Ionic spiderwebs

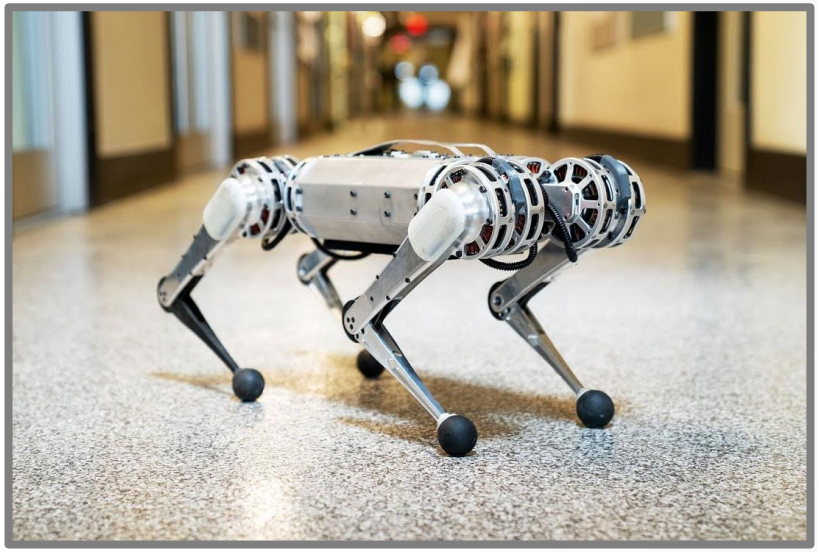
Seoul National University

Multi-functional Soft Materials Lab

Won Jun Song

Machine vs Robot

Machine



Robot

Machine vs Robot

Machine

Robot

Machine vs Robot

Machine

Robot

Machine vs Robot

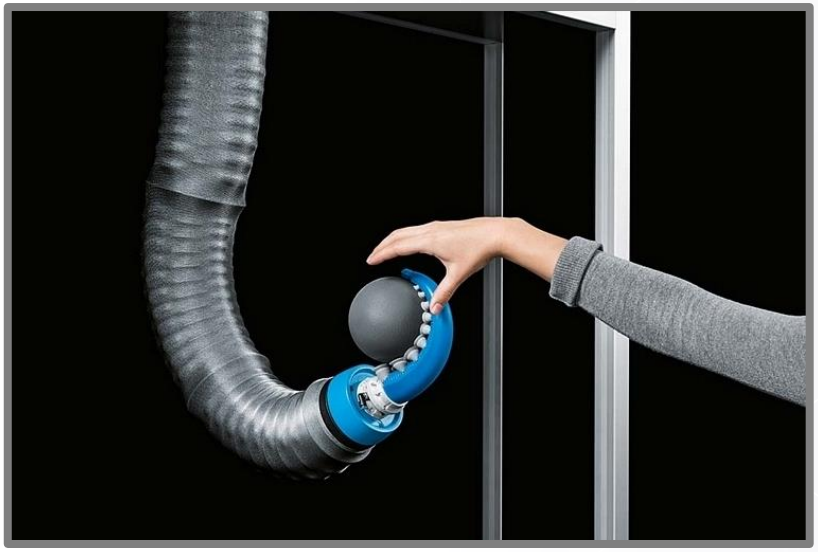
"A robot is a machine that replicates some features of humans or animals"

Goerge M . Whitesides

Soft Robotics, George M. Whitesides, Angewandte Chemie, 57, 4258-4273 (2018)

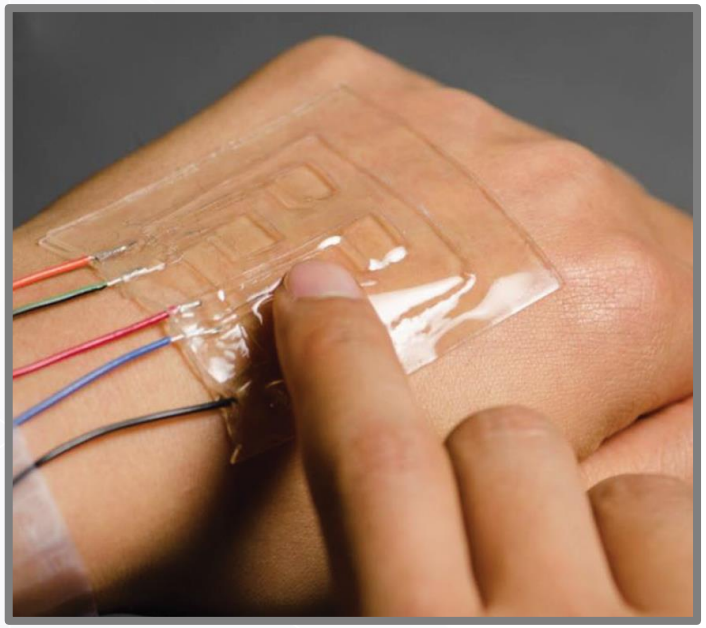
Soft Robotics

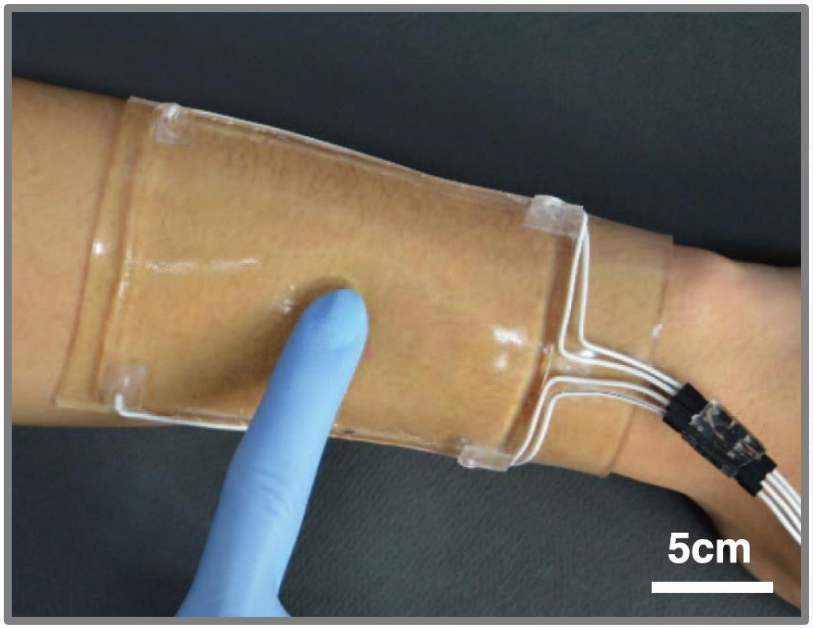
Rigid Robot



Soft Robot

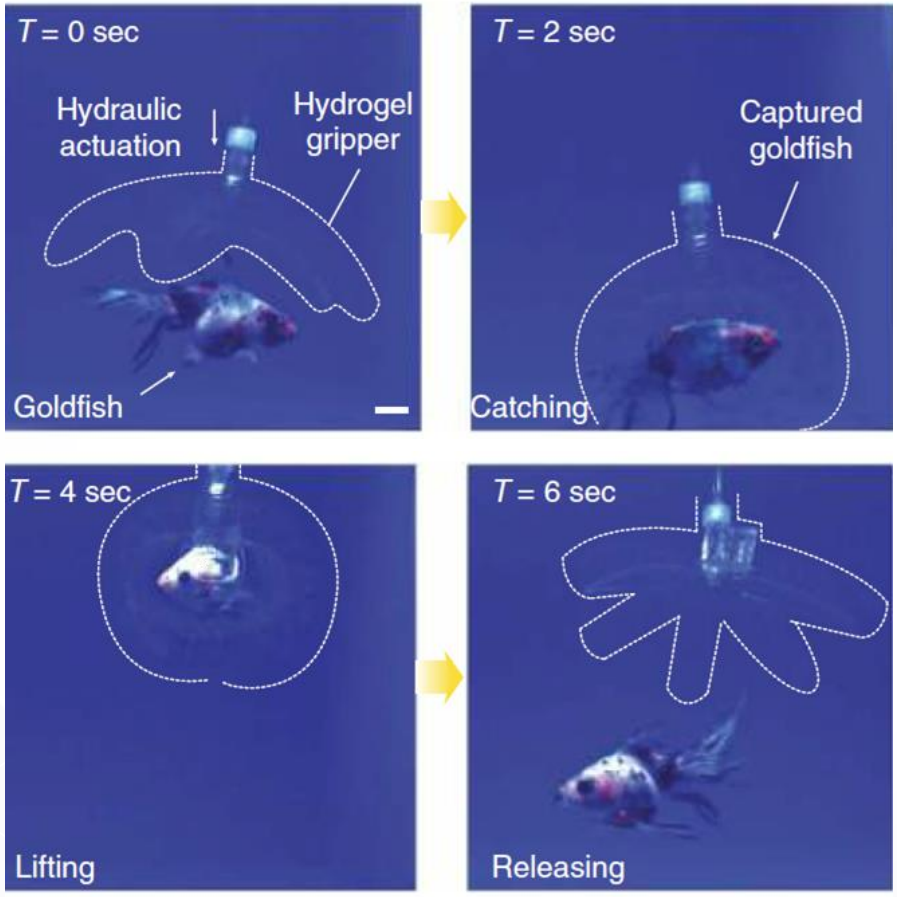
Soft Robotics





Ionic skin, Jeong-Yun Sun et. al, Advanced Materials, 26, 7608-7614 (2014)
Highly stretchable, transparent ionic touch panel, Chong-Chan Kim, et.al, Science, 353, 682-687 (2016)

Soft Robotics



Hydraulic hydrogel actuators and robots optically and sonically camouflaged in water, Hyunwoo Yuk, Nature Communications, 8, 14230 (2017)

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Stretchable, transparent spiderwebs

