



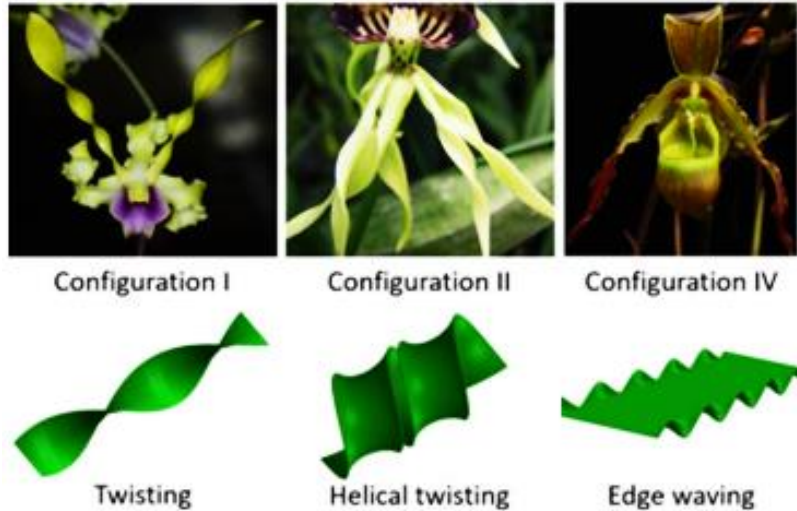
INTERNATIONAL SOCIETY OF
BIONIC ENGINEERING

Reproducing complex biological structures using the Photo-patterning polymerization

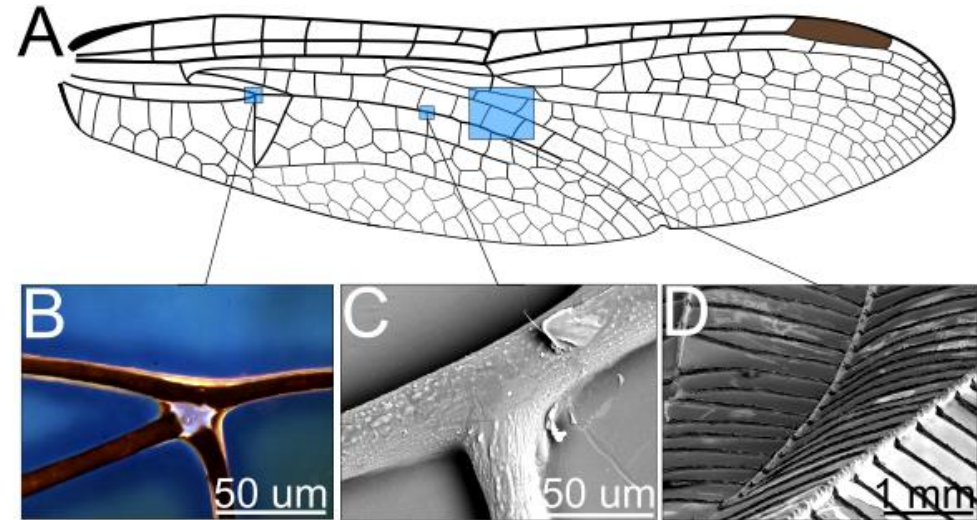
*From plane films
to patterned structures and out-of-plane shapes*

