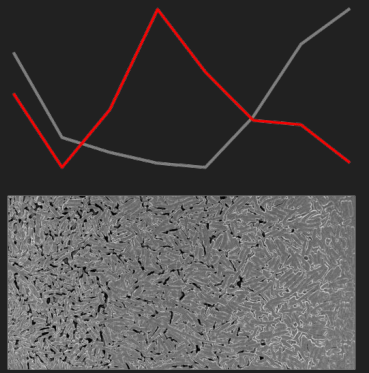
XM

TL

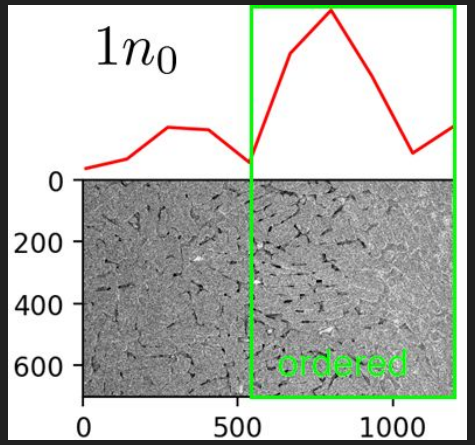
Tasks

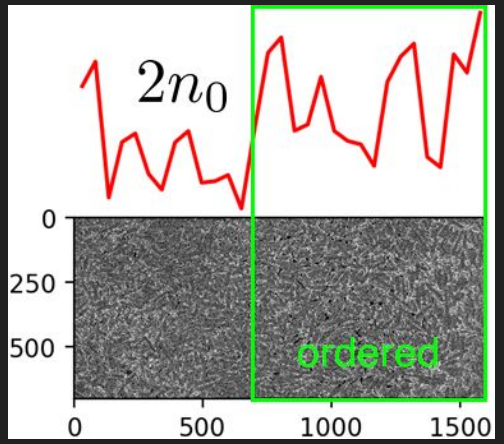
3. Image the micro-structure in drop
   - Brightfield - drop edge structure of all
   - Confocal - drop edge structure of swimmer

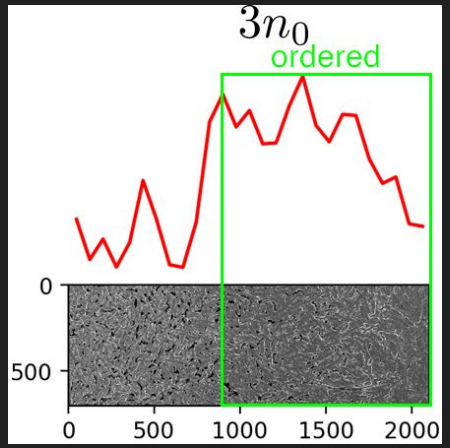
Thought: crack can be inspirations of art - lava crack paint

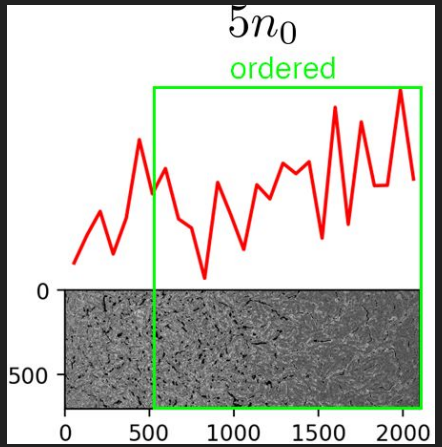









Xiaolei's analysis









- I used the code you sent to me, and tried different values of "width" and "step"
- Xiang said: ziziz not convincing, he would not buy it, and i said: ziziz not a good sign

