

Origami self-assamblly Micro\nano-robotics

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*What about the
future !??*

BACKGROUN D



Atlas / Boston Dynamics®



Kiva System® / Amazon®



ASIMO / Honda®



<West World>



Phantom / DJI®



da Vinci Surgical System / Intuitive Surgical®



Soft Robotic Fish / MIT, R.K.Katzschmann et al.



<Transformers>



Industrial robot / FANUC®



Mars Rover / Nasa



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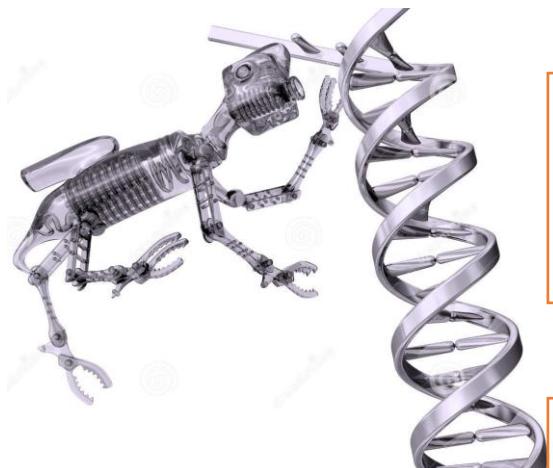


DARPA Warrior Web Exosuit / Ekso Bionics®



<Big Hero 6>

Background: Micro/Nanostructures



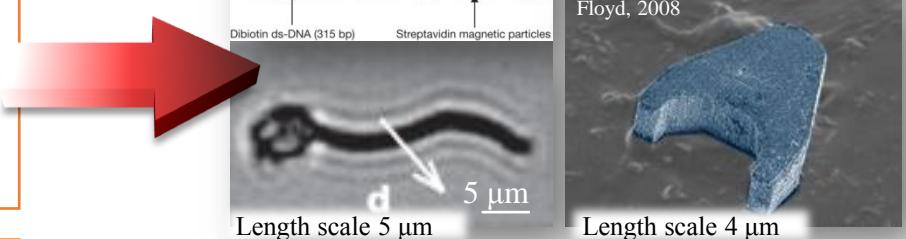
Microrobotics (mm ~ μm)

The term “**Microrobots**” often refers to robots that are small, such as centimeter sized robots. Examples include micro air vehicle (MAV) and mini swarms robots

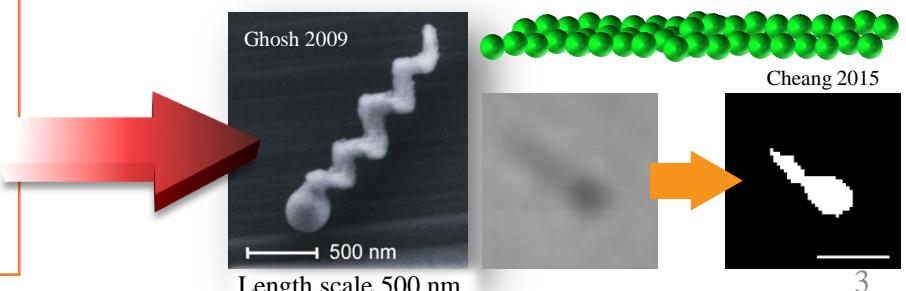


Nanorobotics (0.1 μm ~ 10 μm)

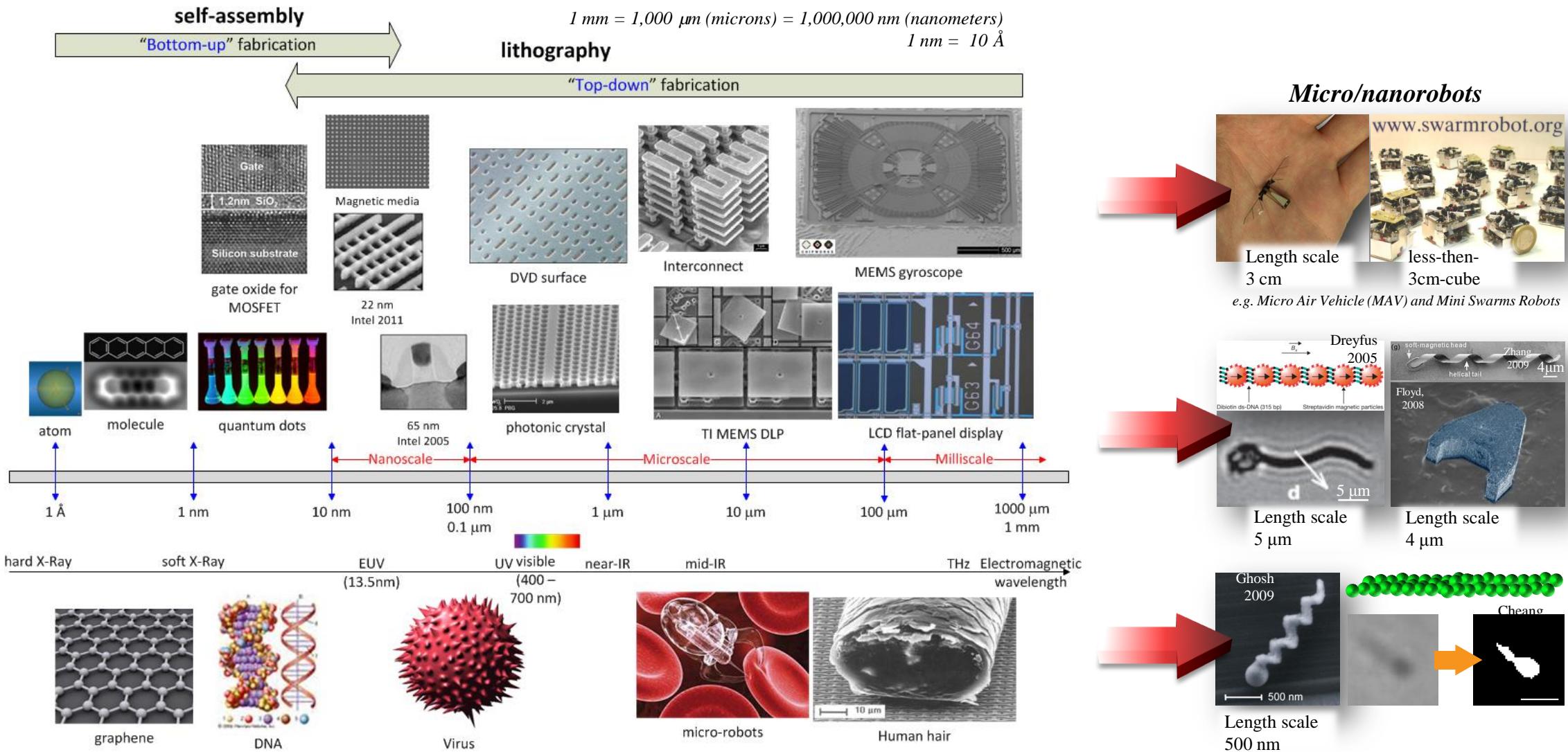
We consider the field of microrobotics to include **robotic micromanipulation** -- manipulation of objects with characteristic dimensions in the millimeter to micrometer (mm ~ μm) range as well as the **design and fabrication** of robotic agents in a similar size range (**microrobots**).



The terms **nanorobots**, **nanoids**, or **nanobots** are often refer to the devices: (1)with size range from 0.10 to 10 micrometers (**0.1 μm ~ 10 μm**). (2)**constructed** of molecular or nanoscale components. (3)robot that allows **precision interactions** with nanoscale objects or which can **nano-manipulate with nanoscale resolution**.



Background: Why Small?



Background: Why Small?

Favorable Policy

Micro/Nano-robots:
The future of medicine?

Government Policy

<Made in China 2025>

"Made in China 2025" is putting forward in the field of **biomedicine** and **high-performance medical instrument** development in view of **new products of chemical drugs**, including **new mechanism** and **new targets for chemical drugs** and **personalized treatment**.

<Healthy China 2030>

The goal of "Healthy China 2030" is to **provide health services to every citizen by 2030**. Life expectancy is to reach 79 years old, aimed at meeting the standard of high-income countries.



8 April, 2018

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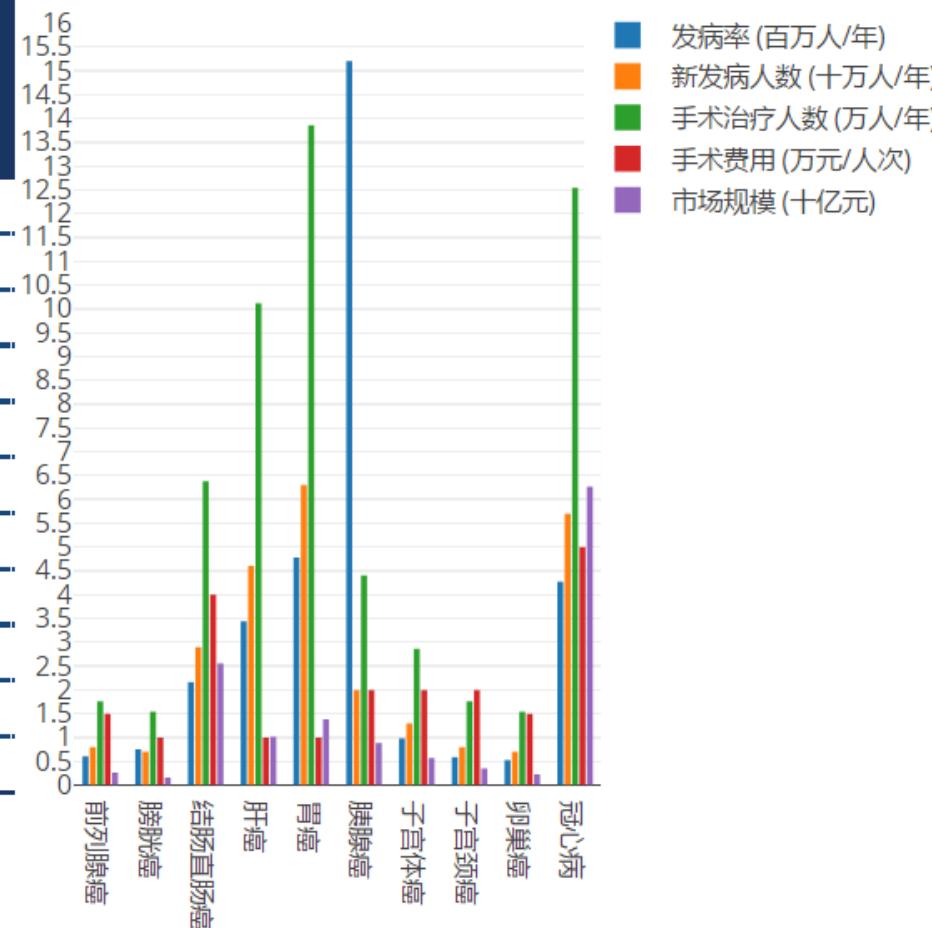
Background: Why Small? Huge Market Potential

THE PROBLEM

科室	病种	发病率 (十万人/年)	新发病人数 (万人/年)	手术治疗人数 (万人/年)	手术费用 (万元/人次)	市场规模 (亿元)
泌尿外科	前列腺癌	6.03	8	1.76	1.5	2.64
	膀胱癌	7.49	7	1.54	1	1.54
普外科	结肠直肠癌	21.6	29	6.38	4	25.52
	肝癌	34.37	46	10.12	1	10.12
妇科	胃癌	47.77	63	13.86	1	13.86
	胰腺癌	152	20	4.4	2	8.8
心胸外科	子宫体癌	9.84	13	2.86	2	5.72
	子宫颈癌	5.84	8	1.76	2	3.52
	卵巢癌	5.22	7	1.54	1.5	2.31
	冠心病	42.68	57	12.54	5	62.7
		合计				136.73

资料来源: Cancer Statistics in China, 申万宏源研究(2017)

中国手术机器人市场规模测算 (2017年)



Background: Why Small? Huge Market Potential

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Market Size	
Kisti.re.kr.(South Korea)	
Global Nano Drug Market	\$ 360.2 B(2016) → \$ 639.9 B(2021)
(1st.) Nanodrugs for Cancer Treatment	\$ 134.4 B(2017) → \$ 300.0 B(2021)
(2nd.) Central Nervous System Disease Treatment	\$ 131.4 B(2021)
(3rd) Infectious Diseases Treatment
WinterGreen Research (USA)	
Global Medical Robots Market	\$ 3.2 B(2014) → \$ 20.0 B(2021)

8 April

Abbott, J., Nagy, Z., Beyeler, F. and N.