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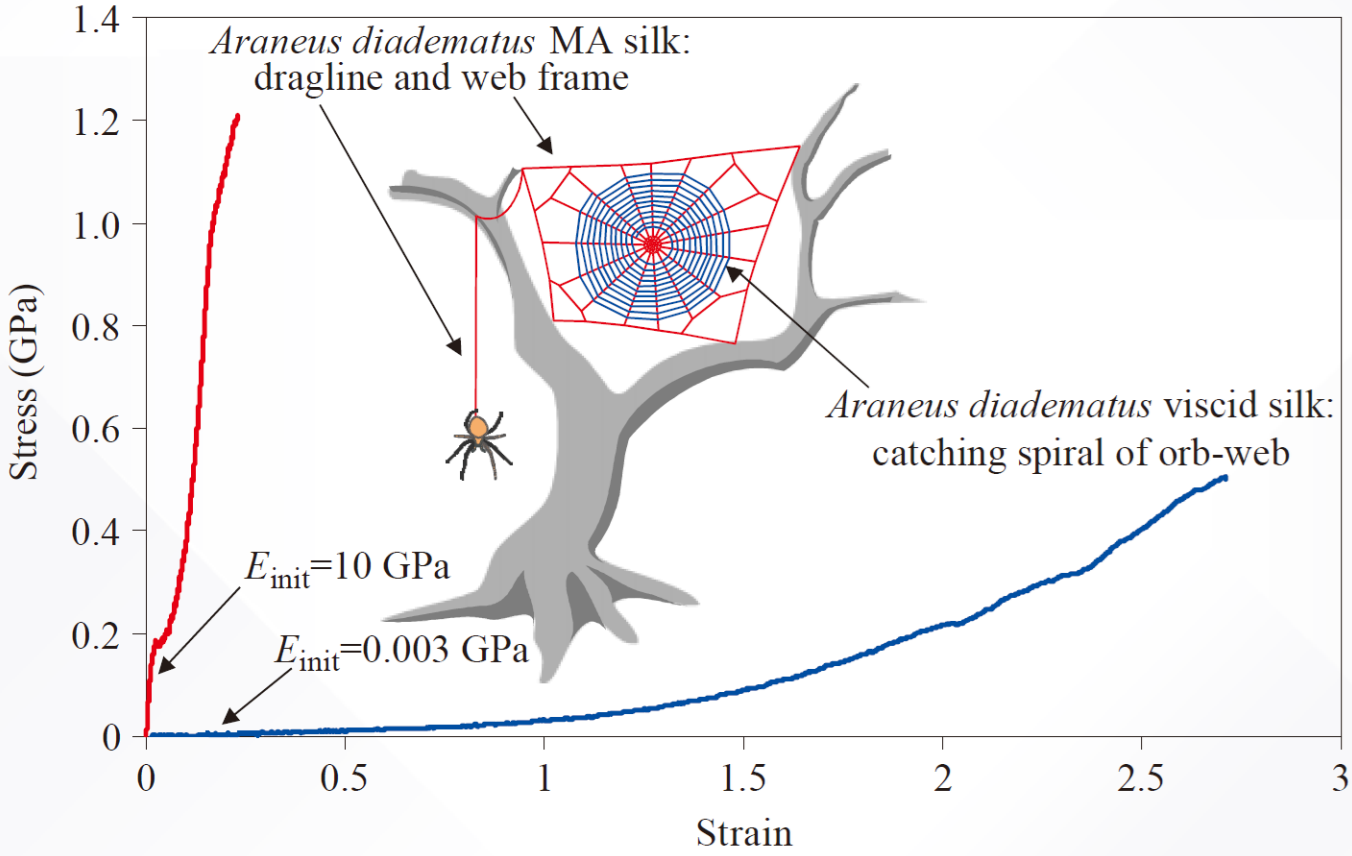
Major Ampullate Silk Gland		structural and dragline silk

The elaborate structure of spider silk, Lin Romer, et.al, Prion, 2:2 154-161 (2008)

Stretchable, transparent spiderwebs

Strength and structure of spiders' silks, Fritz Vollrath, Reviews in Molecular Biotechnology, 74 67-83 (2000)

Stretchable, transparent spiderwebs



The mechanical design of spider silks: from fibrion sequence to mechanical function
J. M. Gosline, et.al, The Journal of Experimental Biology, 202 3295-3303 (1999)

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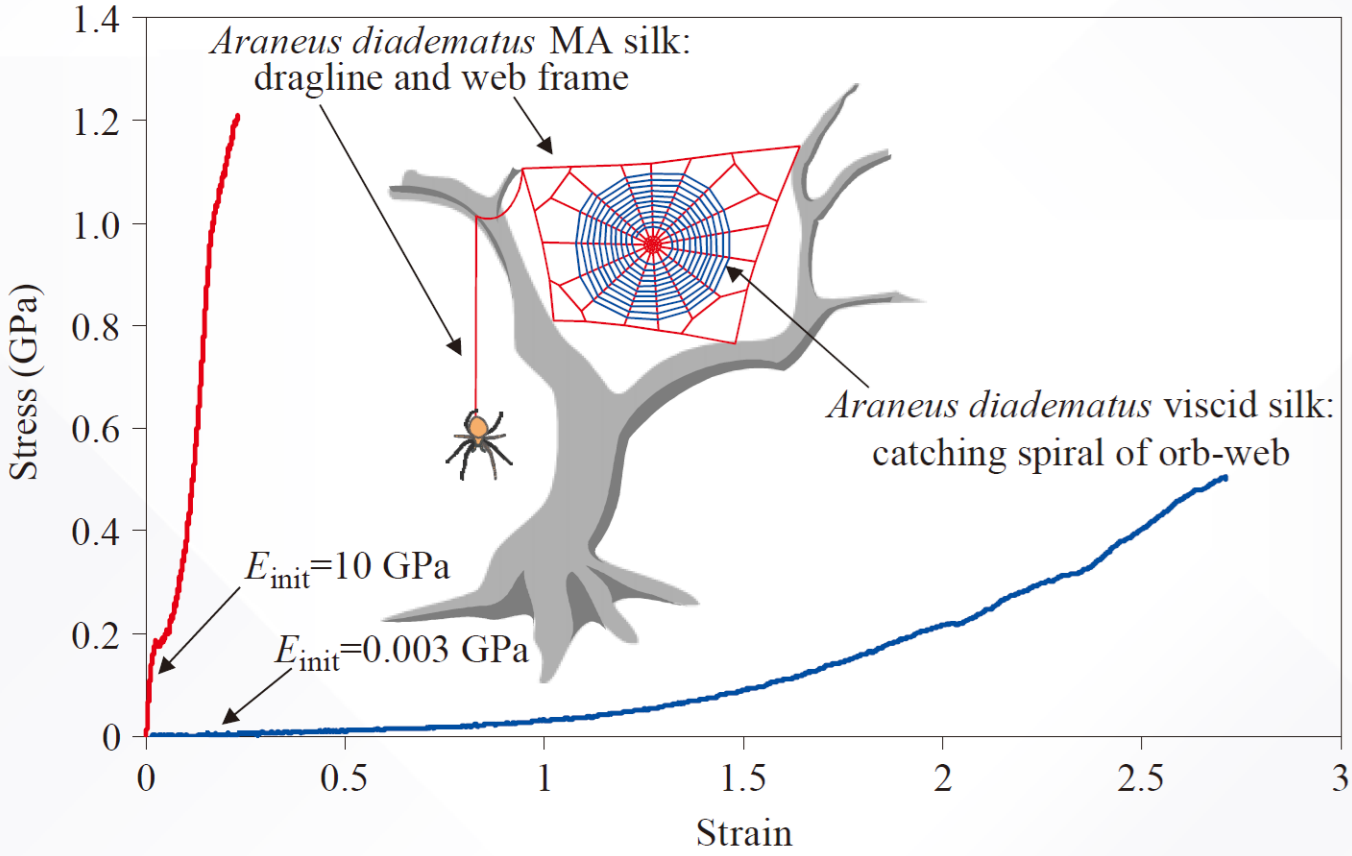