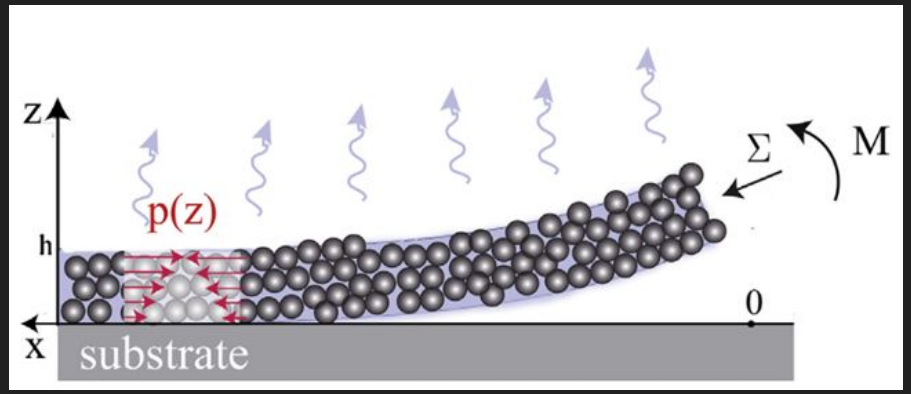
Ordered region size increases with bacteria concentration?

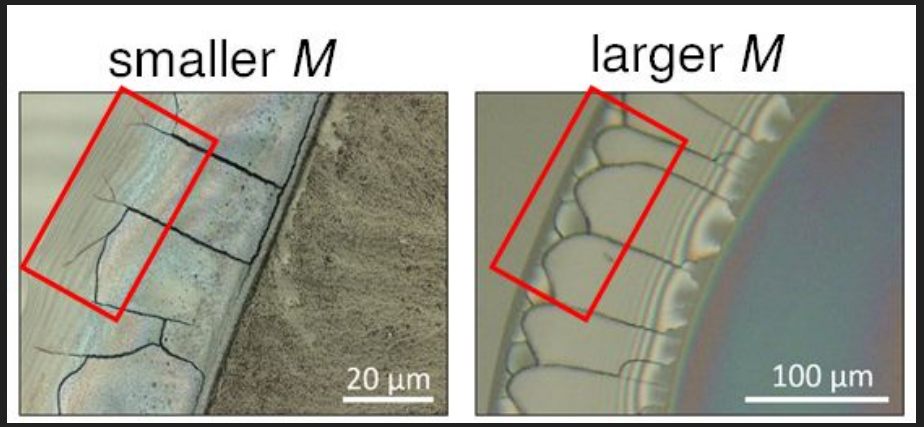
All SEM images (1n0 - 5n0) Link:
https://drive.google.com/drive/folders/1_E6ahYM7_jEcX6ZqFhwuaYGpflr7Wnsm?usp=sharing

Xiaolei’s questions

- 我现在有点puzzle了，你看一些咱们的那些SEM图片，我觉得还是有一个order to disorder transition的，你说呢？
- 而且那个order zone的面积会随着concentration的增加而增加
- 但是我在上一页展示的结果 xiang好像并不买账，阳哥你看看那些图片，看看有什么办法和想法
- 我把SEM图片放在上一页的那个链接里面了
- 我现在还是有点puzzle，如何把FFT中的orientation和真实的crack对应起来，（好像这个问题没有说清楚，我可能得视频和你说）