科室	病种	发病率	新发病人数	手术治疗人数	手术费用	市场规模
		(十万人/年)	(万人/年)	(万人/年)	(万元/人次)	(亿元)
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资料来源: *Cancer Statistics in China*, 申万宏源研究(2017)

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Background: Why Small? Many applications made possible

Examples:

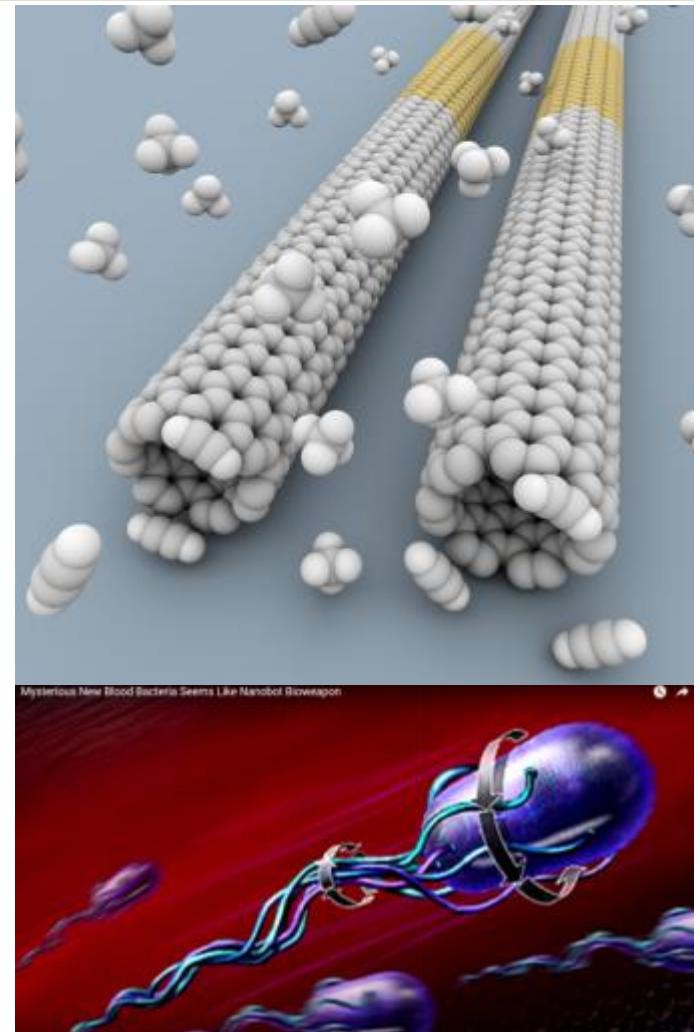
Materials Science	Powders, Coatings, Carbon Nano-Materials, C-NanoFabrics, Self-assembly
Energy	Solar Power and PhotoVoltaics, Hydrogen Fuel Cells, LED White Light
Medicine/Biotech	Genomics, Proteomics, Lab-on-a-Chip, C-Nanotubes, BuckyBalls, bioMEMS
Electronics	MRAM, NRAM, Q-Dots, Q-Bits, Sensors
Devices	Lithography, Dip Pen Lithography, Nanoimprinting, Laser Beam, AFM, TEM
Robotics	Micro/nanorobots, Precise Manipulation, Non-Invasive Surgeries, Targeted drug Delivery

Fruition of micro/nanorobotics can bring about a technological revolution in medicine

8 April, 2018

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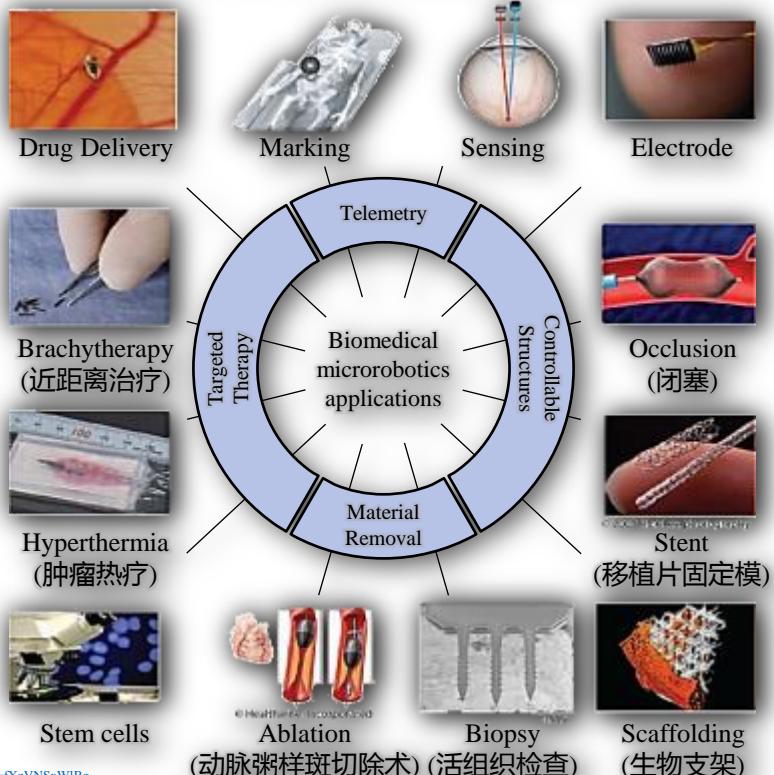


B A C K G R O U N D

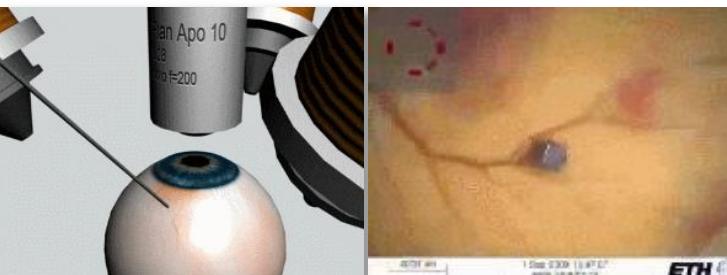
Background: Why Small? Potential Medical Applications



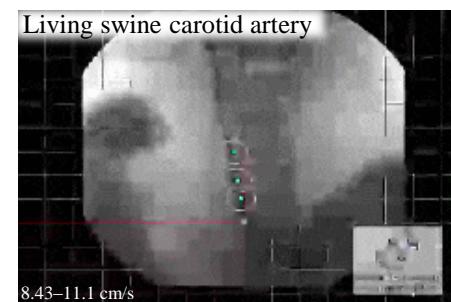
Can Fantasy becomes Reality? Micro/Nanorobots, future of medicine?



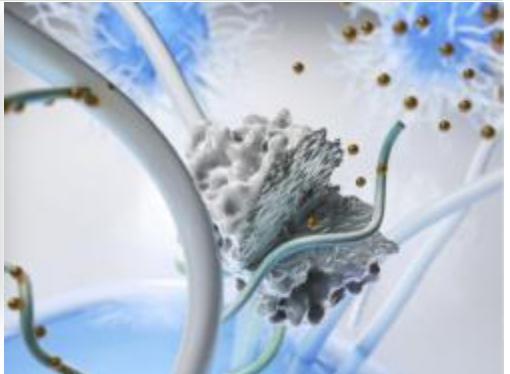
Biopsy – minimal invasive retrieval of tissue sample



Drug delivery – precise target, minimize side effects



In vivo Navigation – steer microparticles in artery

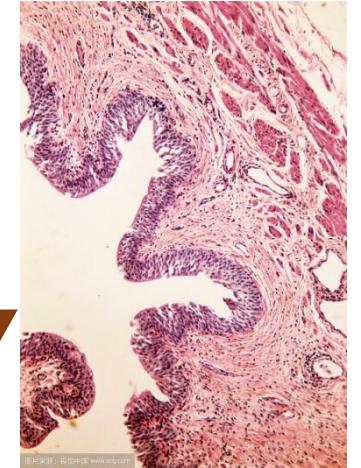


Genetic modification – gene and cell therapy



Why Origami?

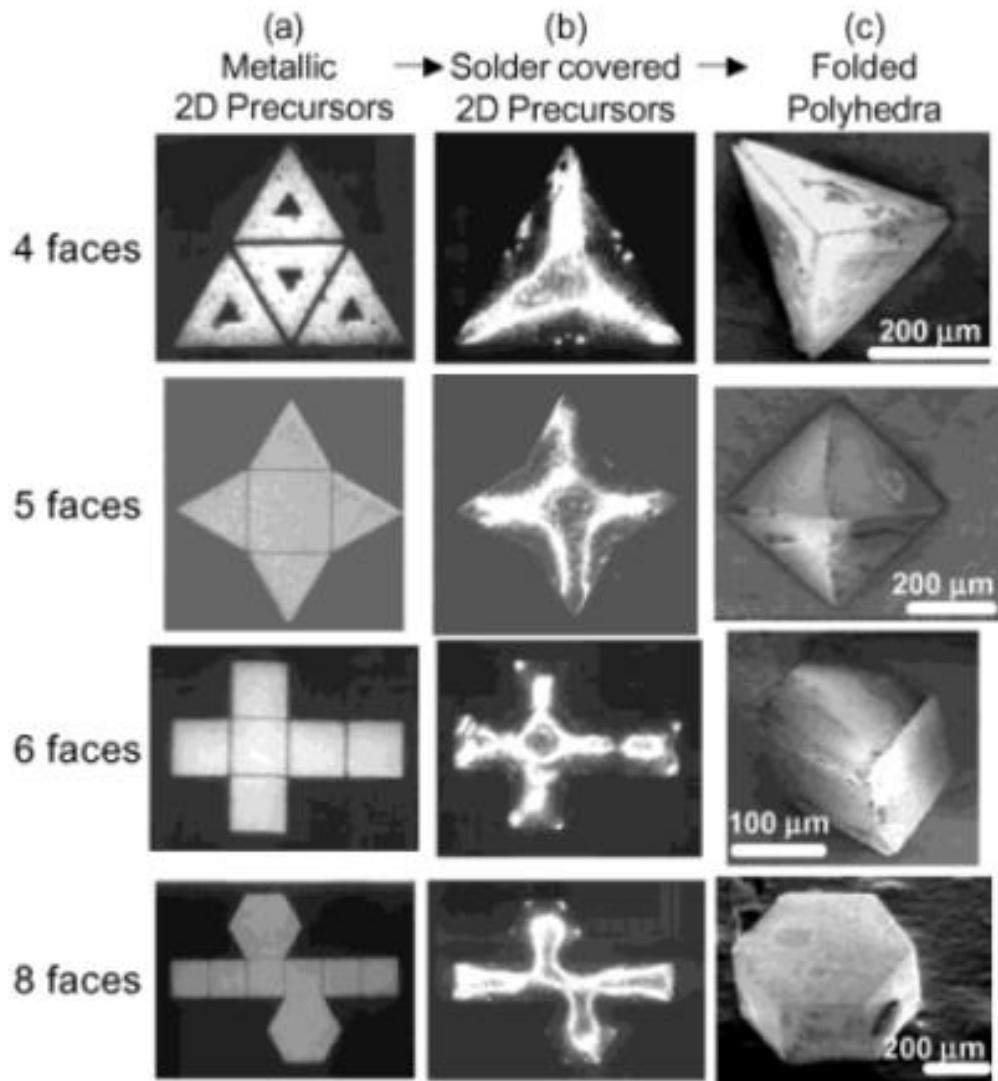
1. Establish methods for controlling the properties of materials systems and the function of devices constructed with them, not only through chemistry and morphology, but also through 3D architectures.
2. Precise organization of biological and non-biological materials in three-dimensional (3D) space holds great promise for a vast array of applications in the fields of structural biology, biophysics, sustainable energy, photonics, electronics, medicine, etc.
3. More specific surface area as cells did, can carry more cargos.