The case was provided by
H Fukunishi, M Hayashi, S Ito, H Rajabi

1. Biological Prototype



C. Huang, et al., *PNAS*, 2018



H. Rajabi, et al., *J. Exp. Biol.*, 2020

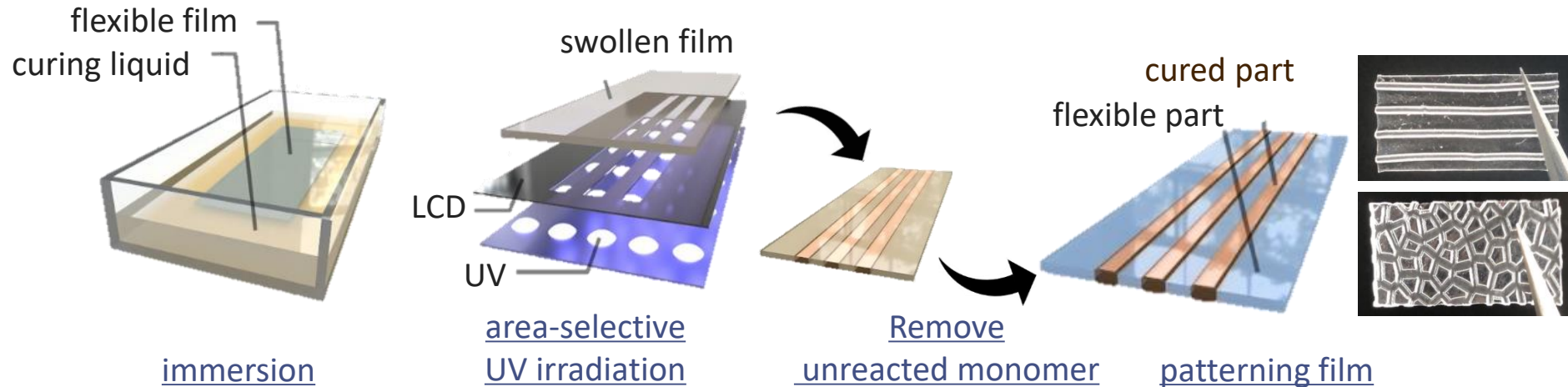
◆ Research goals:

1. Development of patterned structures with different stiffness levels
2. Creating 3D shapes of complex biological structures from flat films using these patterning structures

2. Design and Processing

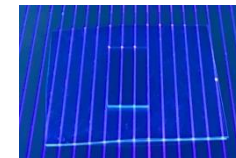
Develop patterning structures with different stiffness in resins

◆ Photo-patterning polymerization



- ① Creating a flexible film
- ② Immersing it in a UV-light-sensitive curing liquid
- ③ Irradiating the swollen film with UV light area selectively using a UV 3D printer
- ④ Removing unreacted curing liquid

LCD panel is used as a variable photomask



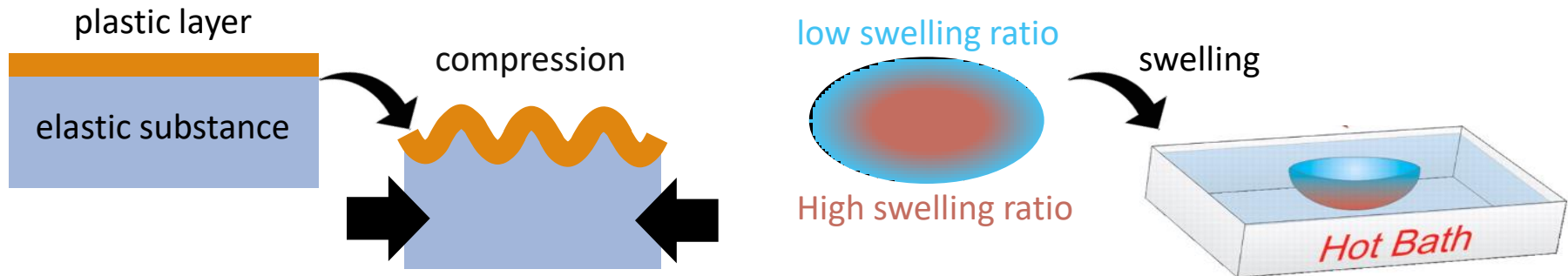
☆ We can adjust the design and hardness easily by changing the irradiation area or combinations of films and liquids