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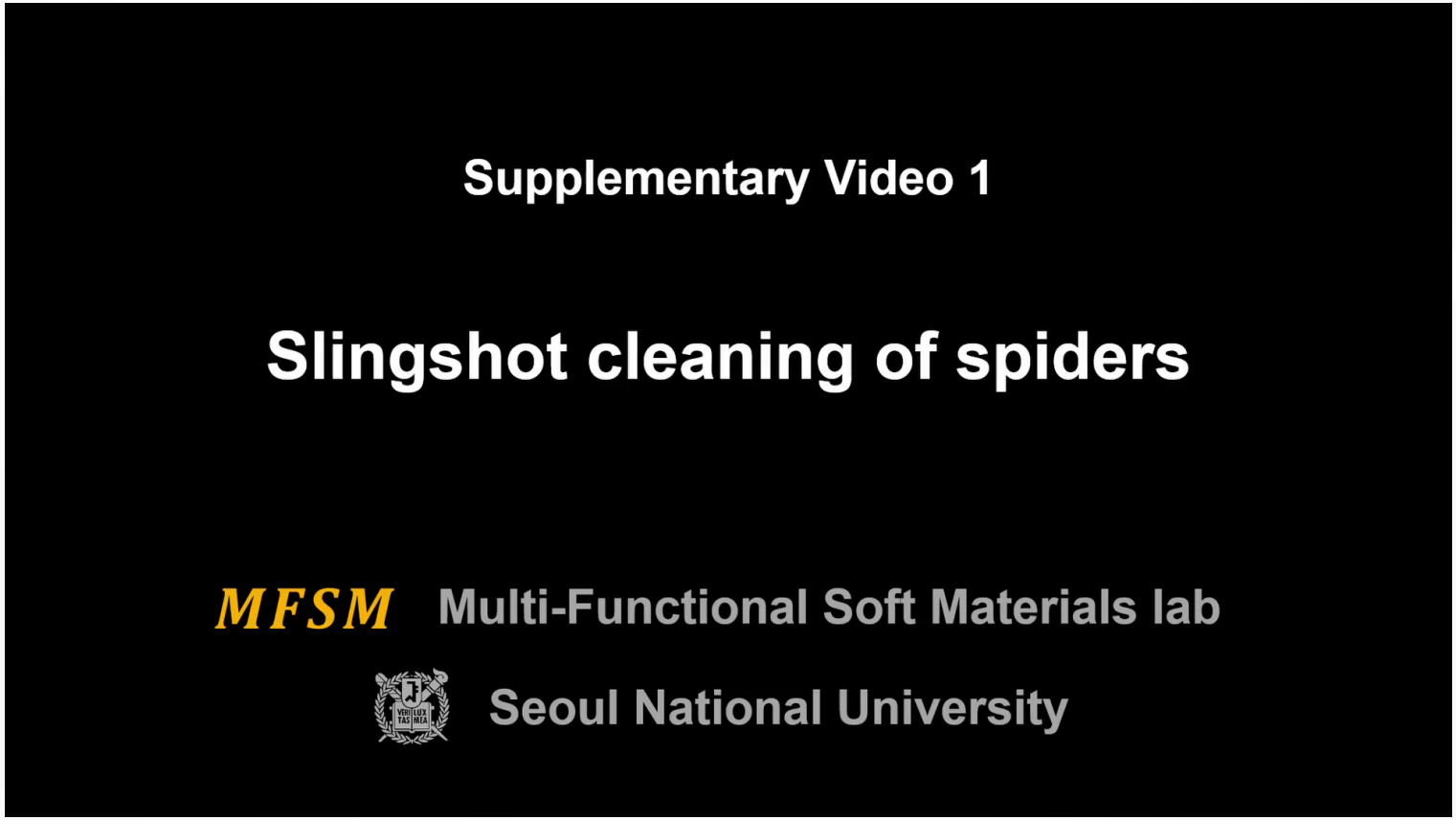
Stretchable, transparent spiderwebs

Stretchable, transparent spiderwebs

Strategies of spiders to minimize the contamination

https://www.youtube.com/watch?v=xzhpoLmdZAI&t=333s

Strategies of spiders to minimize the contamination



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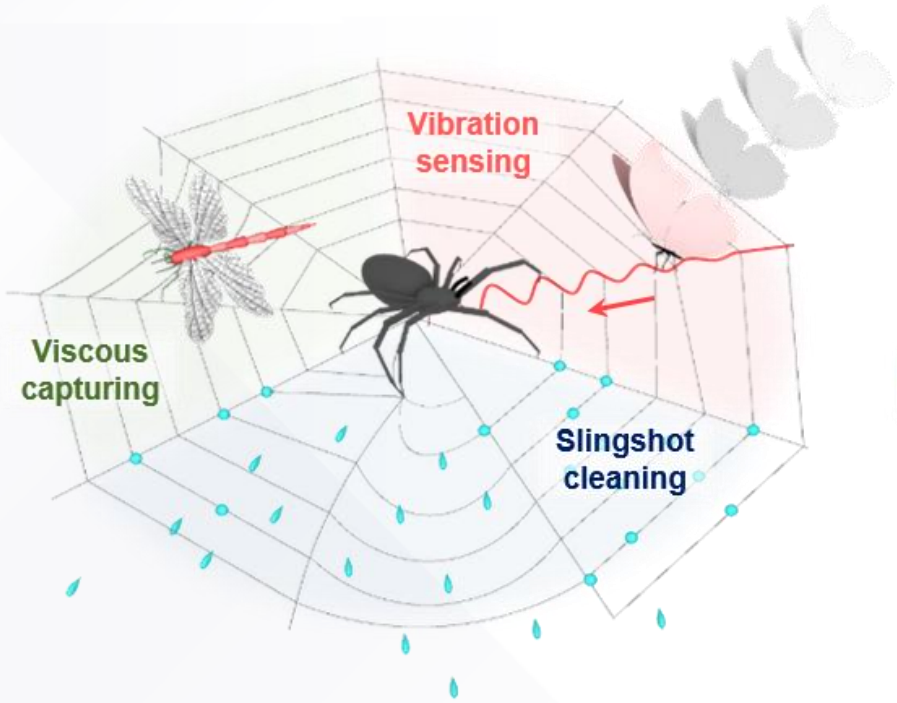
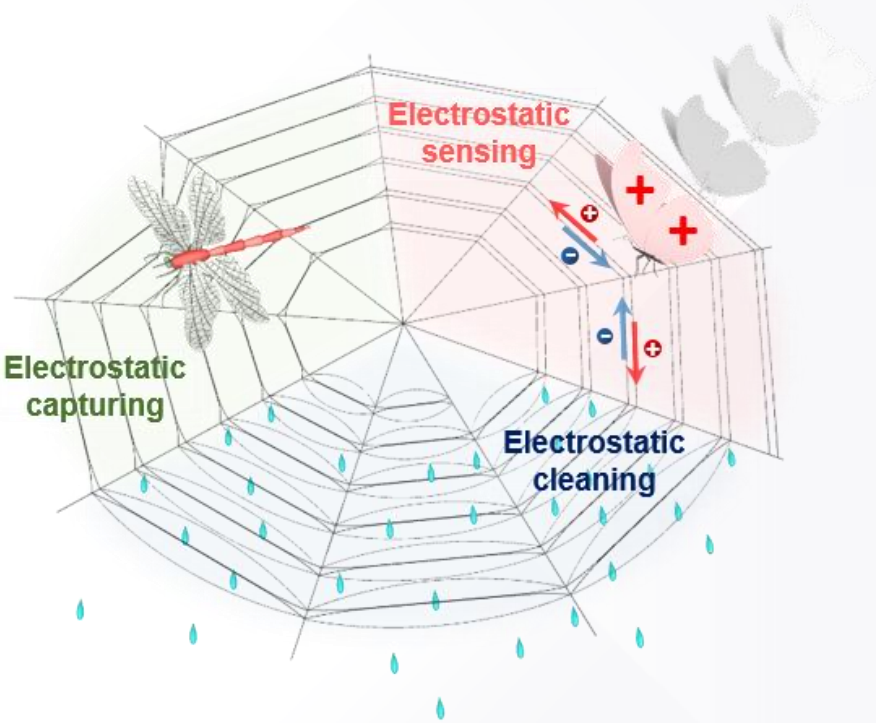
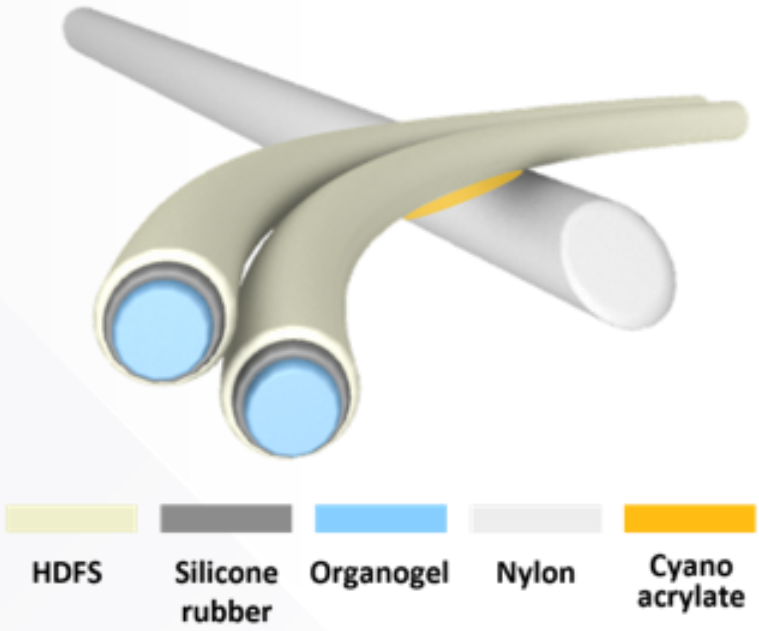
Strategies of spiders to minimize the contamination

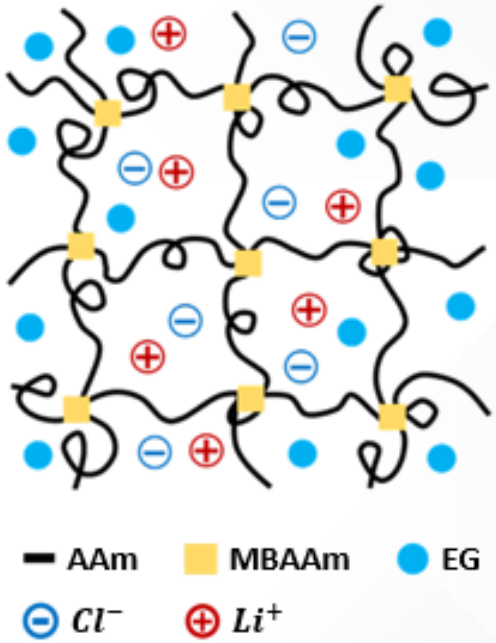




Submitted

Electrostatic adhesion capturing





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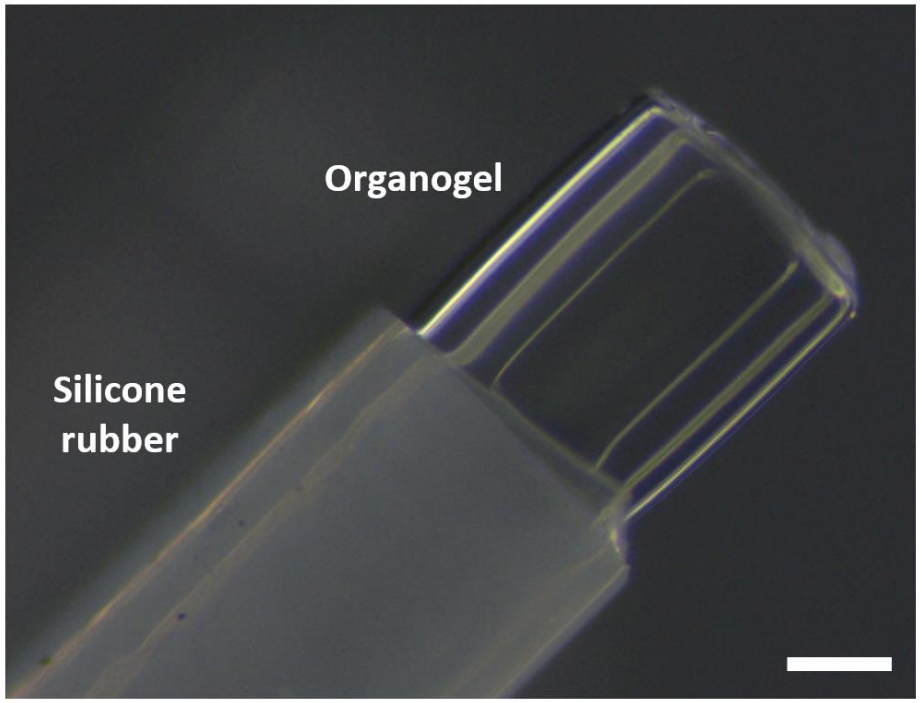