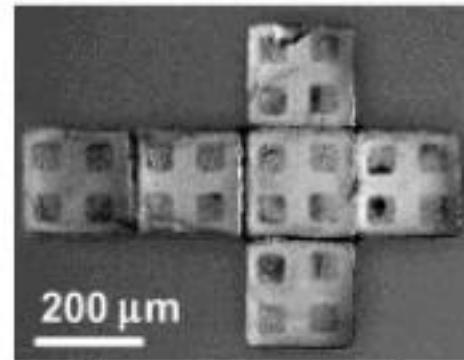
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Background: Origami Inspired Micro/Nano Composites

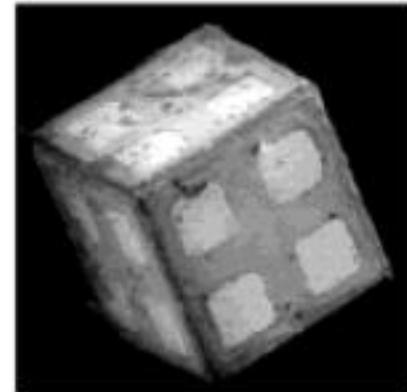


(a) Patterned 2D precursor



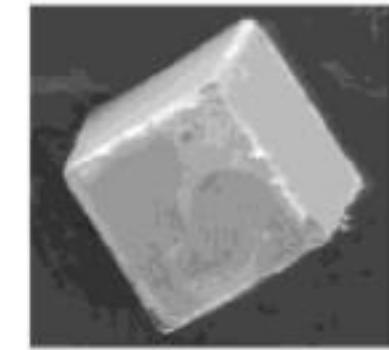
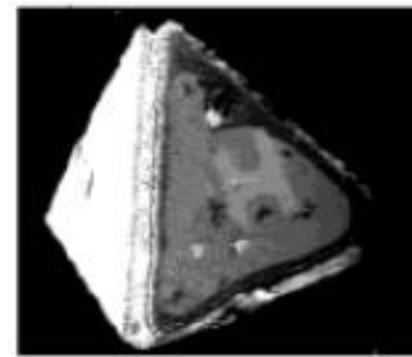
200 μm

auto-folding



(b) 200 micron patterned cube

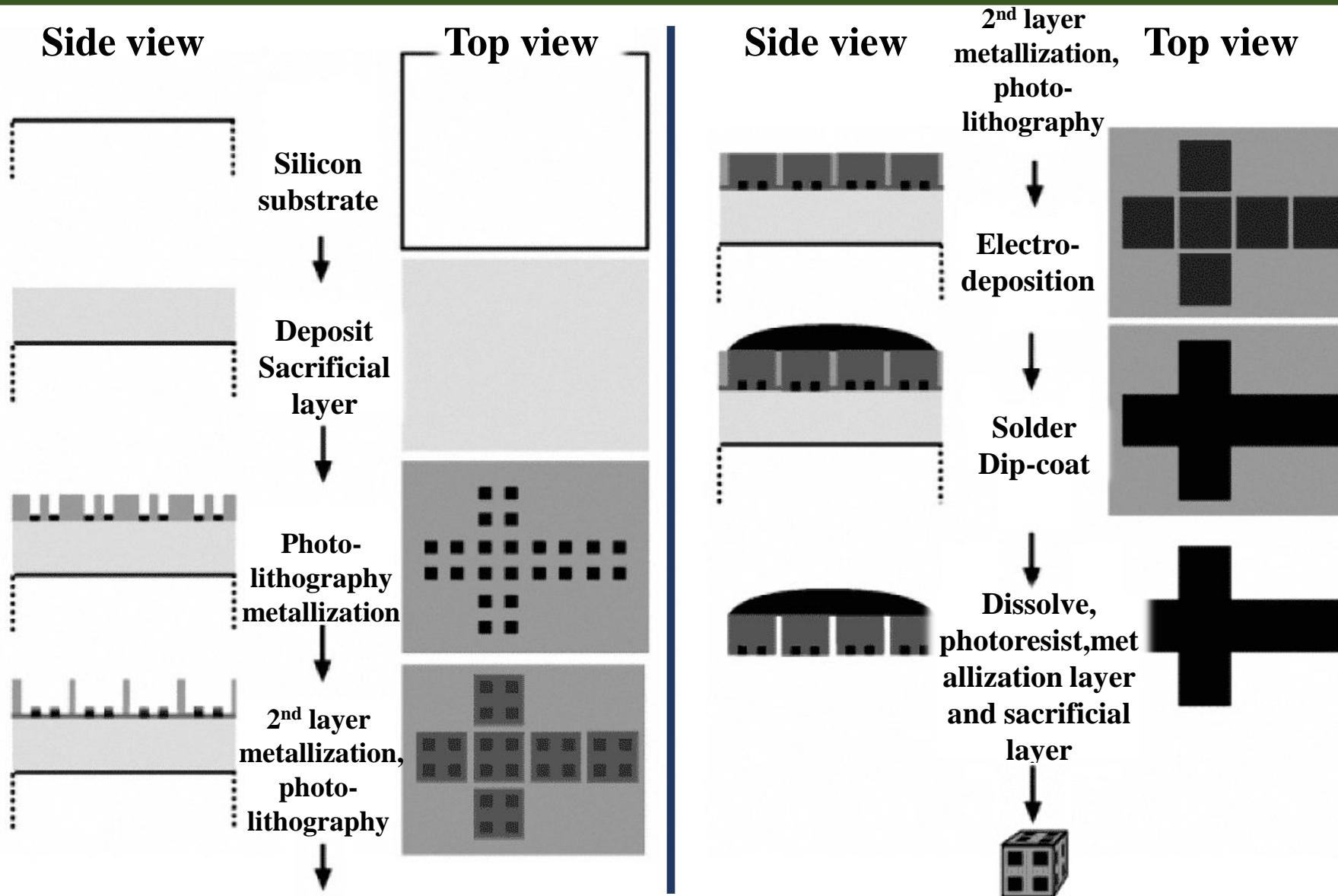
(c) 200 micron patterned pyramid (Letter H-Harvard)



(d) 200 micron cube with <100> Si chip on each face

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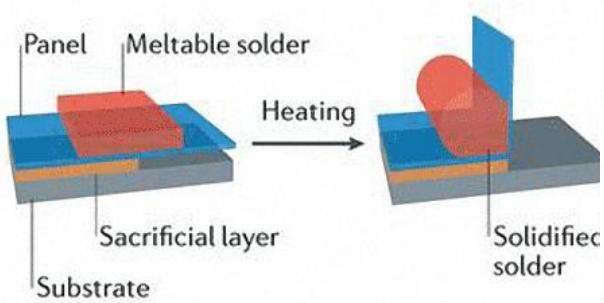
Background: Origami Inspired Micro/Nano Composites



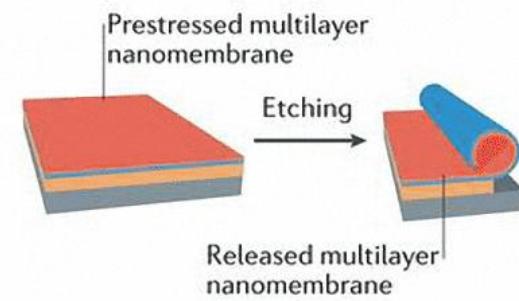
Background: Origami Inspired Micro/Nano Composites

