No more laundry?

An innovative and economical fabrication technique developed by HKU Scientists could make the dream come true!

衣物免洗終能實現?

港大科學家發明研發出理想化的防水防油物料

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https://www.nature.com/articles/ncomms15823

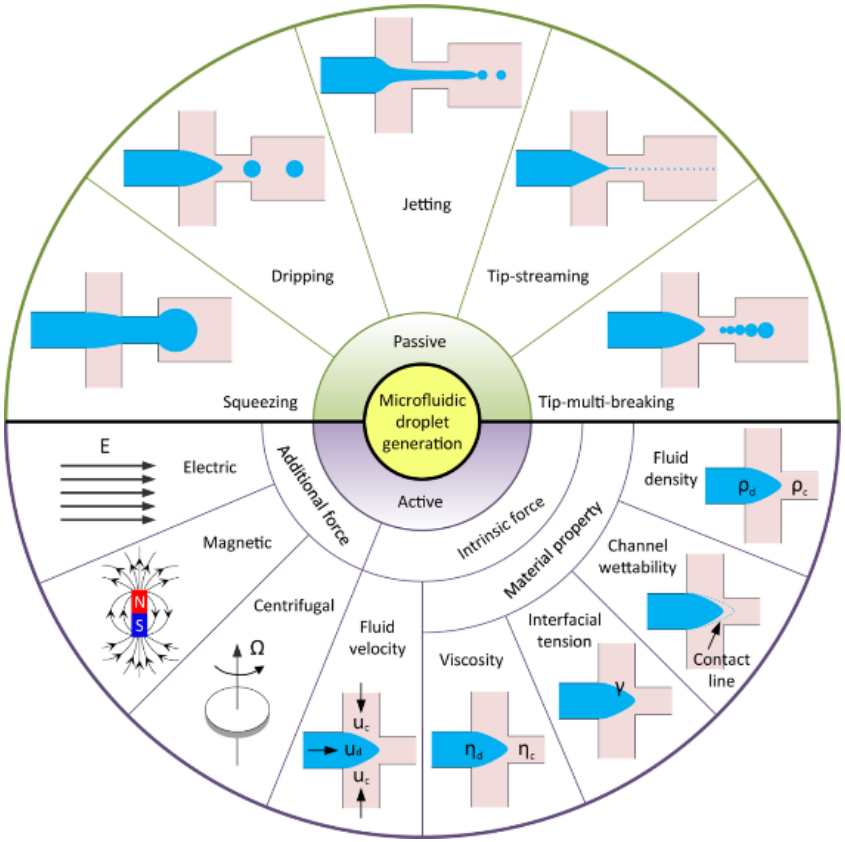
DOI: 10.1038/ncomms15823

14 November 2017

Microfluidics & Materials
微流控與材料

Material property depends on substance and structure; we develop microfluidic technology to precisely tailor/create structures at micro/nano- scales.

材料的性質取決於所用物質和物質的結構；我們發展微流控技術以在微納米量級上精准調控物質結構。



Zhu & Wang, Lab on A Chip, 2017

Artificial blood vessels
人工血管

Embolic microparticles
栓塞微球

Liquid-repellent surfaces
疏液表面

Micro/nano-droplet-manipulation surfaces
微納液滴操控表面

Spider-web-like microfibers
蜘蛛網式空腔纖維

Thermal waves/resonance heat-transfer media
熱波熱共振傳熱介質

Background 背景

Liquid-repellent surfaces 防水防油表面

In nature 自然界實例

Superhydrophobic lotus leaf
超疏水荷葉

https://www.youtube.com/watch?v=D1lh0vjNFdk

Water strider
水黽

https://www.youtube.com/watch?v=4CU8gYYkwSw

Fog collection by desert beetles
沙漠甲蟲收集水

Planet Earth II, Episode 4: Deserts, BBC

Applications 應用

Daily life 日常生活

https://www.youtube.com/watch?v=rEEdyBkD1YE

Military equipment 軍事設備

https://buzzorange.com/2017/01/12/aircraft-carrier-liaoning/

Background背景

Requirements for high-performance liquid-repellent surfaces
高性能防水防油表面的要求

- **Robust liquid repellency**
- **良好的防水防油性**
- **Long-term durability**
- **耐久性**
- **Large-scale fabrication**
- **大面積製備**
- **Low-cost fabrication**
- **成本低廉**

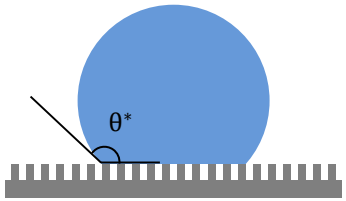
https://www.youtube.com/watch?v=i3jA40arq9Y

Background背景

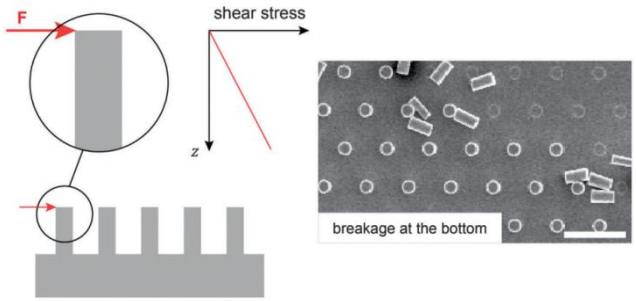
Challenges 挑戰

- **Trade-offs between liquid repellency and mechanical durability**
  防水防油性和強韌度難相容