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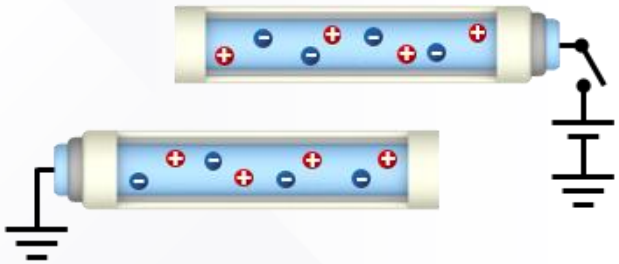
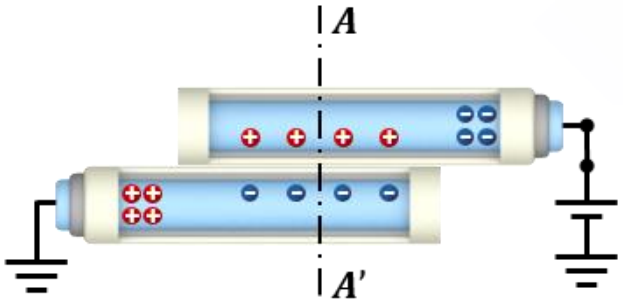


OFF-state
$(V_{excitation} = 0)$



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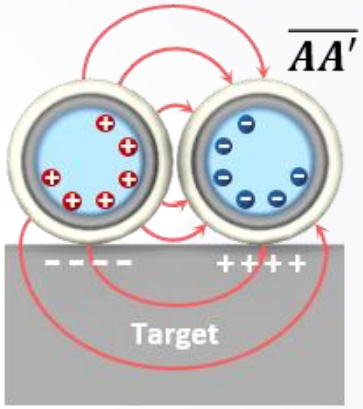

Cross section

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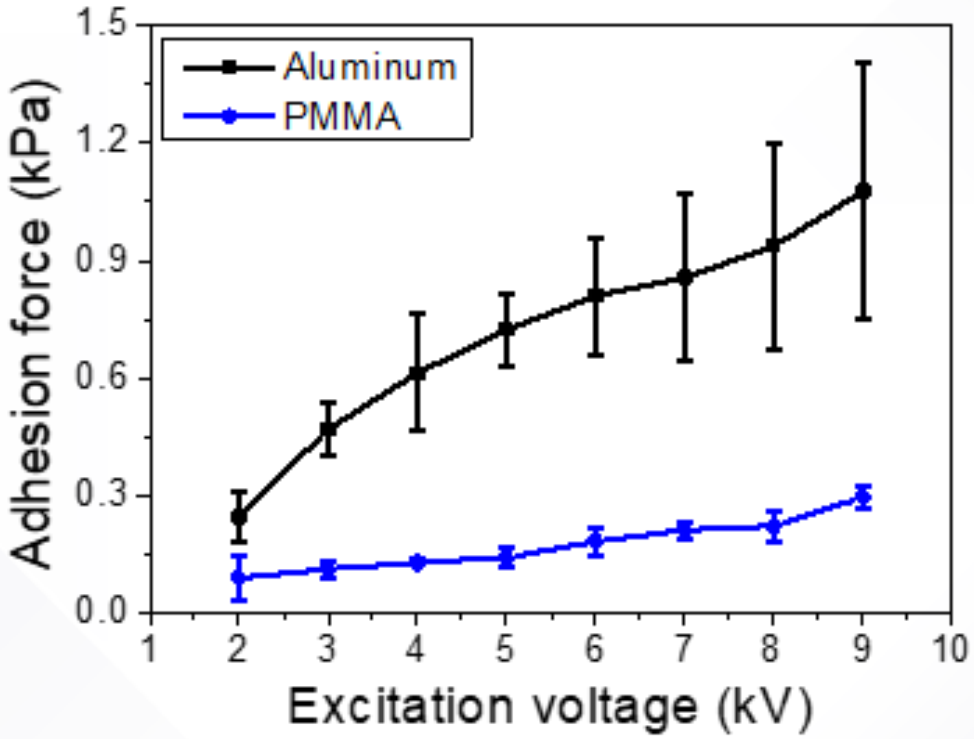
Electrostatic adhesion capturing



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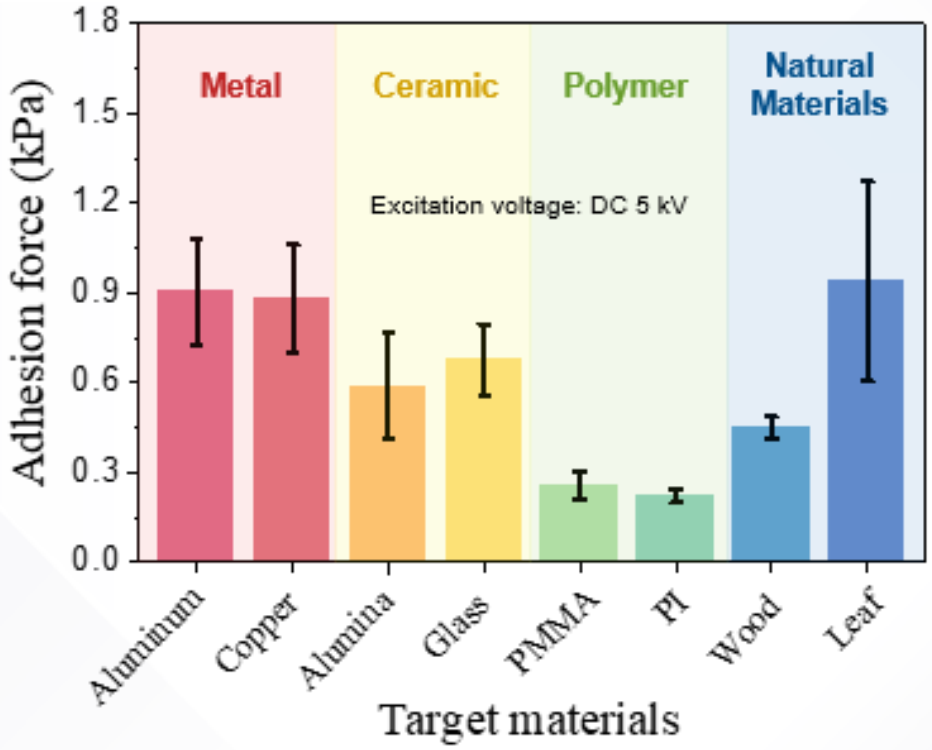

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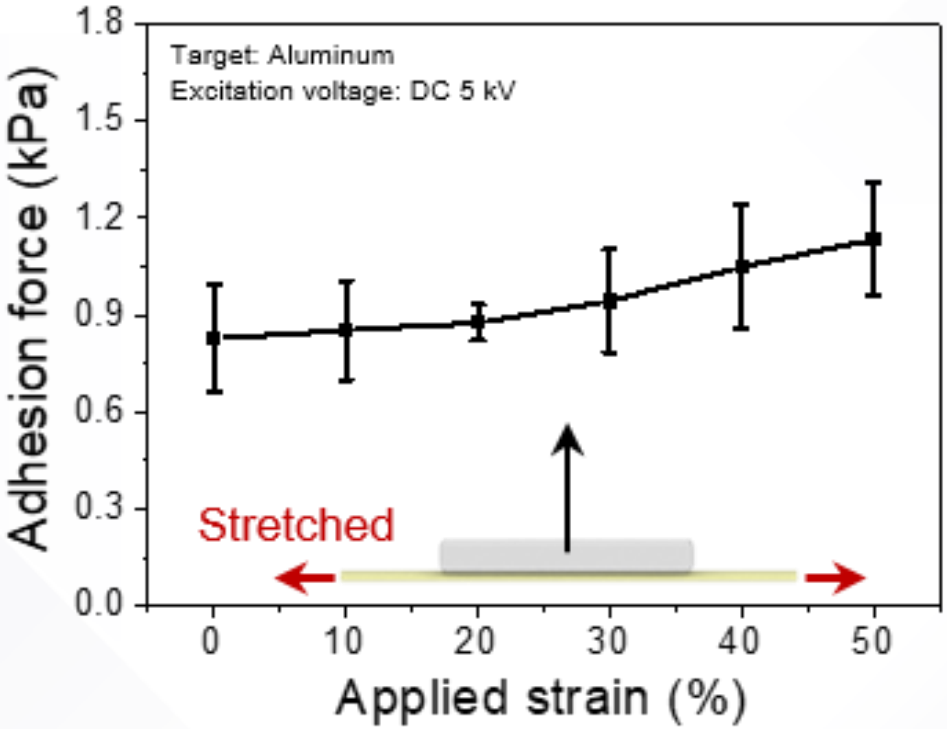
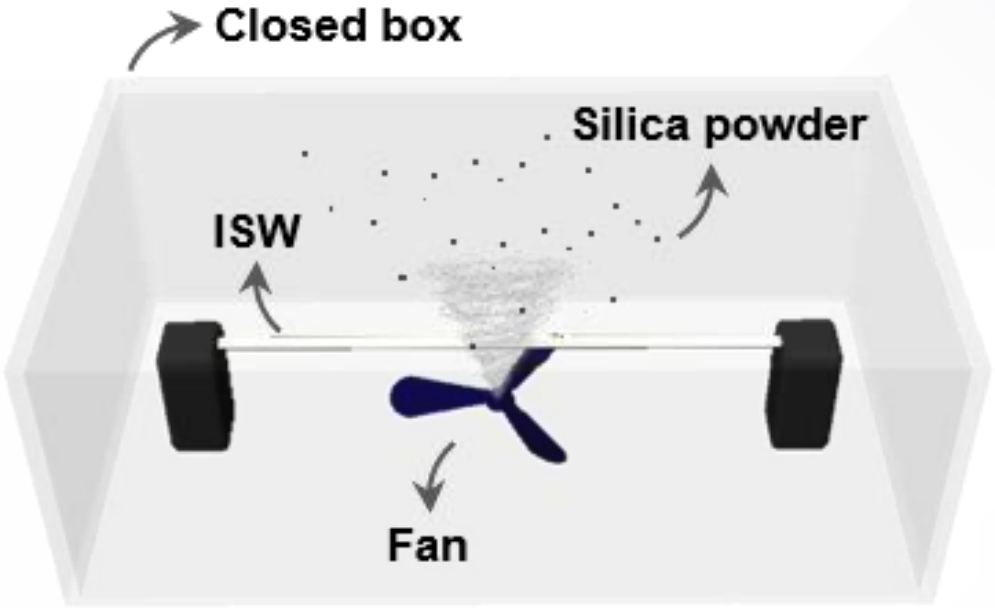