a Mechanisms of folding deformation

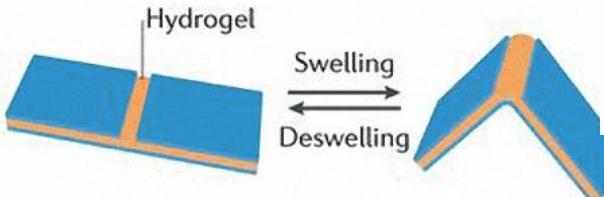
Capillary forces



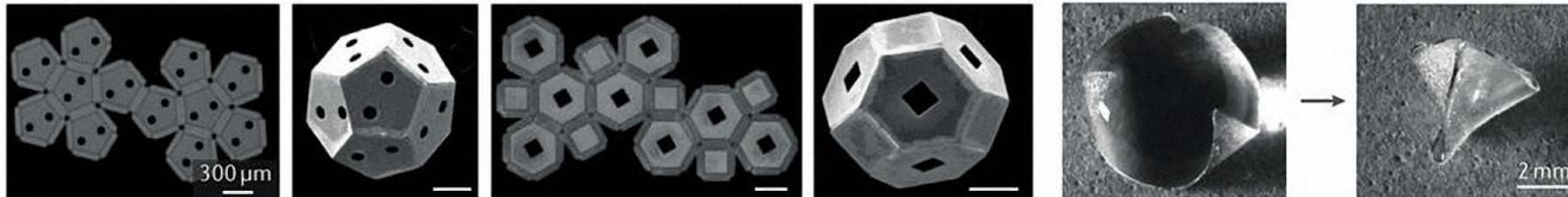
Thin-film residual stresses



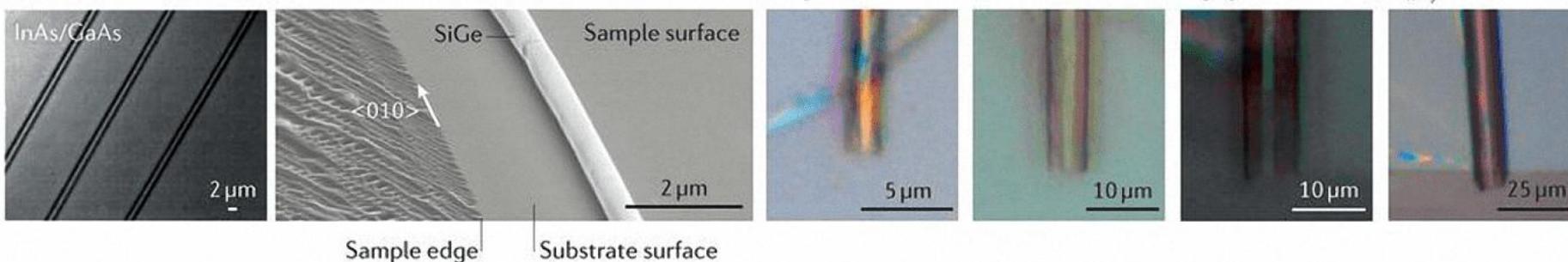
Active materials



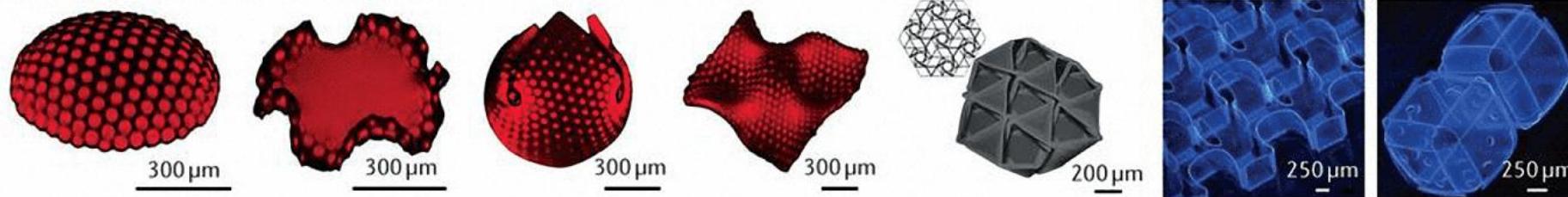
b SEM images of folded structures



c Residual stress-induced self-folded and rolled structures



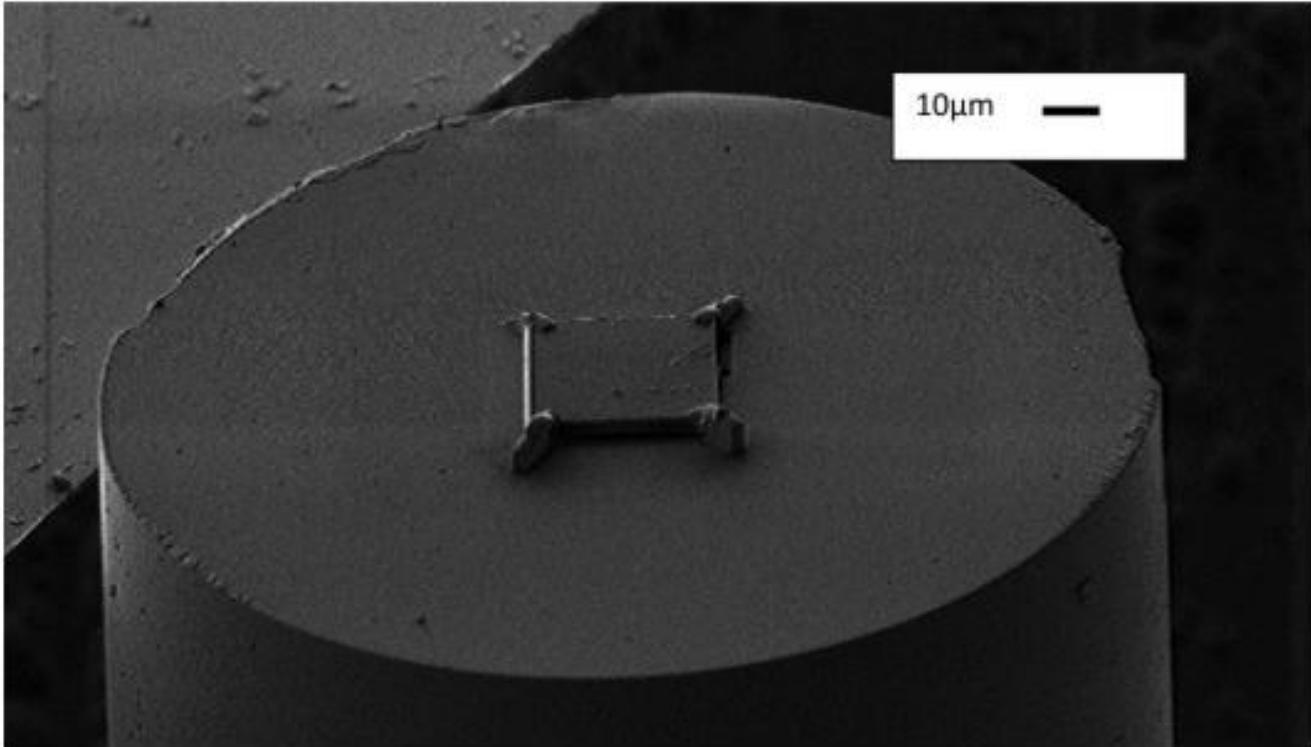
d Self-folded structures in active materials



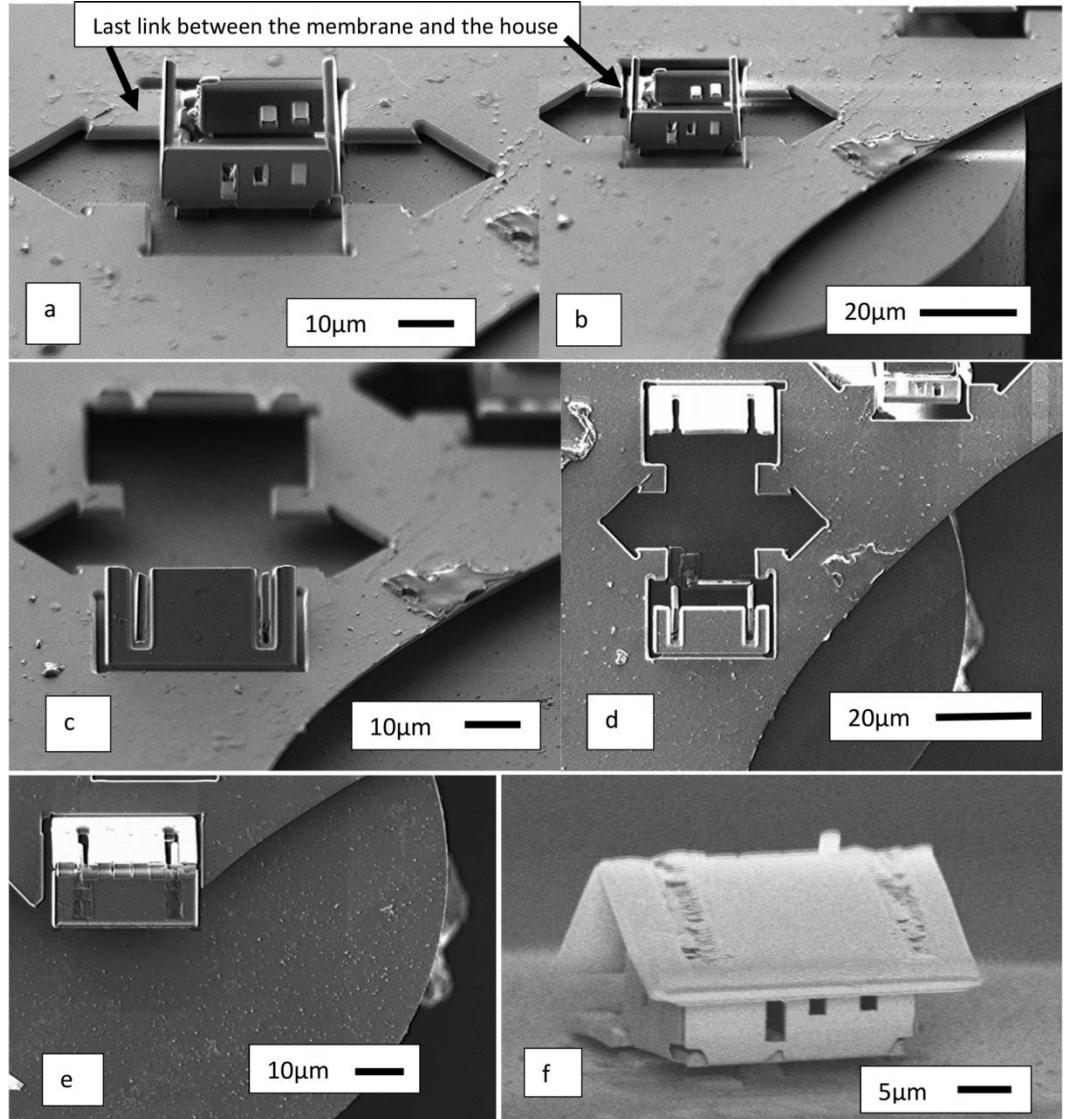
Nature Reviews | Materials

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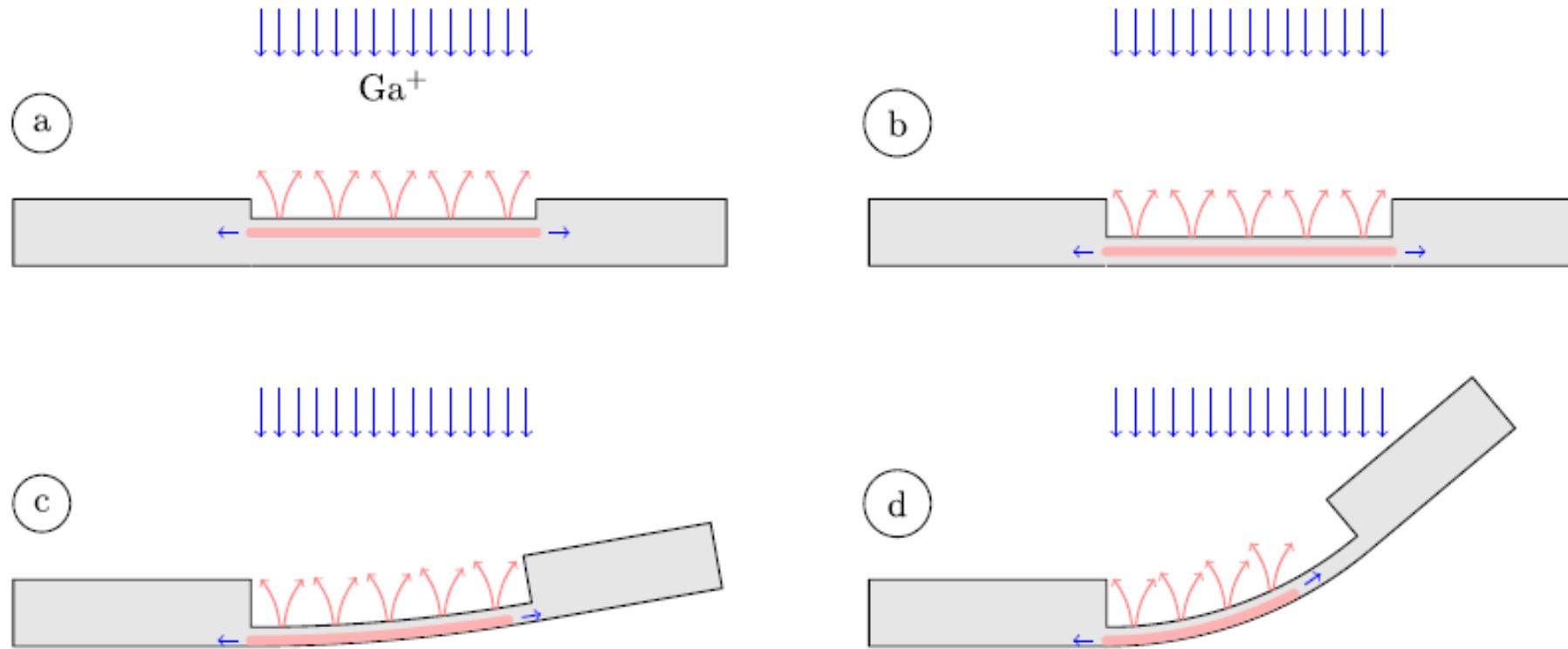
Background: Origami Inspired Micro/Nano Composites



Mirror of silica is assembled at the center of an optical SMF28 fiber. The space between the top of the optical fiber and the back face of the mirror is controlled by four small plots of 1.4 μm thickness. The size of the mirror is 25*25*1.2 μm .