2. Design and Processing

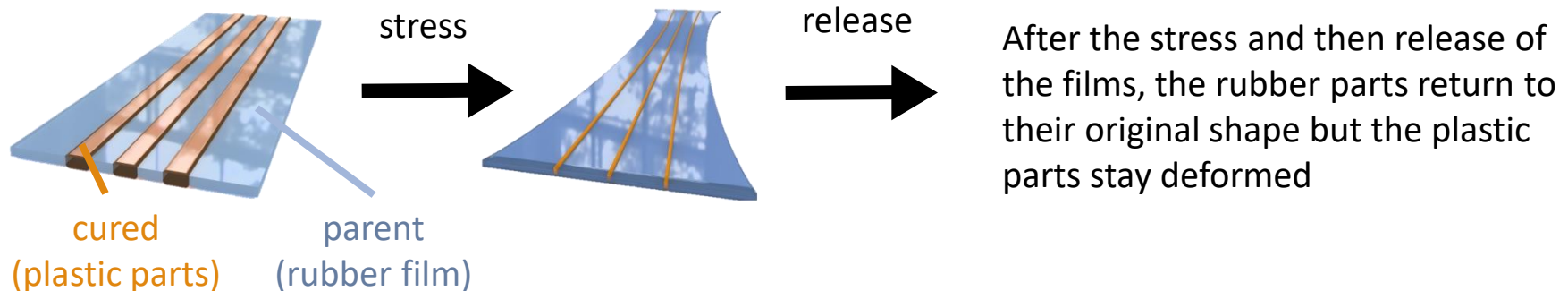
Propose a morphing method using these patterning structures

◆ Approach: using the buckling phenomenon

- Buckling is used to form periodic 3d shapes in thin films
- When a material is subjected to external forces such as compression, swelling, or growth, and some parts deform in differential responses
⇒ the stability of the material decreases, leading to a change in shape to reach a stable state



- How to use the phenomenon in patterning films? ⇒ combination of rubber and plastic

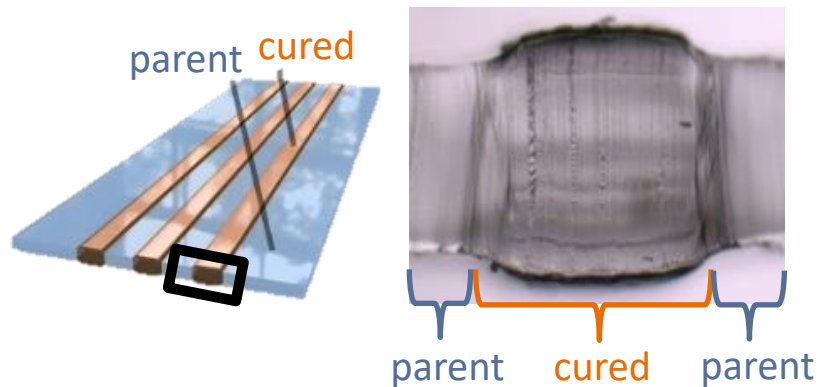


3. Achievements and Application

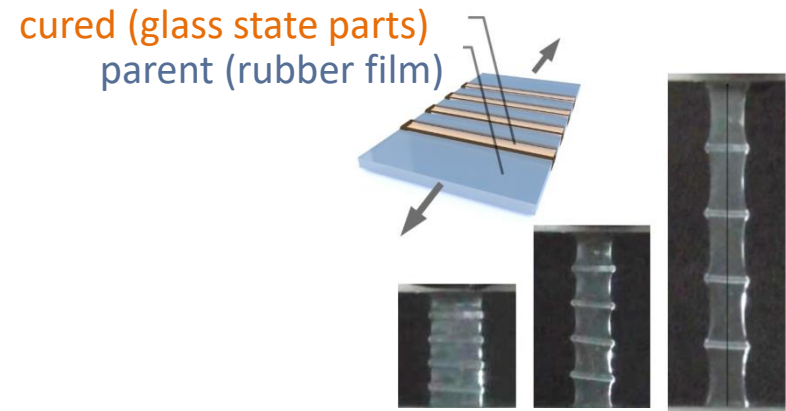
Develop patterning structures with different stiffness in resins