Submitted

Electrostatic adhesion capturing

Submitted

Electrostatic induction sensing



Accelerated contamination test system

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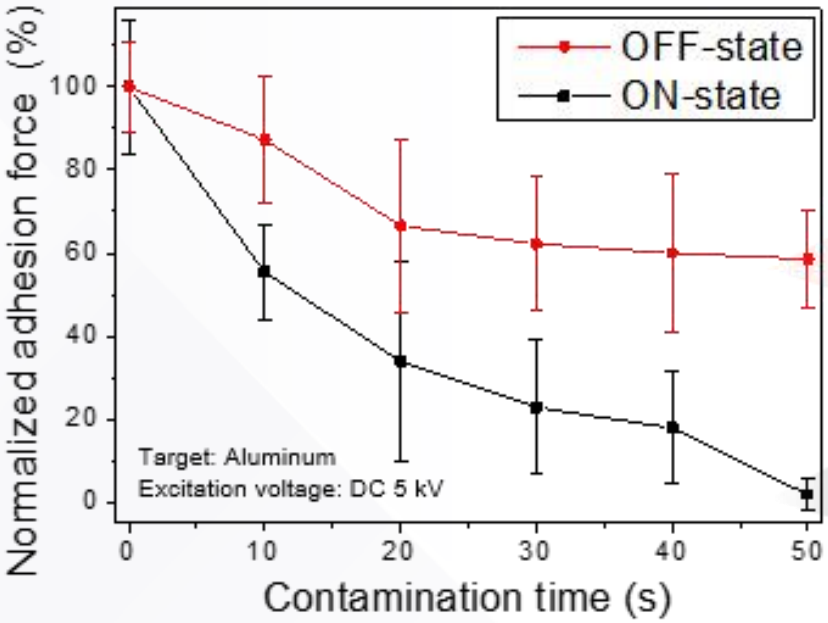
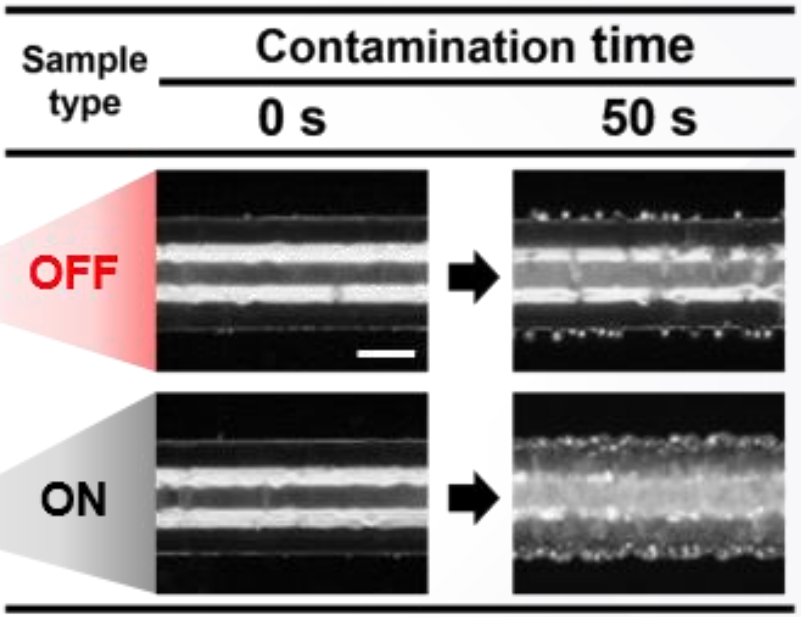
Electrostatic induction sensing





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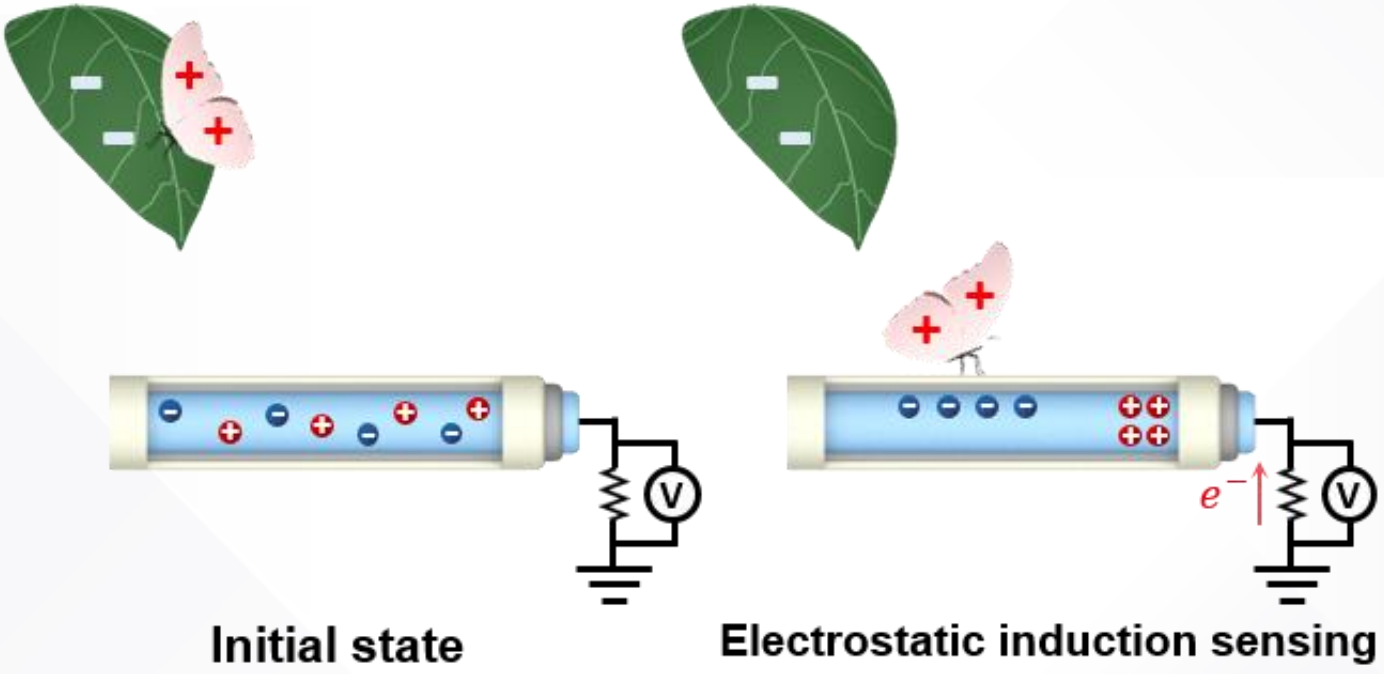

Initial state

Electrostatic induction sensing

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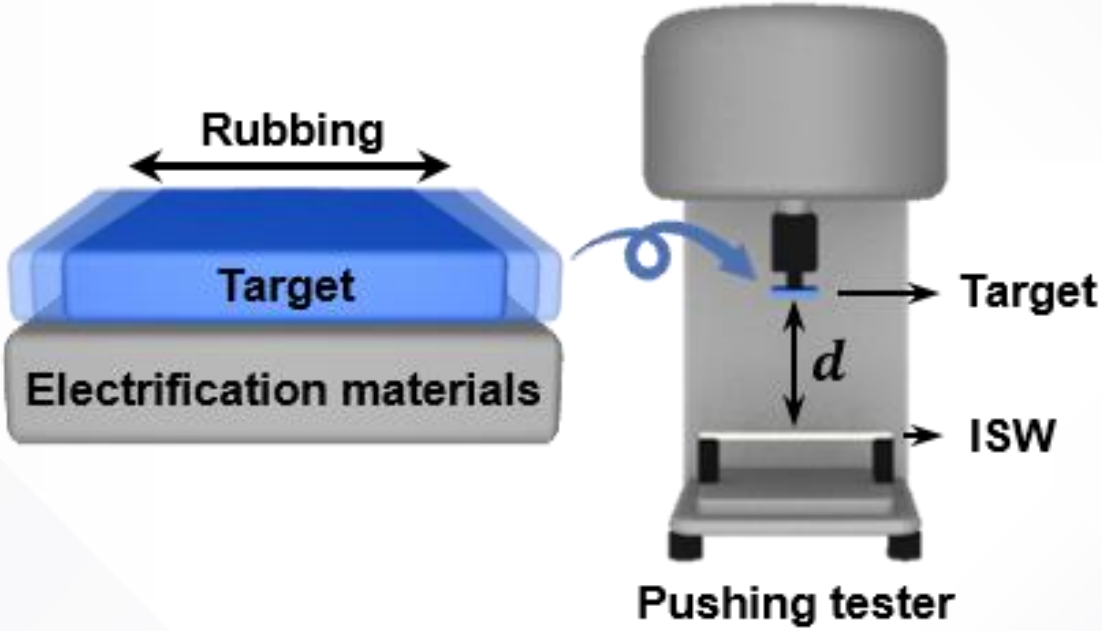
Electrostatic induction sensing