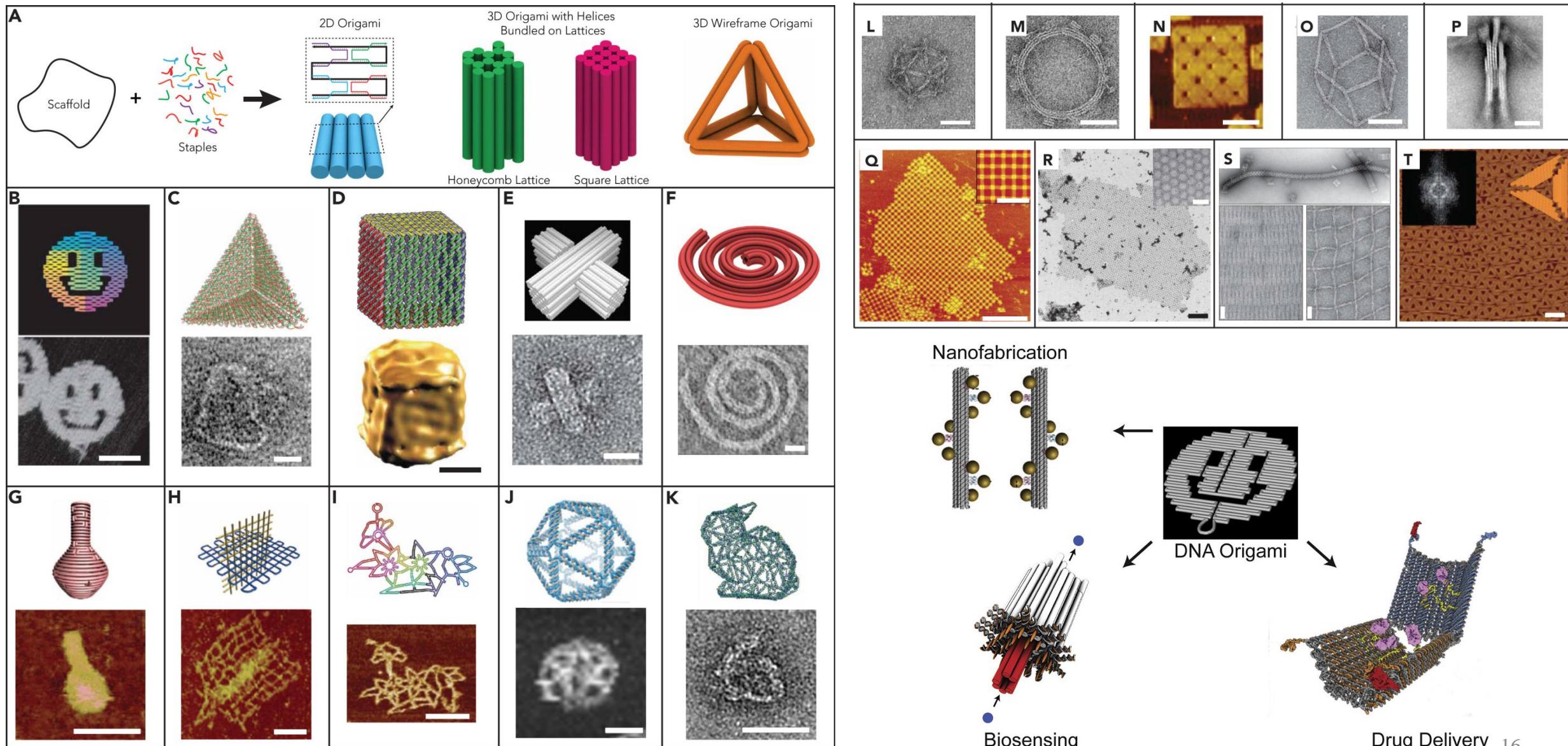
Background: DNA Origami nano-machine



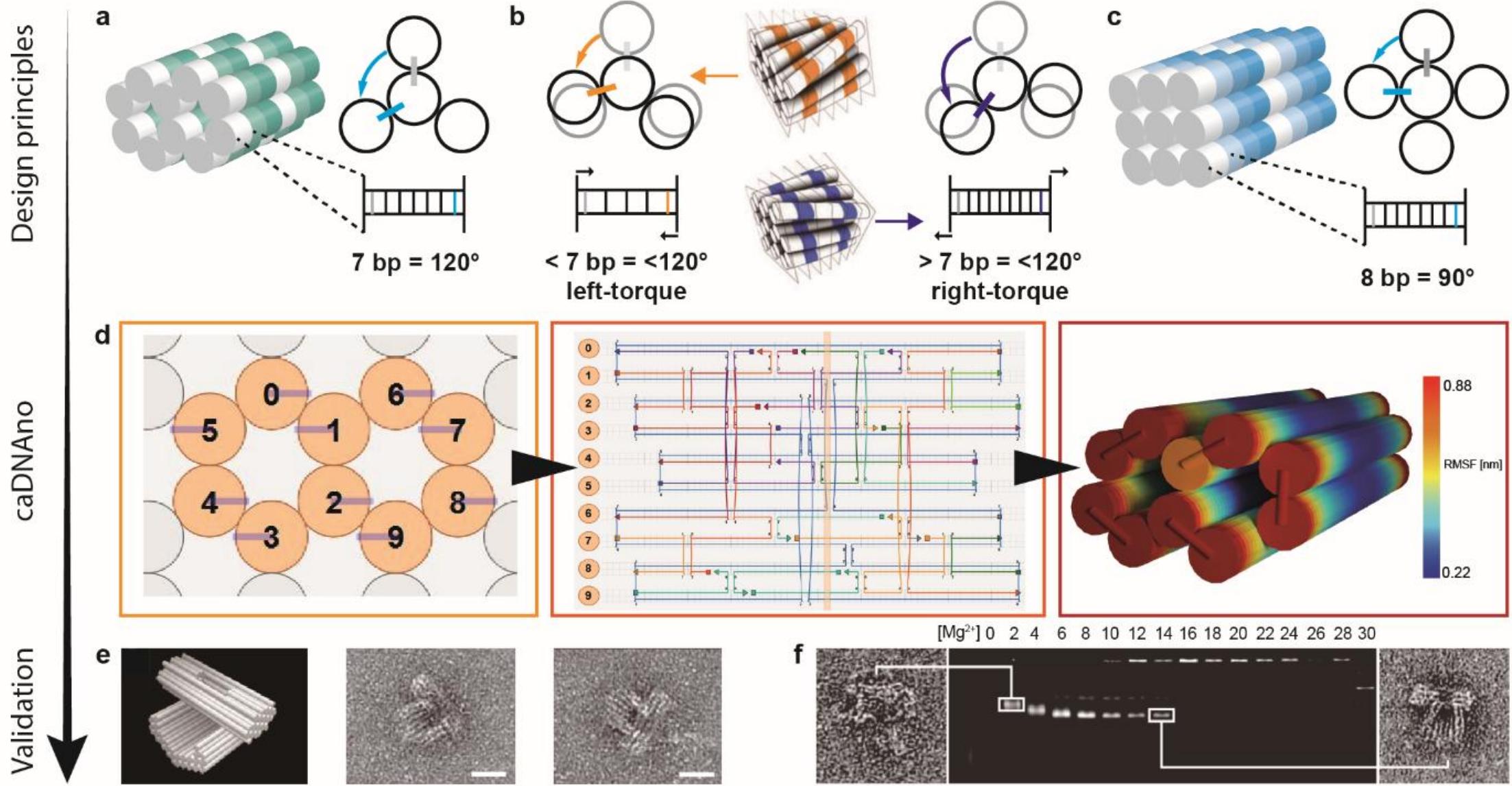
(Color online) Theory of the origami process:

- The first step of this process corresponds to a sputtering with gallium ions of the interesting area.
- When the bulk of the link between the membrane and the panel to fold corresponds to a specific thickness, a bimetallic strip appears.
- The effect of sputtering produces a differential dilatation coefficient into the upper part in white and the down part in red of the link.
- The panel self-fold from 0 to 90.

Background: DNA Origami nano-machine



Background: Origami Inspired Micro/Nano Composites



My Design

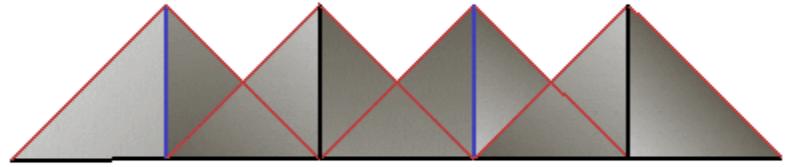
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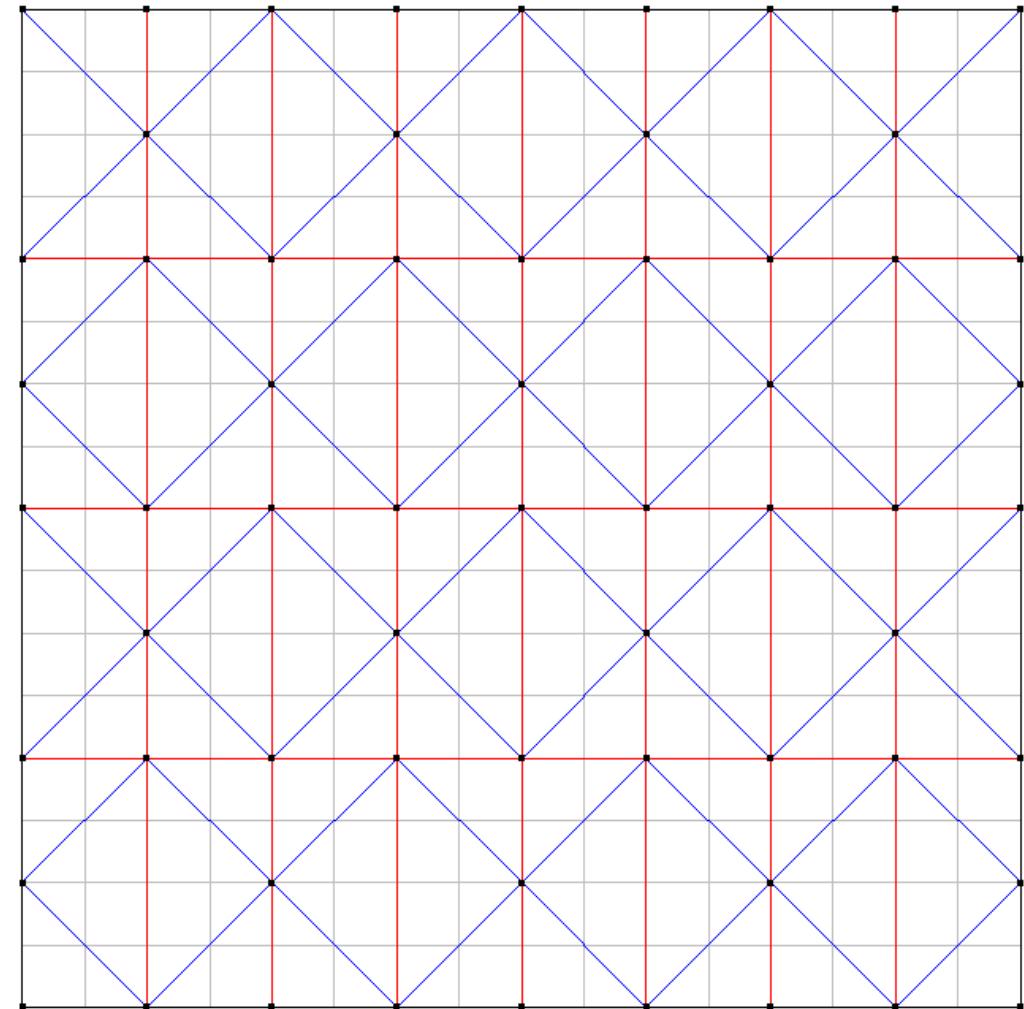
SUSTech
Southern University
of Science and
Technology