◆ Properties of the patterning films

A: cross-section

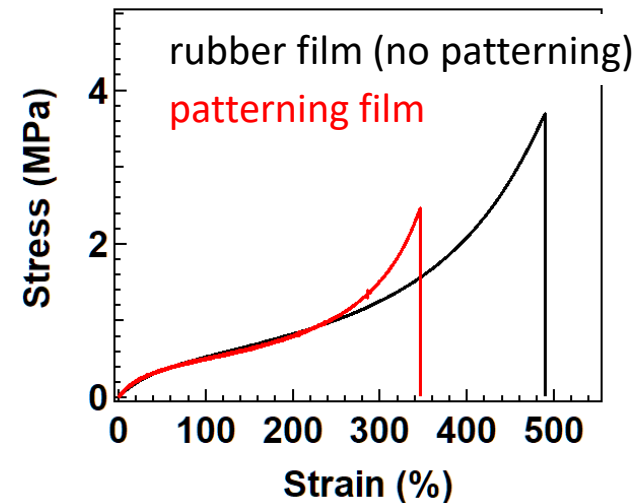
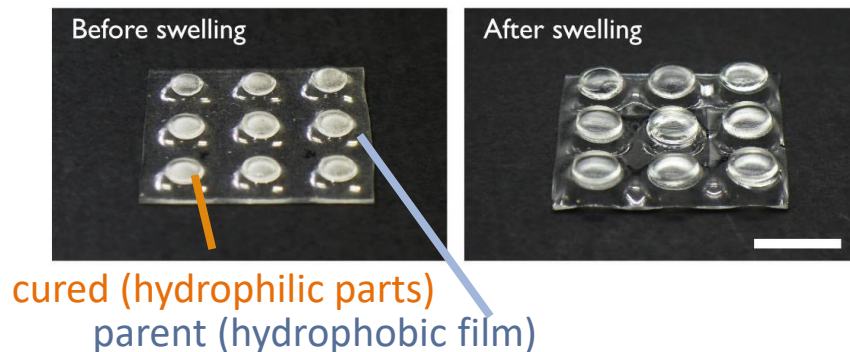


B: combination of rubber and glass state



✓ Homogeneous: good adhesive properties

C: combination of hydrophilic and hydrophobic

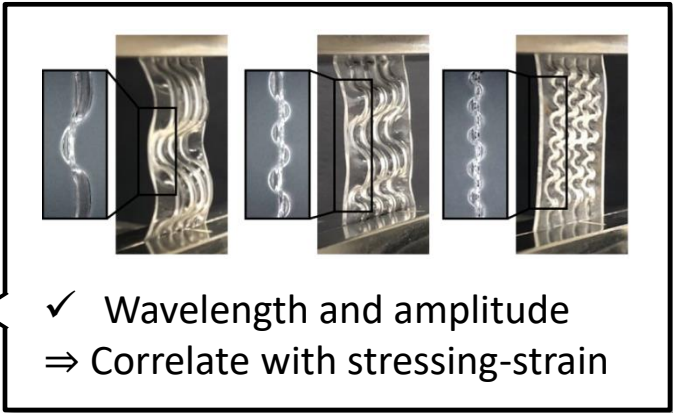
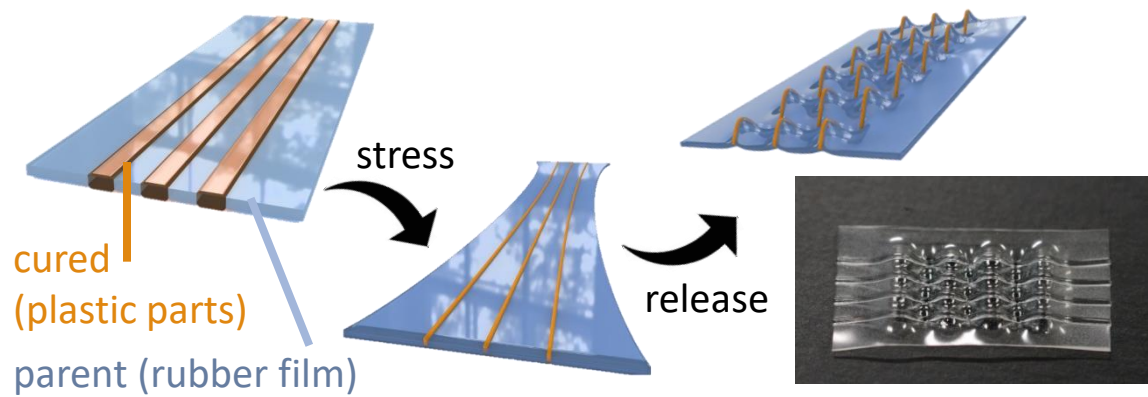