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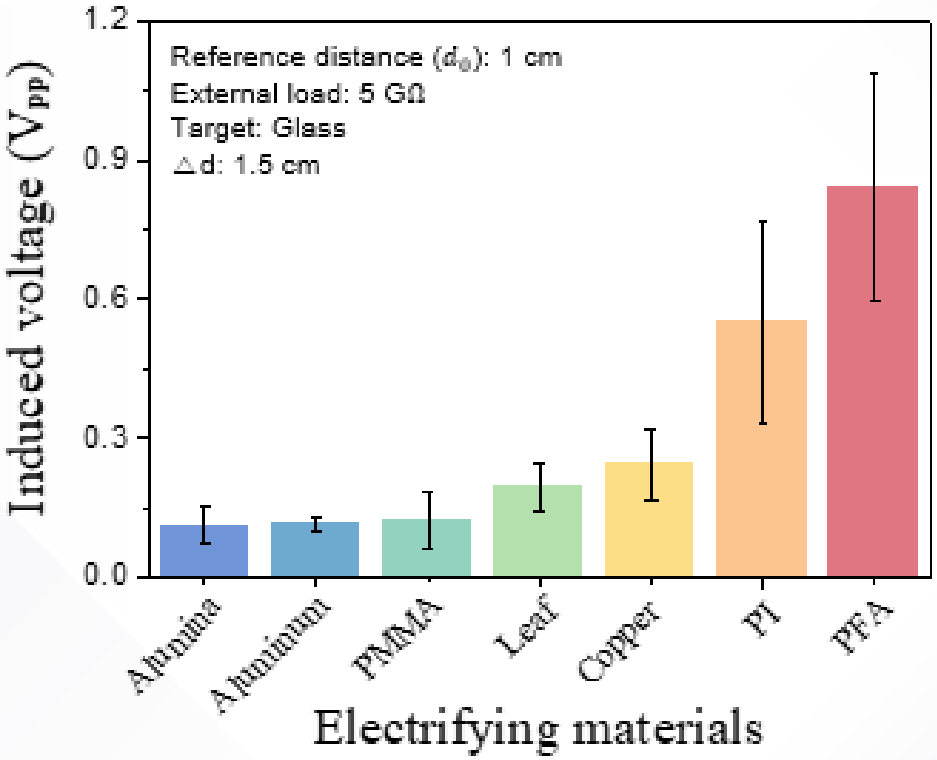

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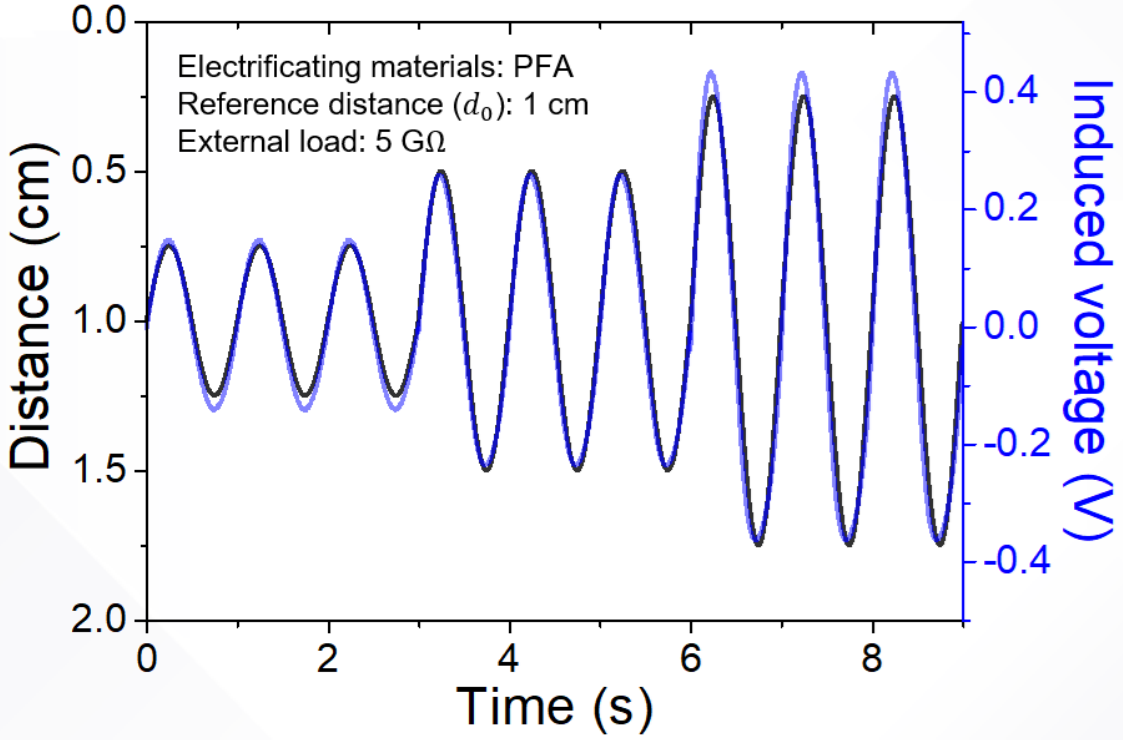

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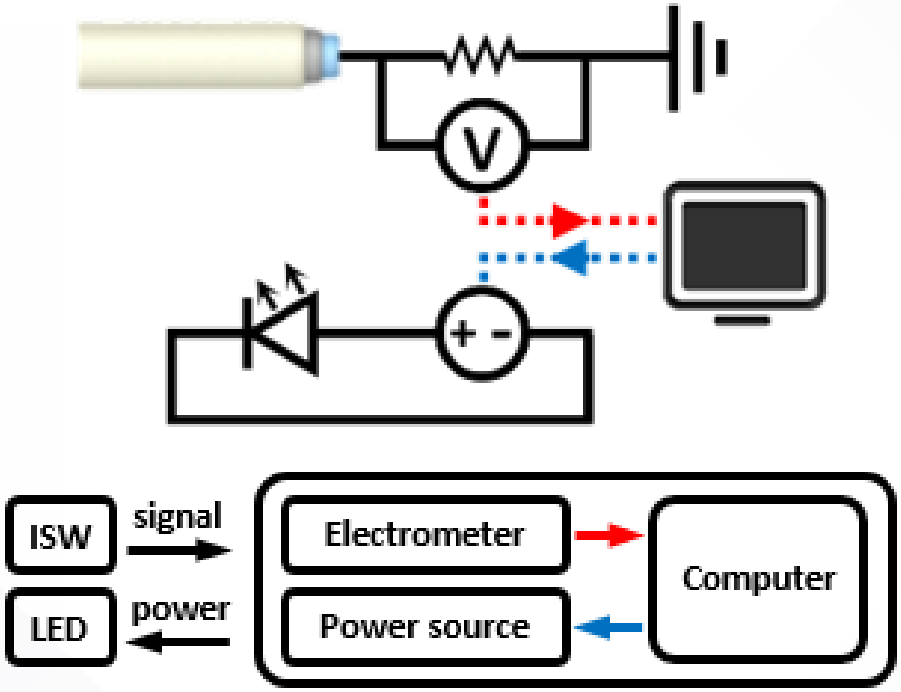