Idea: Delamination & crack pattern



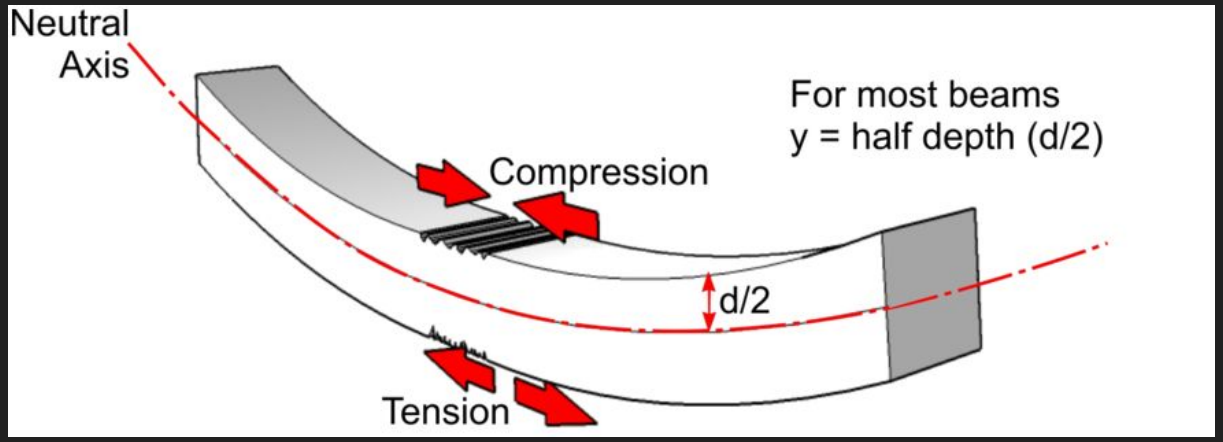


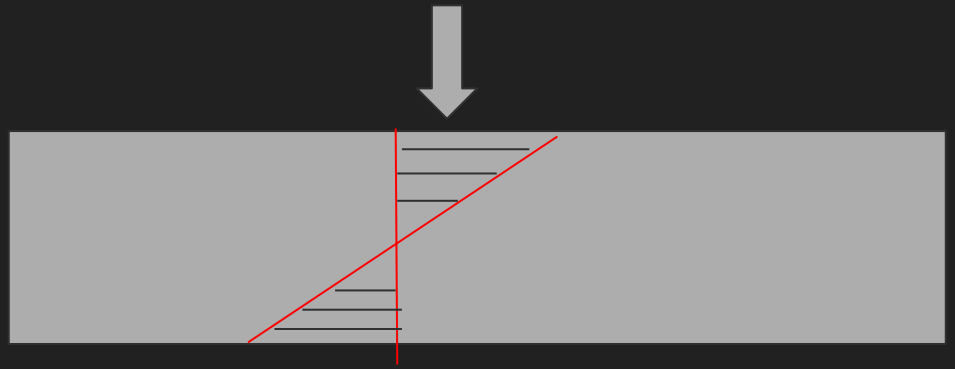
$$M = \int_0^h \left(z - \frac{h}{2}\right) \sigma_{xx}^{eff} dz \sim hP_{pore}$$

$\phi_0 = 1 \times 10^{-3}$

$\phi_0 = 8 \times 10^{-3}$

Delamination drives the formation of exterior crack pattern near the contact line





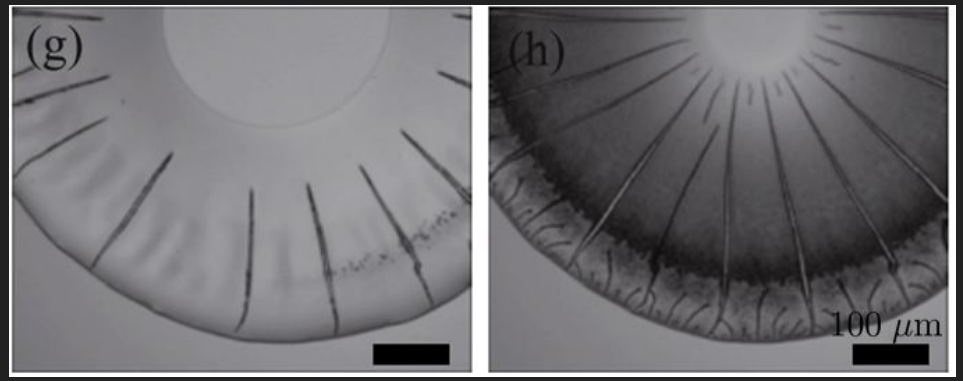
Bending Equation:

$$\frac{M}{I} = \frac{\sigma}{y}$$

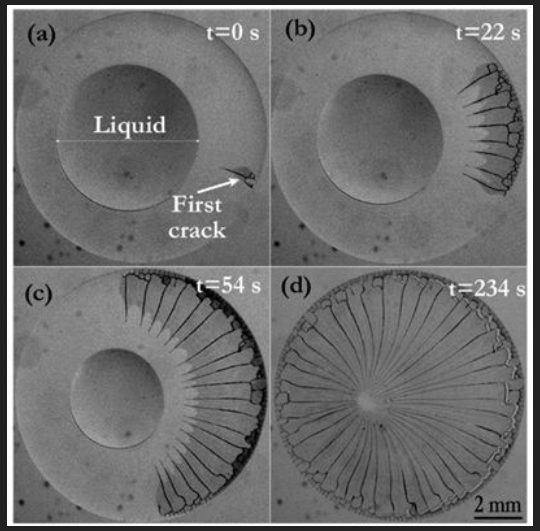
M: bending moment
I: Moment of inertia
\sigma: bending stress
Y: 2/d

drying → delamination→ bending→ tensile stress→ cracks perpendicular to the direction of tensile stress

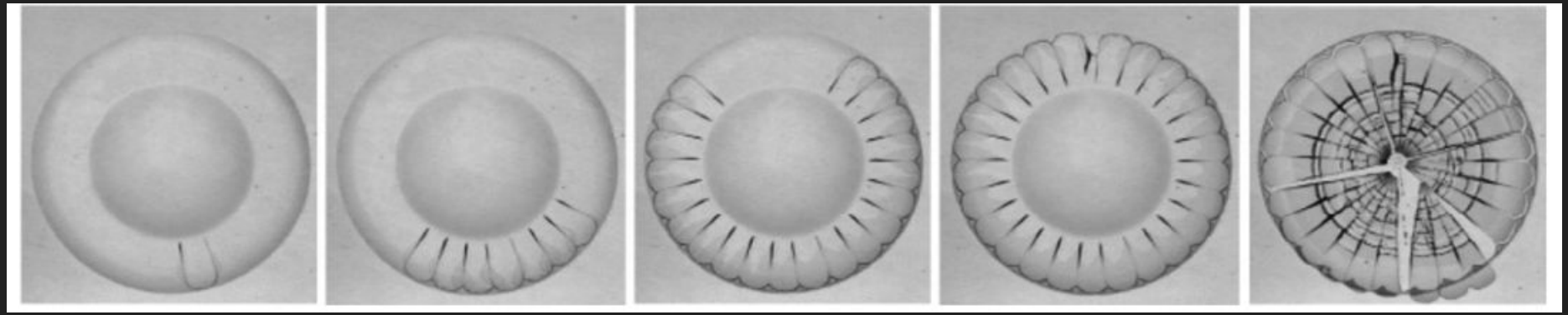