Design: Origami Inspired Micro/Nano Composites

CAD

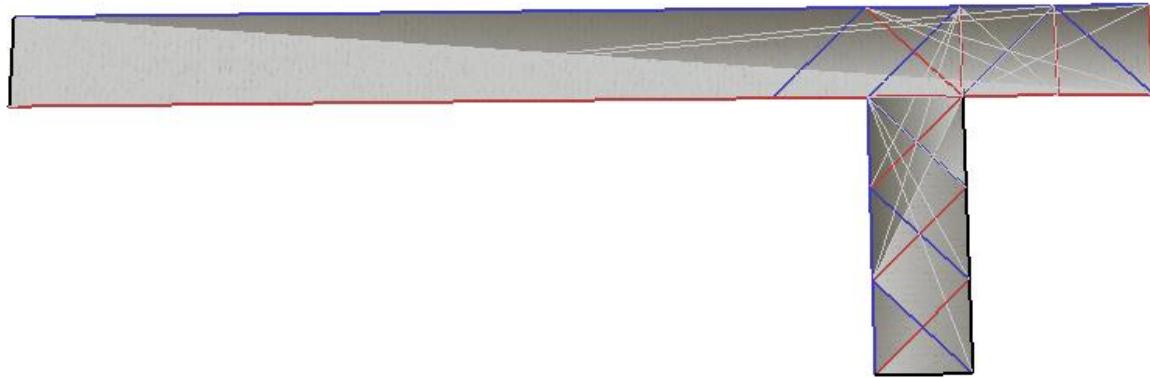


Crease patterns (CP) (折痕图)