✓ Area-selective cured was confirmed

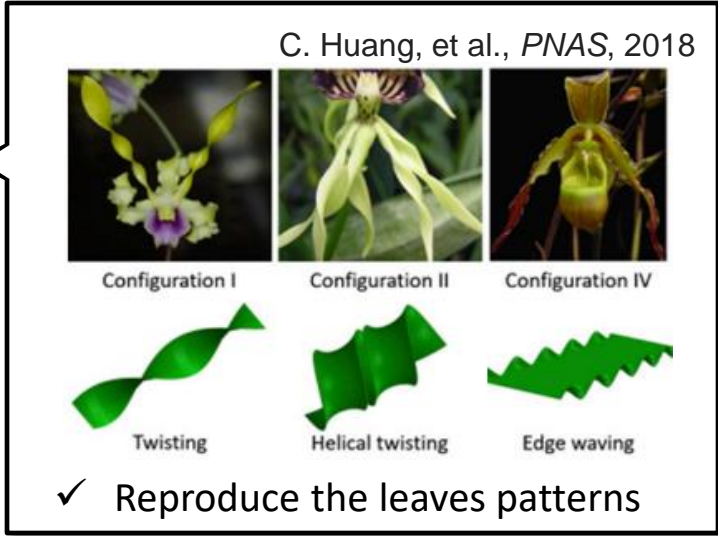
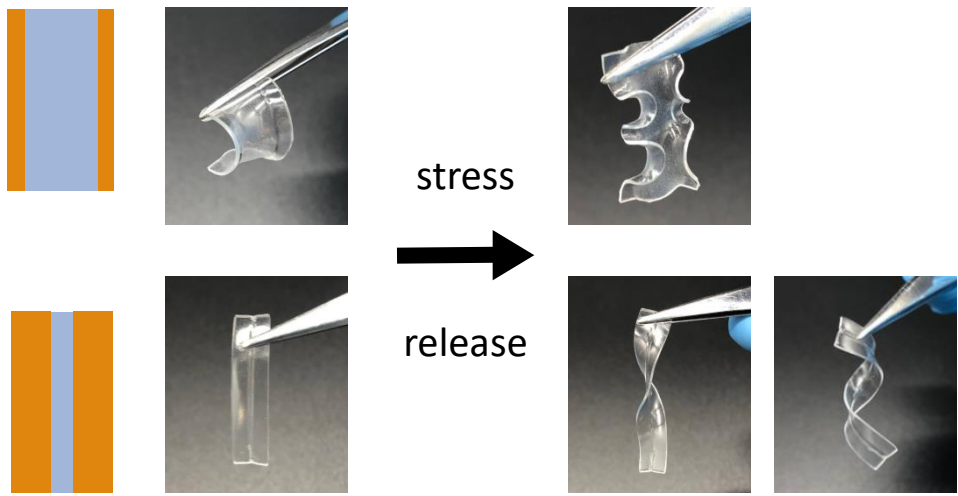
3. Achievements and Application

Propose a morphing method using these patterning structures

◆ wrinkle structures



◆ changing the patterning design





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◆ Results:

1. Developed patterned structures with different stiffness levels in resins
2. Creating 3D shapes from flat films using these patterned structures

***The Photo-patterning polymerization technique
can be used for Reproducing complex biological
structures.***