Some examples



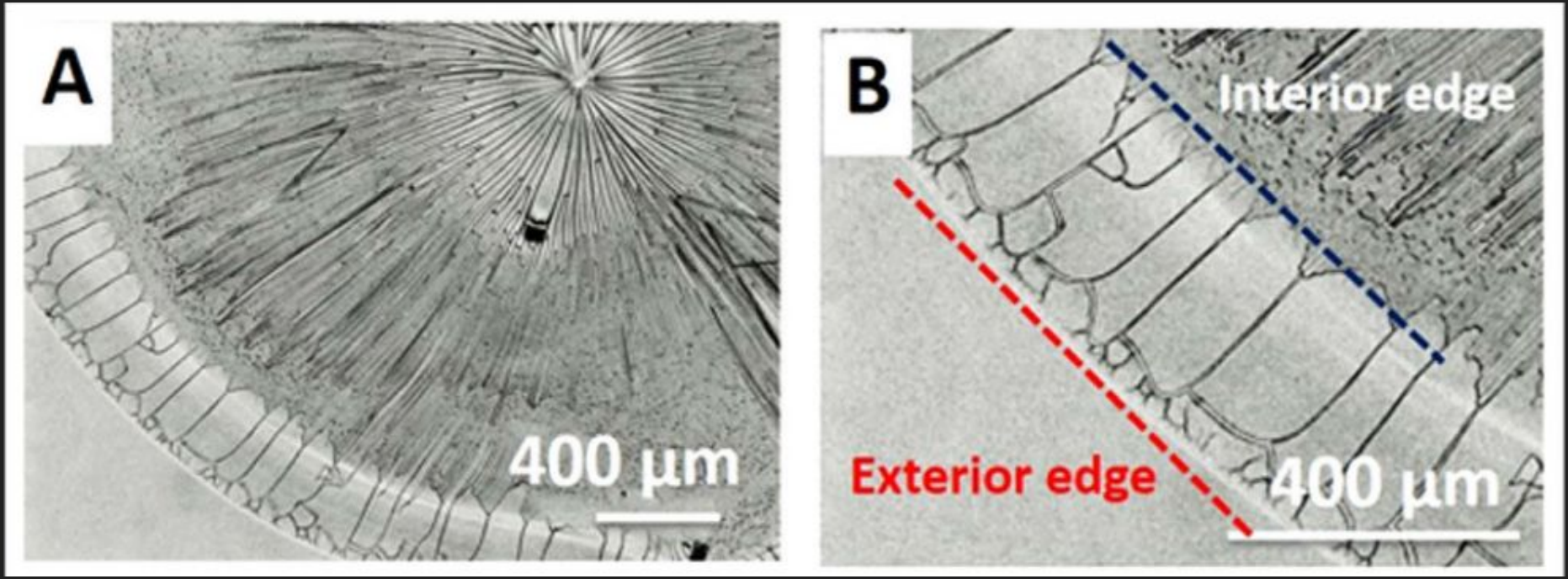
polytetrafluoroethylen particles, r=25nm, 30% wt



silica, r=25nm, 24% wt, Jing, et al., JPCB (2012)



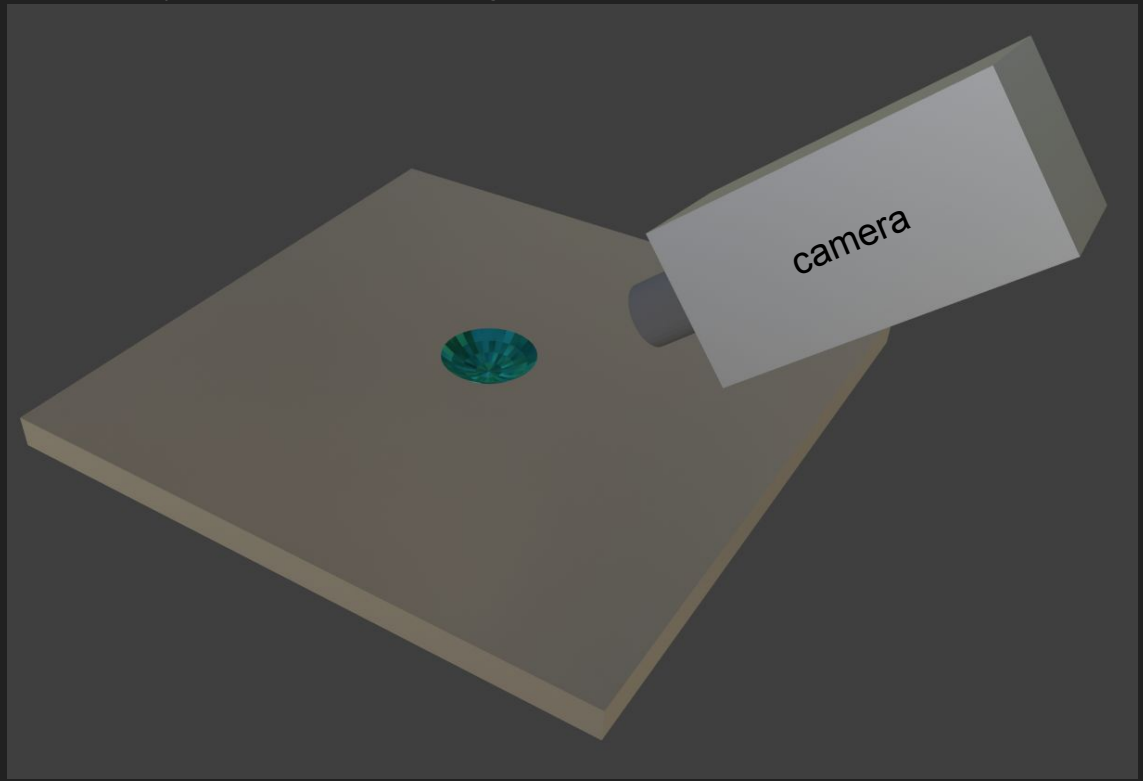
Silica, volume fraction =0.2,r=8 nm, Giorgiutti-Dauphine, et al., Eur. Phys. J. E (2014)