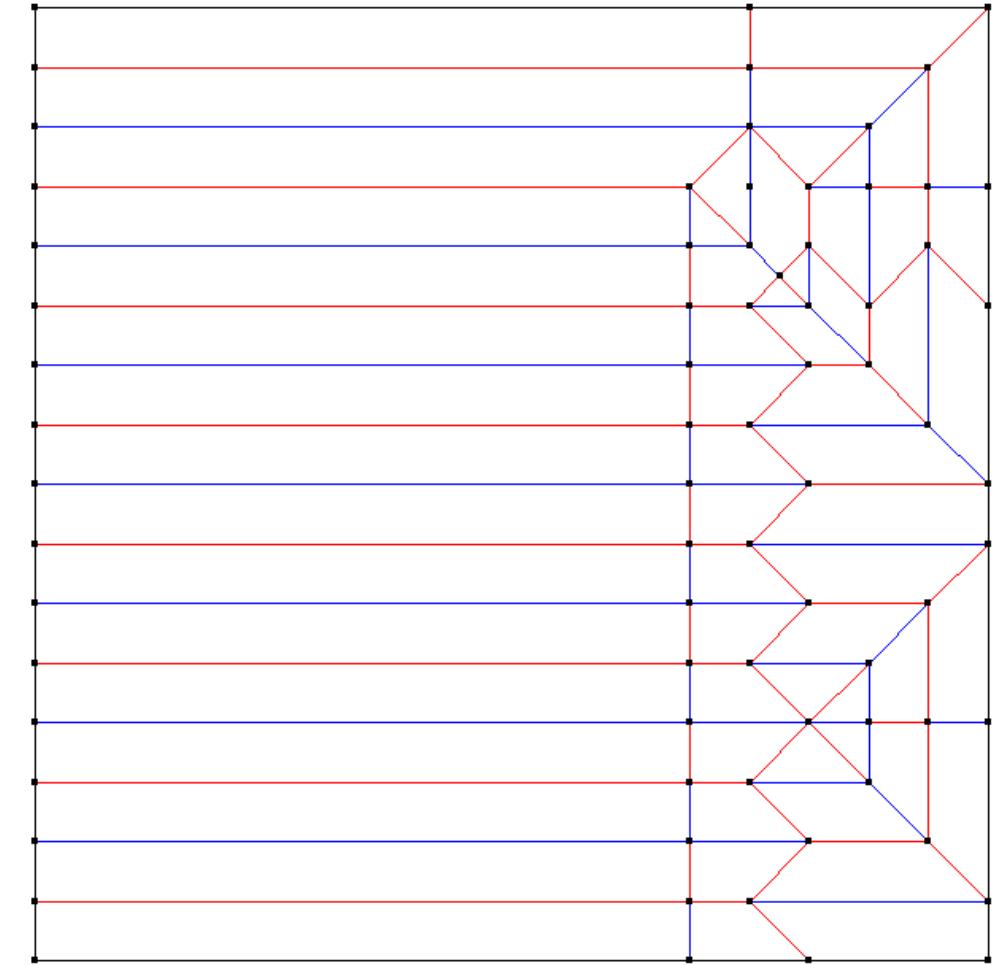


Design: Origami Inspired Micro/Nano Composites

CAD

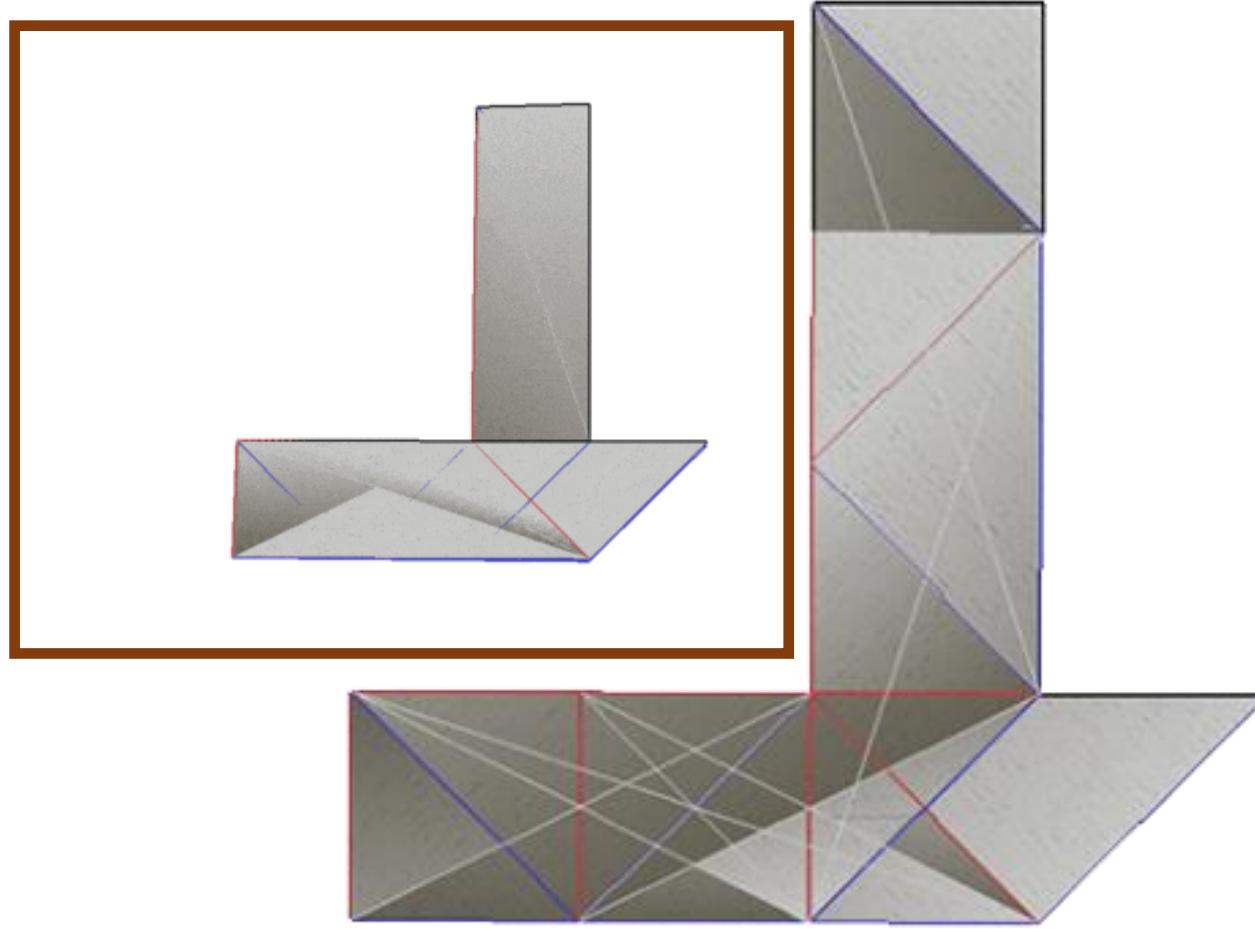


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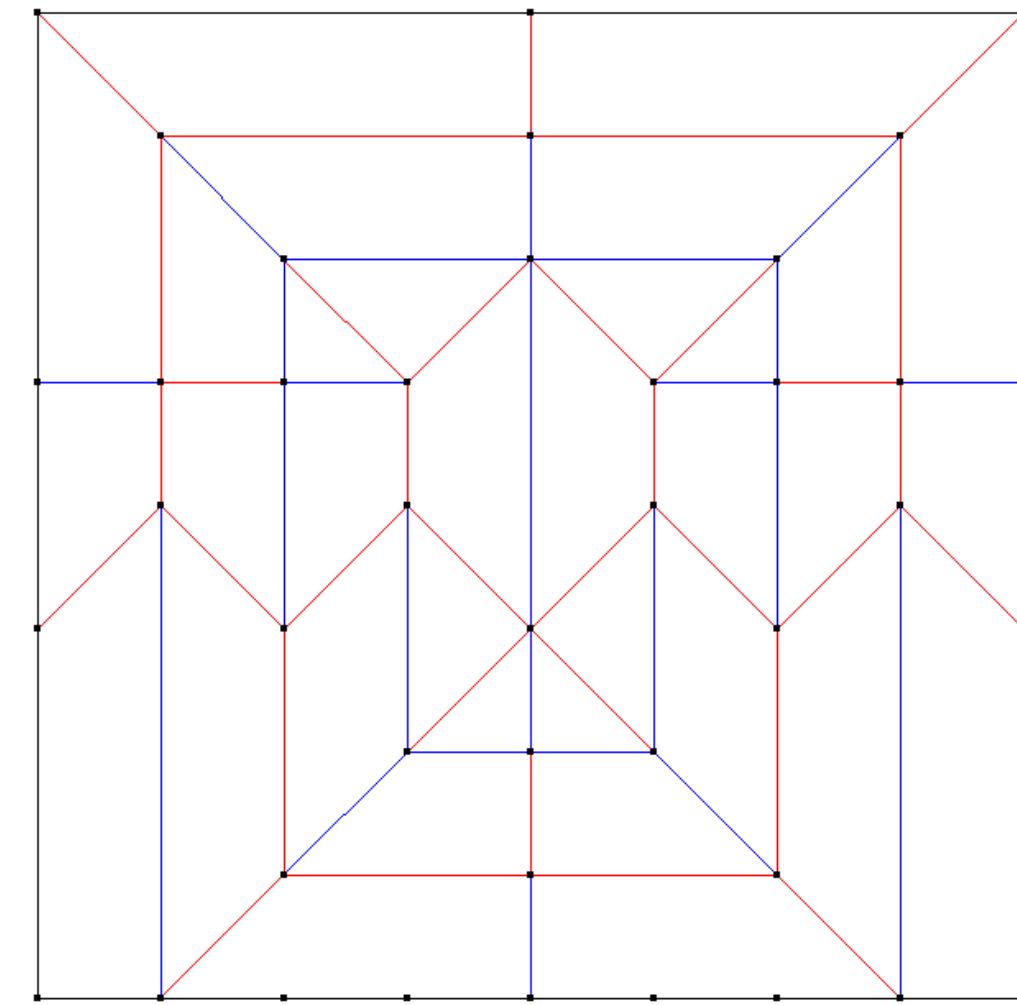


Design: Origami Inspired Micro/Nano Composites

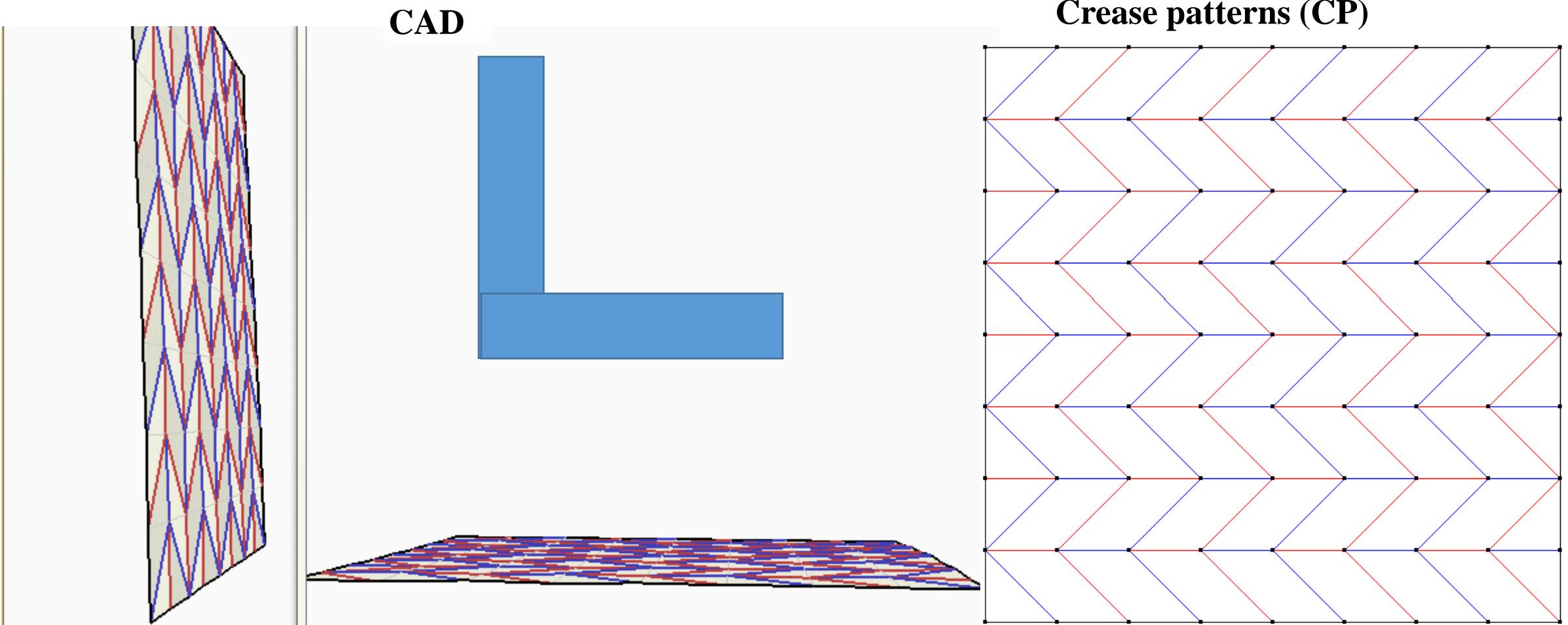
CAD



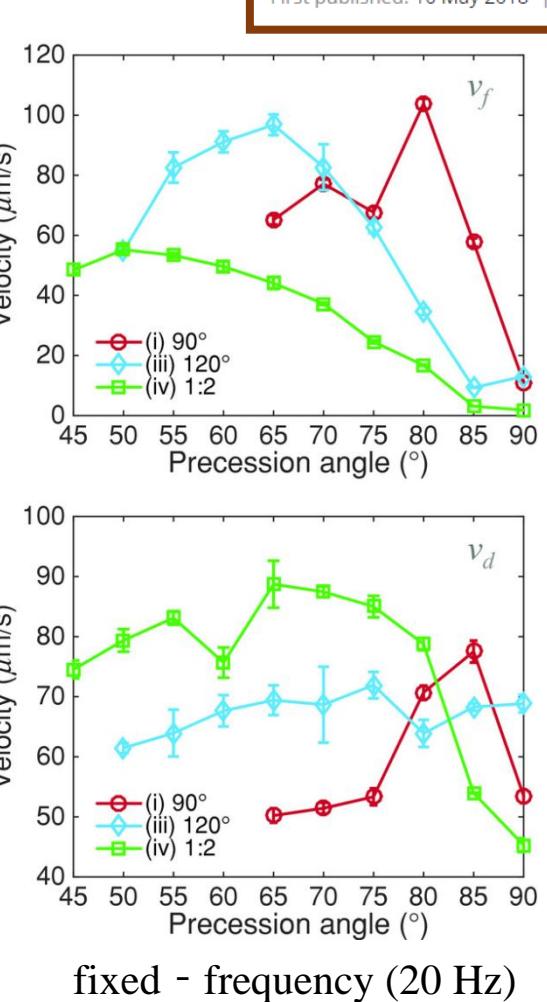
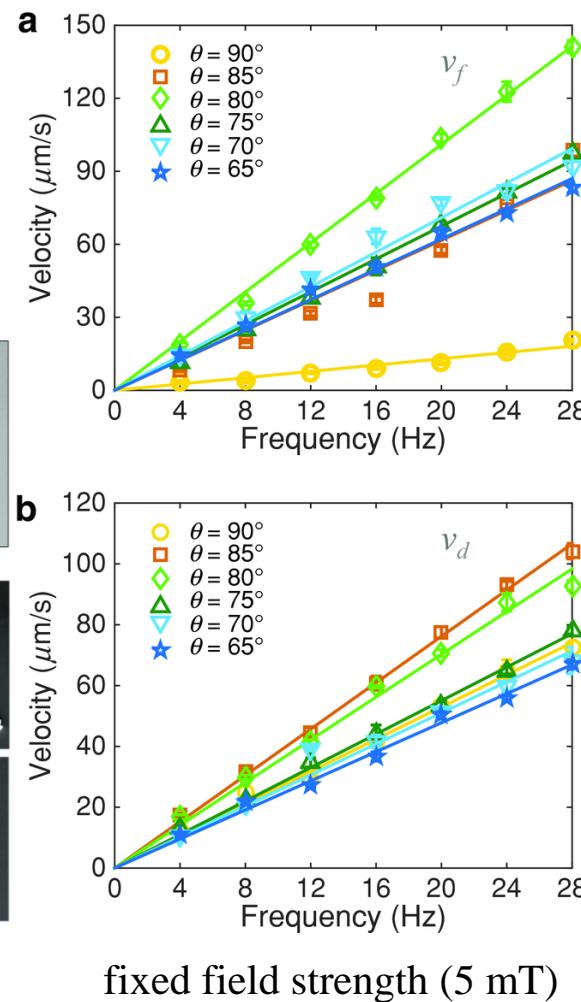
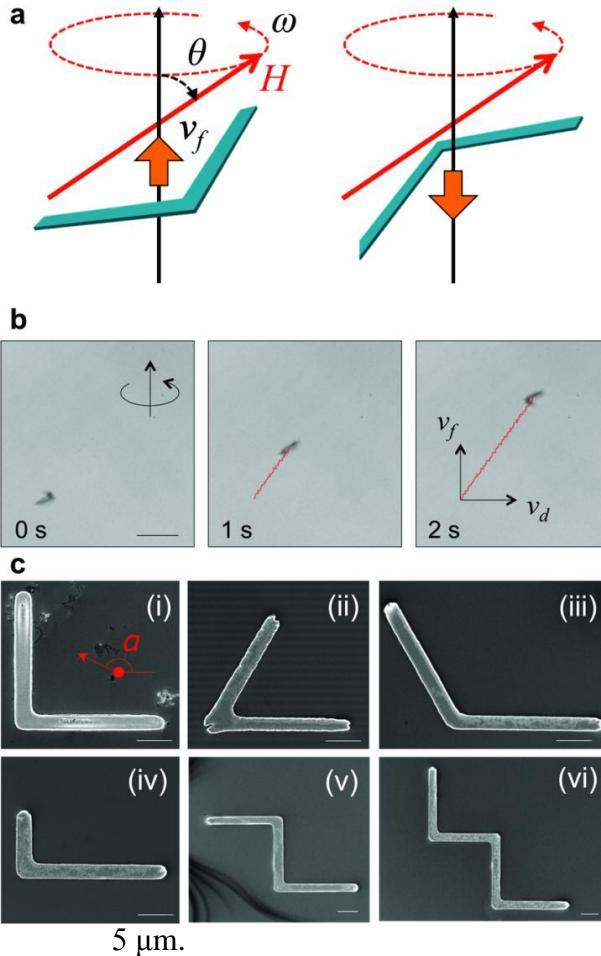
Crease patterns (CP)