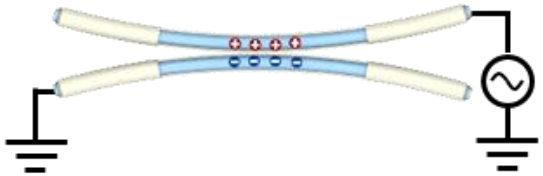
Submitted

Electrostatic induction sensing

Submitted

Electrostatic vibration cleaning

Initial, $V_{input} = 0$

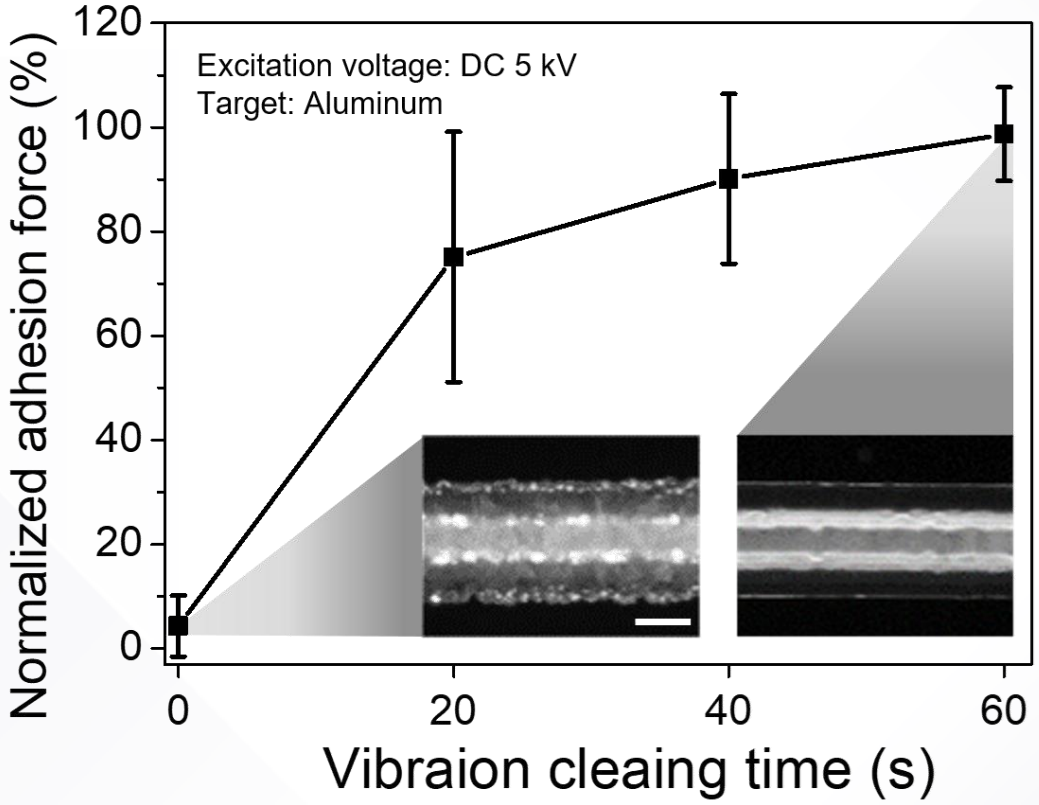


Attracted, $V_{input} > 0$

Released, $V_{input} \to 0$

Submitted

Electrostatic vibration cleaning



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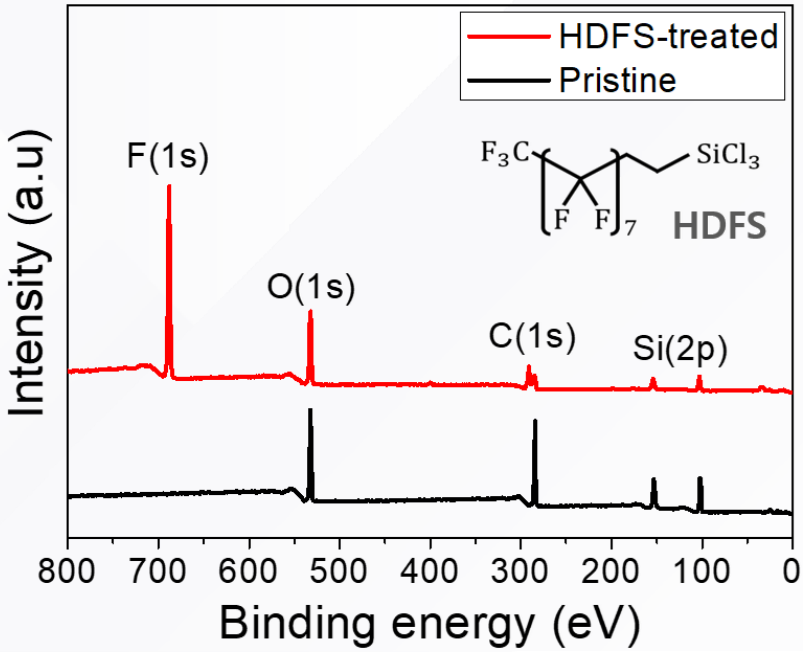
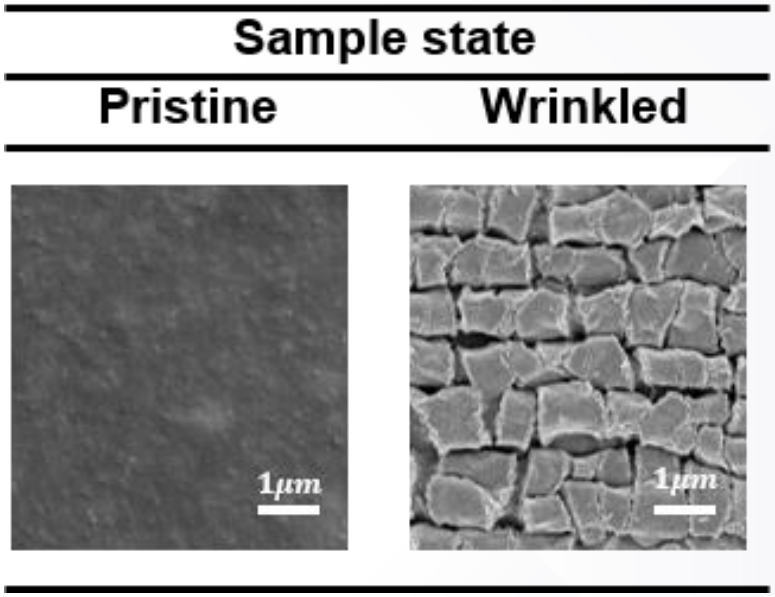
Electrostatic vibration cleaning





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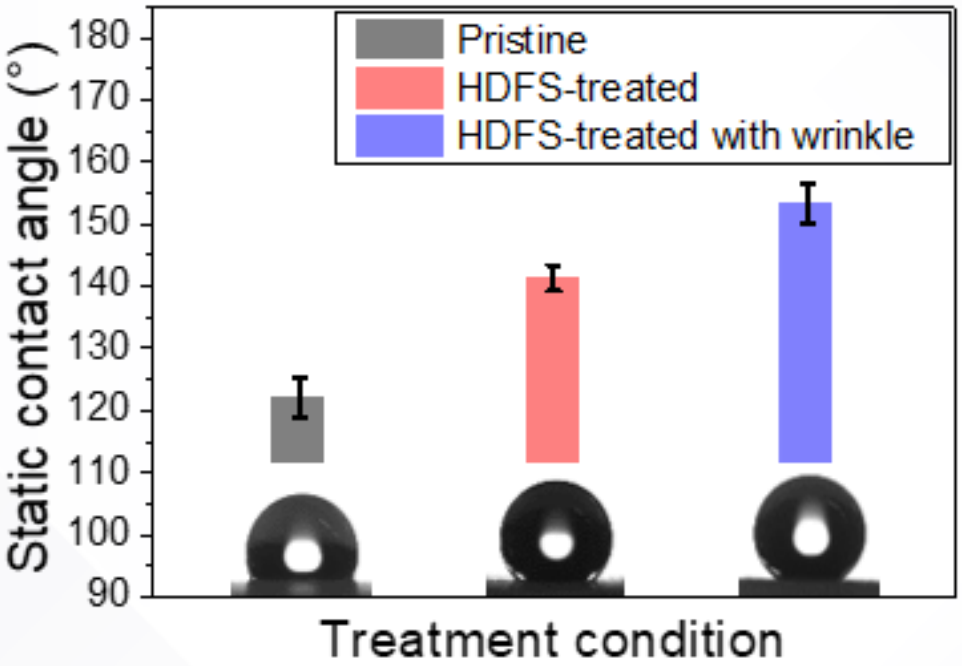

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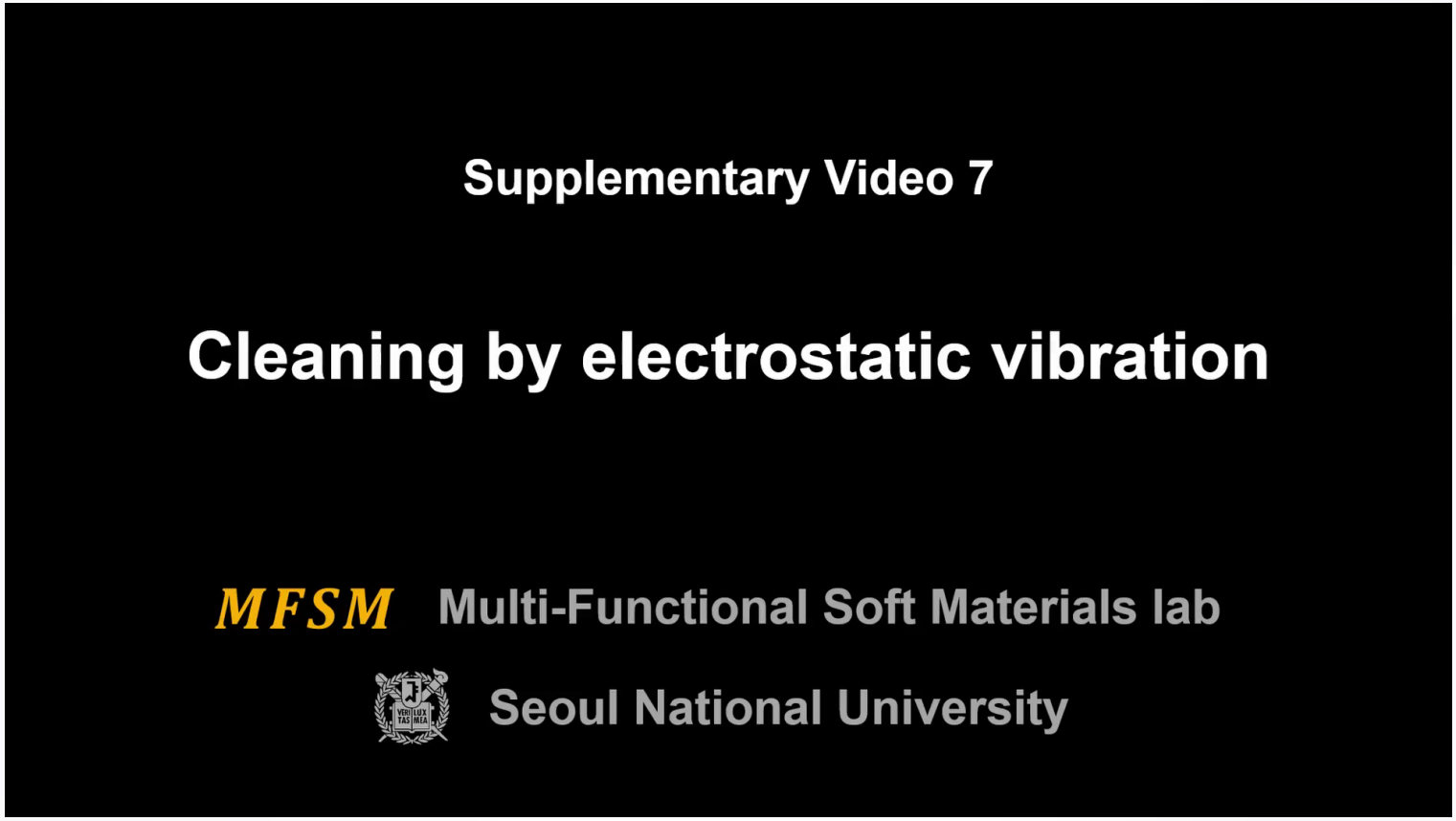