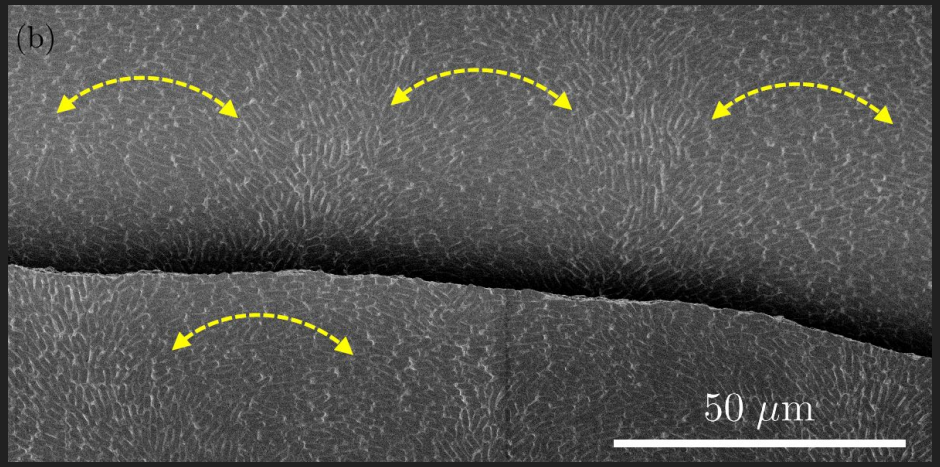
silica, r=16nm, 3% wt, Dugyala, et al., Sci. Rep (2016)

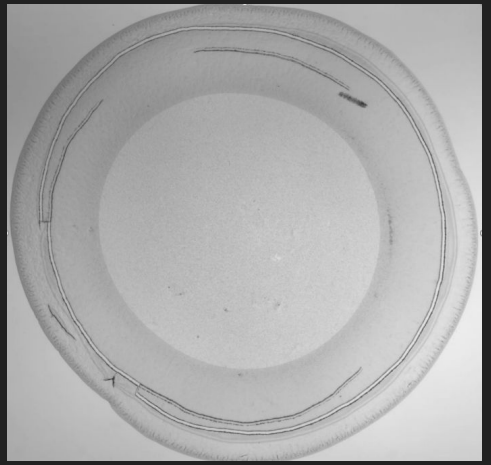
Zhengyang’s comments

- The change in orientational order is not obvious
- If we do SEM using samples with actual cracks, what can we see?
- I think delamination could play a role. Can we image the drying process from an angle, at the same time image from below, and try to find the coupling between the crack formation and delamination?



Some questions





In our PIV test, did we see the “vortex” structures similar to the structures you showed in your paper? I.e., at the edge of the drying drop?