Design: Origami Inspired Micro/Nano Composites



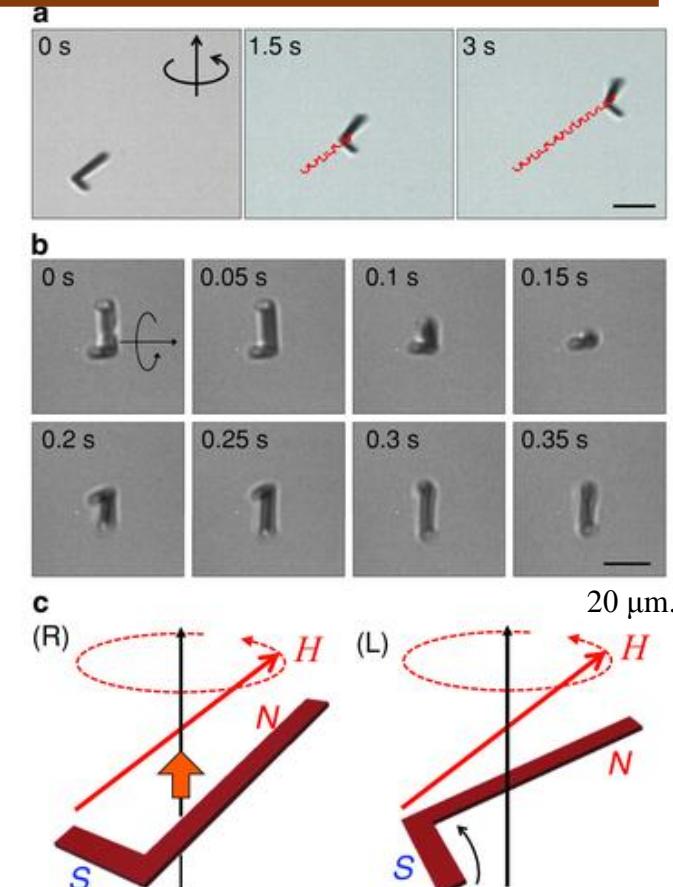
Controlled Propulsion Properties



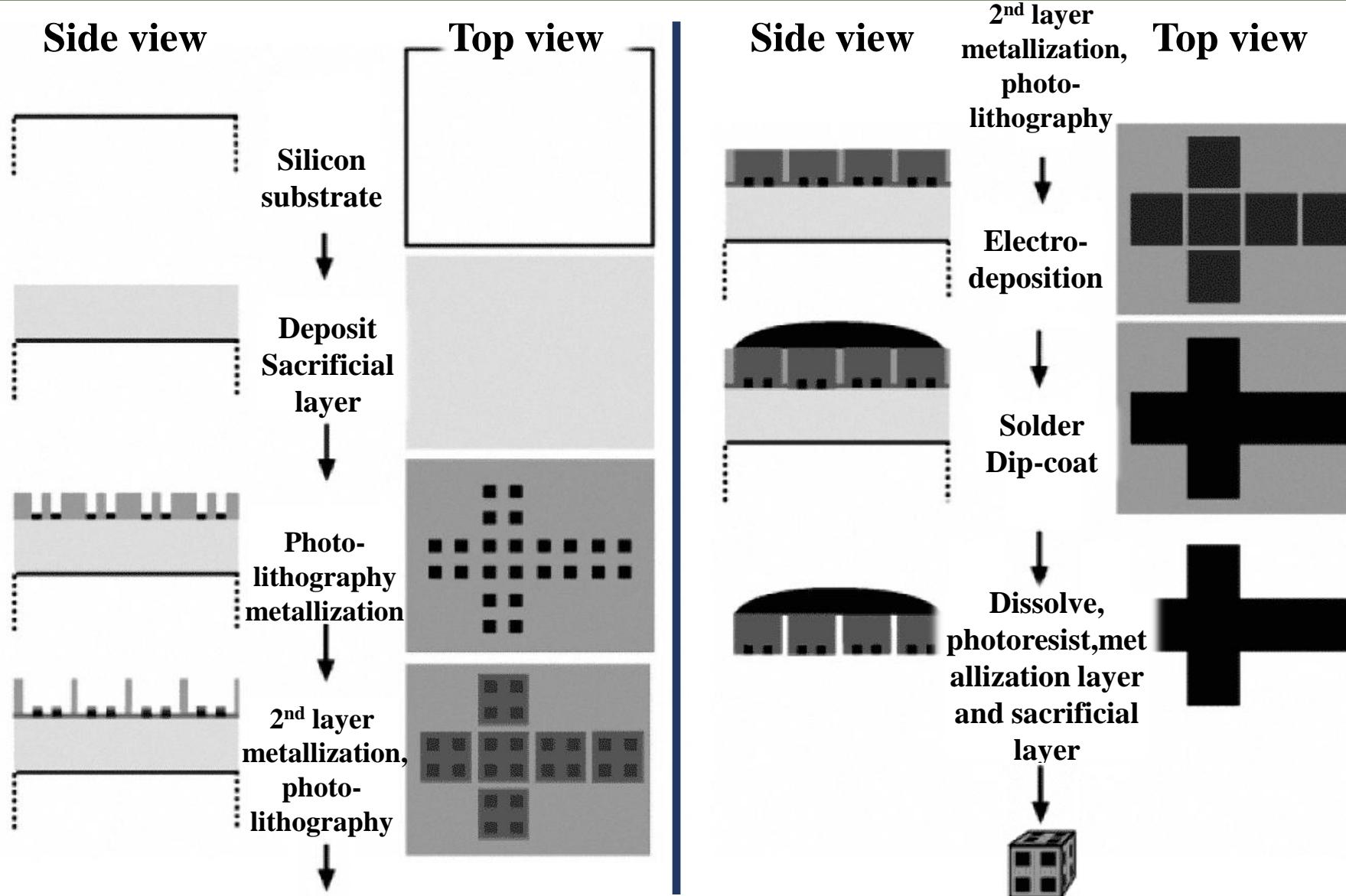
Controlled Propulsion of Two-Dimensional Microswimmers in a Precessing Magnetic Field

Soichiro Tottori ✉, Bradley J. Nelson ✉

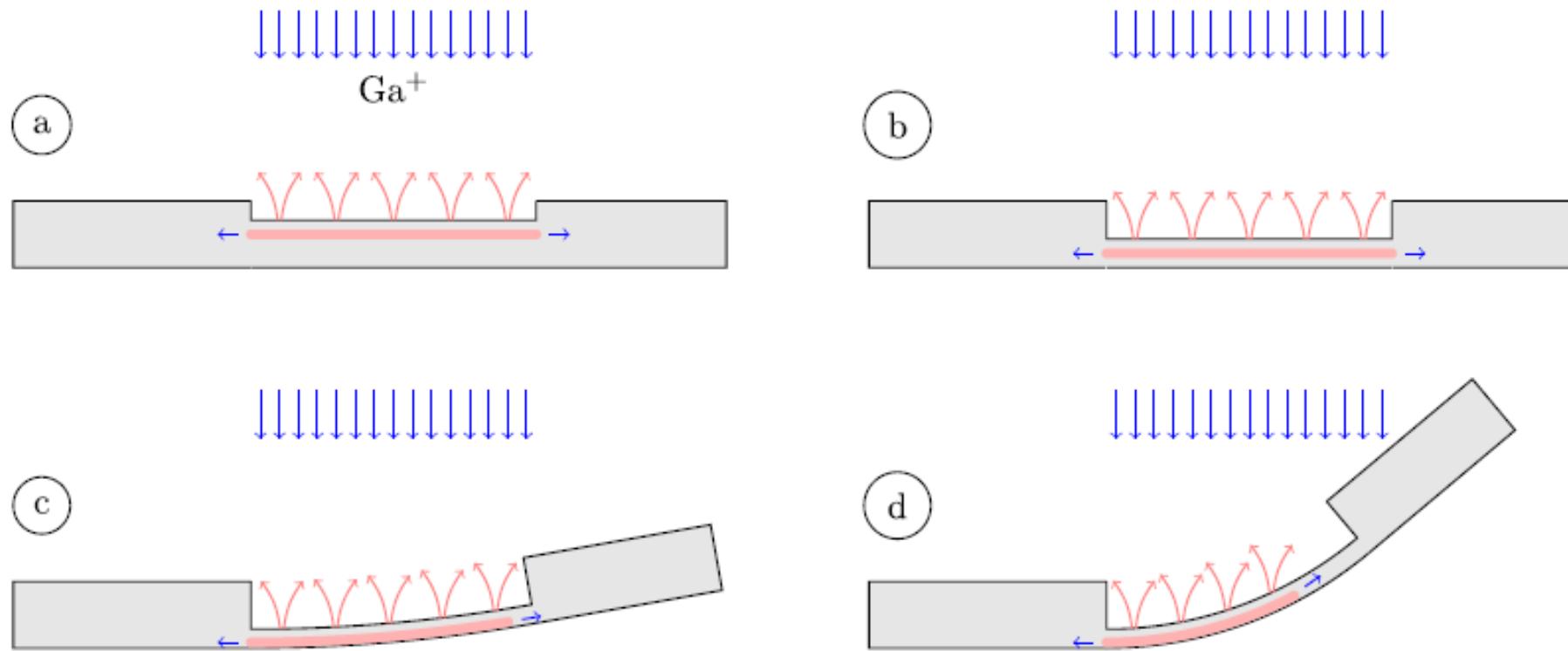
First published: 10 May 2018 | <https://doi.org/10.1002/smll.201800722>



Fabrication Methods ②



Fabrication Methods ①



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Fabrication Methods ③: DNA Origami

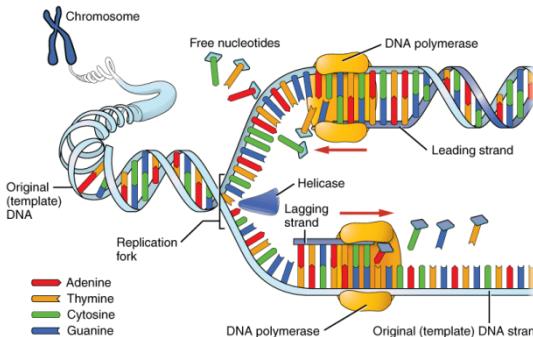
Design (caDNAno®)



(caDNAno®)



Verify (Cando®)



Online Simulation Website for DNA Origami
canDo

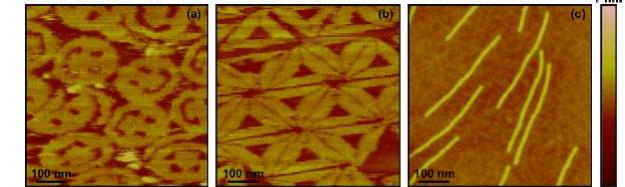
Synthesis (PCR)

PCR(Polymerase Chain Reaction)
Annealing

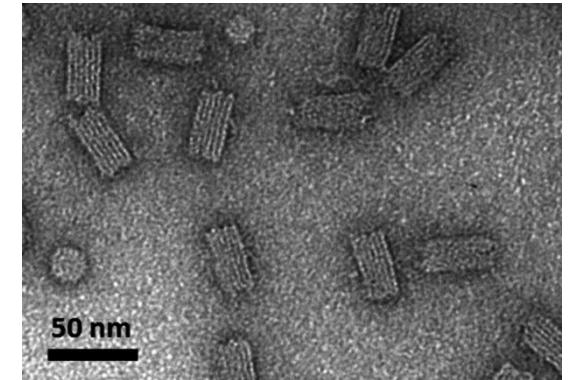


View Results

AFM



TEM



Future Work

1. Analysis its material properties.
2. Study the swimming swimming performance.
3. Design more shape and functions.

Thanks for listening !
Q&A