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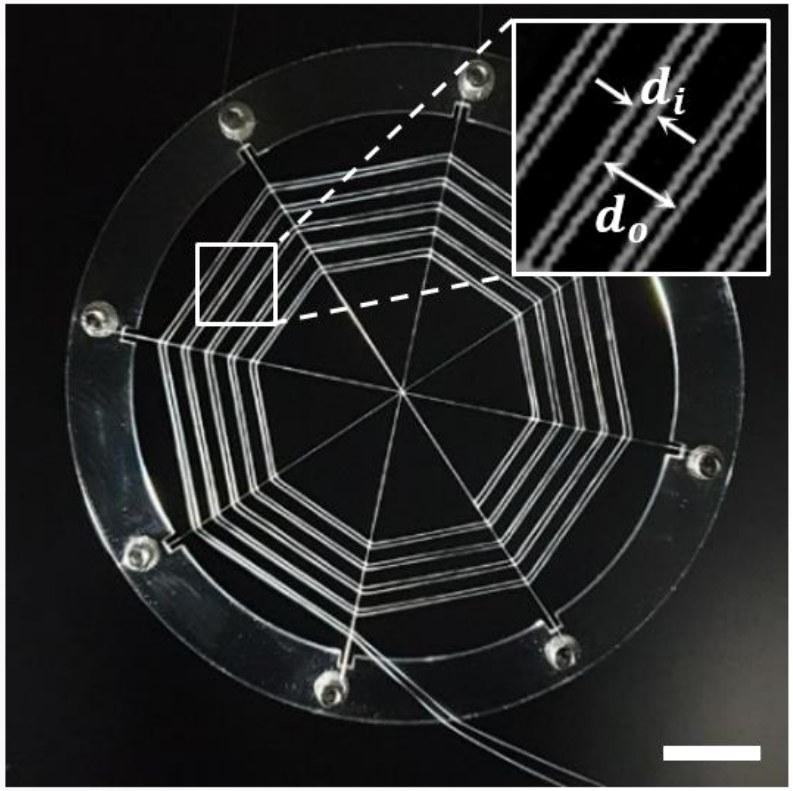
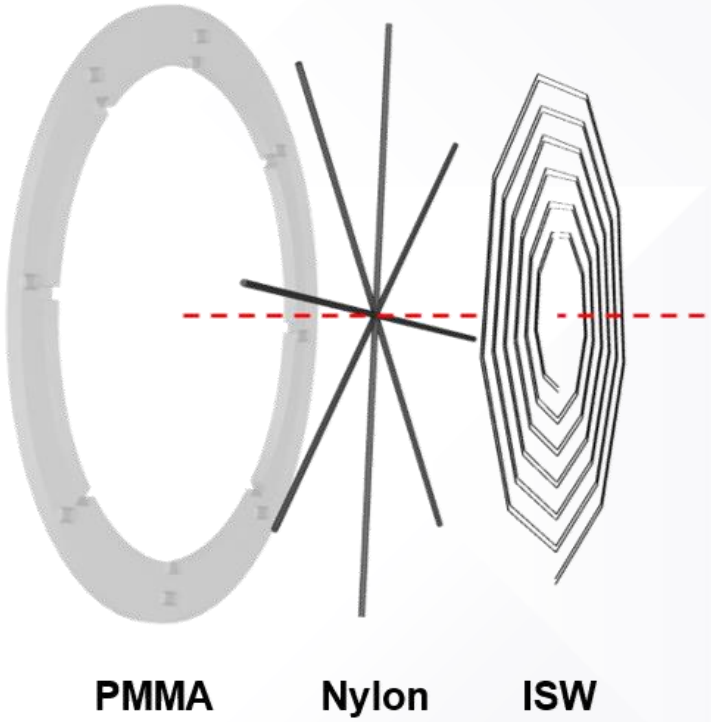
Ionic spiderwebs





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Ionic spiderwebs

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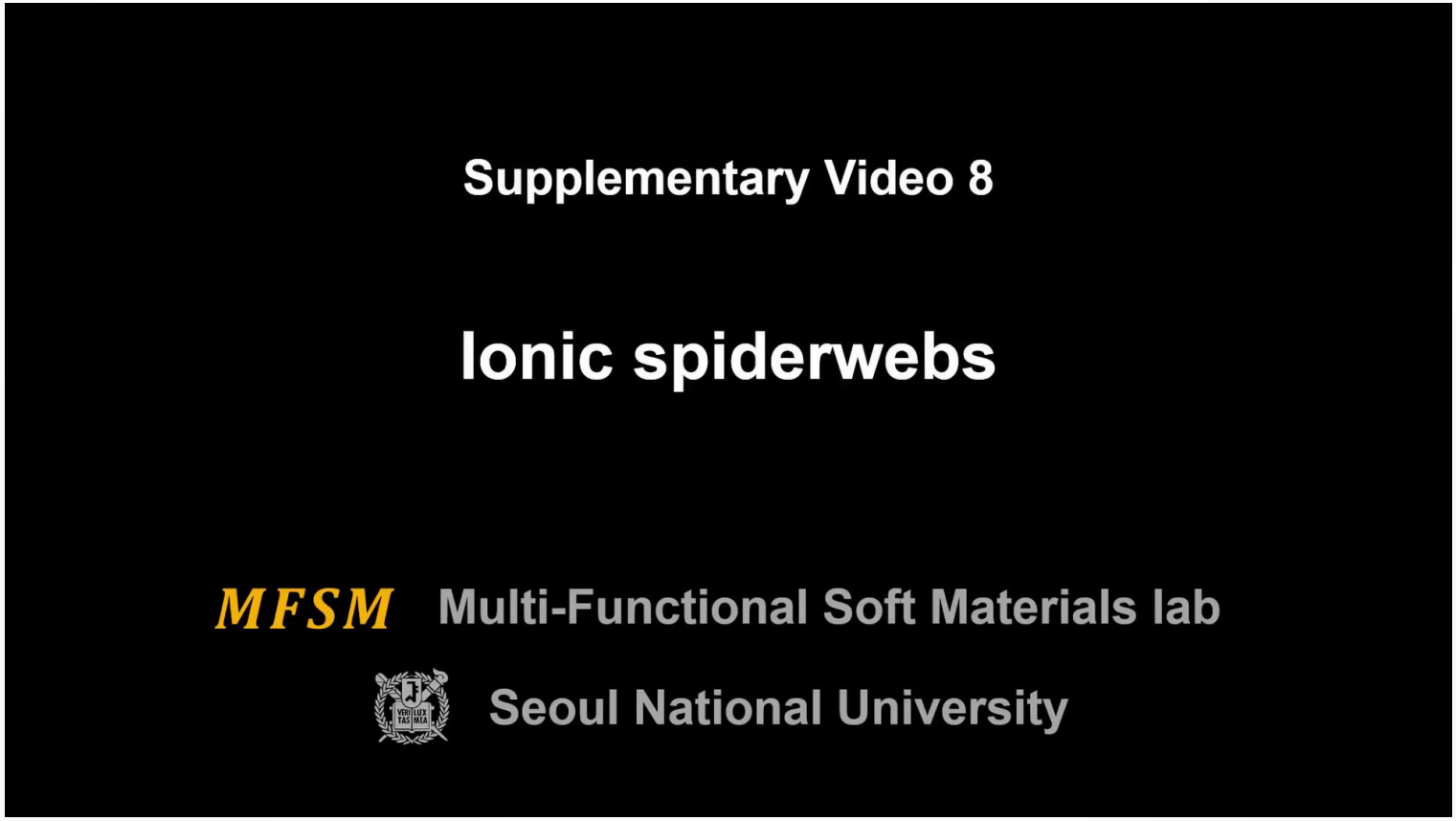

Submitted

Ionic spiderwebs

Capturing

Essential function of the web
but causing contaminations by adhesion

Spiderweb	ISW
Viscous adhesion to capture preys	**Electrostatic adhesion** to capture targets
Stretchability to enhance adaptability	**Stretchability** to enhance adaptability
Translucency for passive camouflage	**Translucency** for passive camouflage
Reinforce the structure by structural silk	**Reinforce the structure** by nylon fiber

Submitted

Ionic spiderwebs

Sensing

Preventing contamination by minimizing the adhesion	
Spiderweb	**ISW**
Prevent contamination by building sparse initial webs	**Prevent contamination** by turning off the adhesion
Sense vibration caused by preys	**Sense voltage** caused by targets
Reinforce the adhesion by wrapping additional webs	**Reinforce the adhesion** by turning on the adhesion

Submitted

Ionic spiderwebs

Cleaning

Recovering adhesion by eliminating contaminants	
Spiderweb	**ISW**
Use mechanical force to deform webs	**Use Maxwell force** to deform webs
Eliminate contaminants by releasing the webs	**Eliminate contaminants** by releasing the webs

Submitted

THANK YOU

SNU MSE MFSM 송원준