Roughing surfaces
製造表面結構

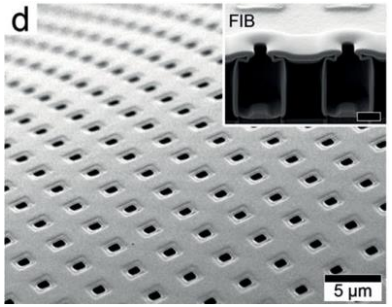


Low mechanical stability
低強韌度



Chem. Soc. Rev., 2016, **45**, 323

Weak liquid repellency
防水防油性差

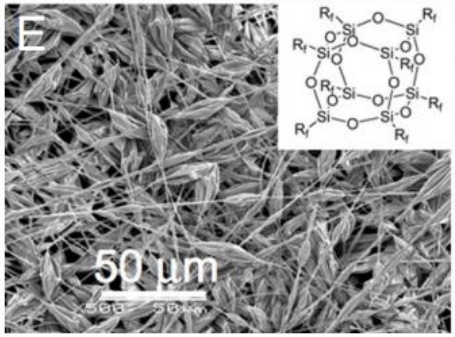


Adv. Mater., 2014, **26**, 2029

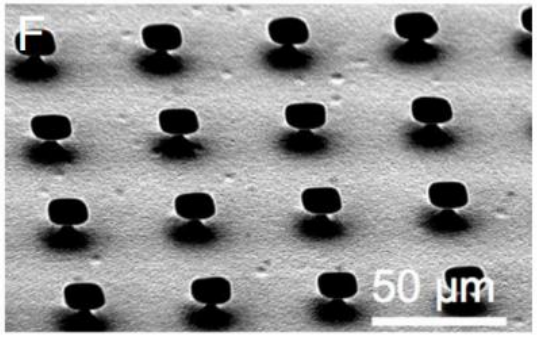
- **Mutually exclusive fabrication of large-scale manufacturing and precise control over surface structures 大面積製備和精確控制表面結構二者互斥**

Bottom-up 自下而上

Large-scale
面積大
Low-cost
成本低
Random structures
結構隨機



Top-down 自上而下



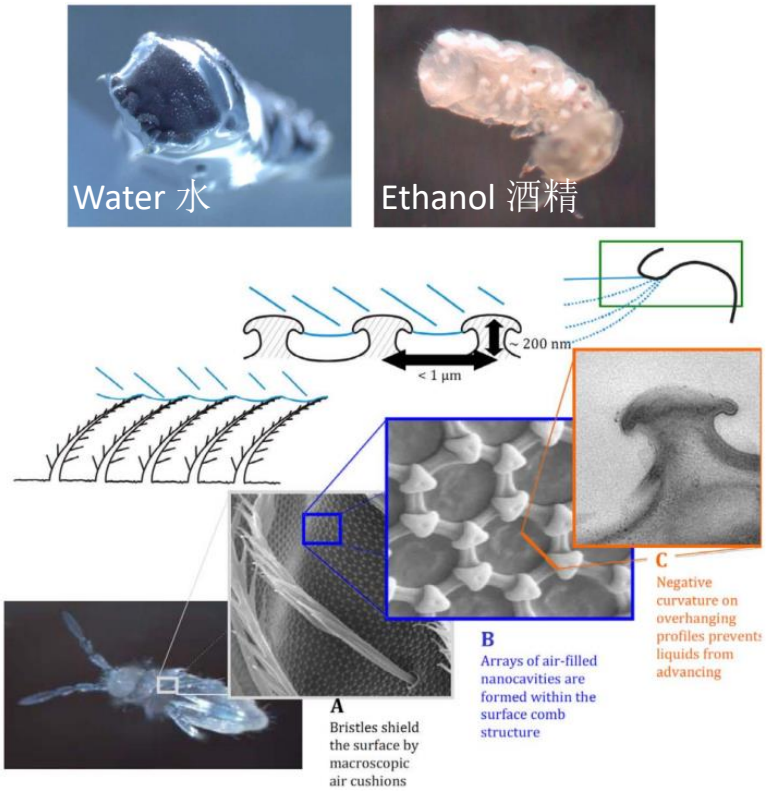
Well-ordered structures
結構均勻
Laborious
過程複雜
Difficult to scale up
難以大面積製備

Proc. Natl. Acad. Sci. U.S.A., 2008, **105**, 18200

Background 背景

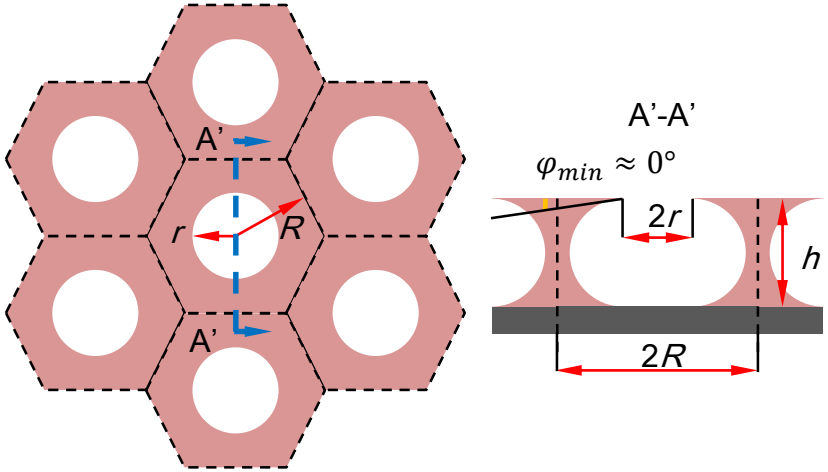
Bio-inspired design of surface structure 仿生學表面設計

Cuticles of springtails 跳蟲表皮



PloS One, 2011, **6**, e25105

Our design: interconnected micro-cavities with re-entrant profiles.
設計思路：互連的凹角微腔結構



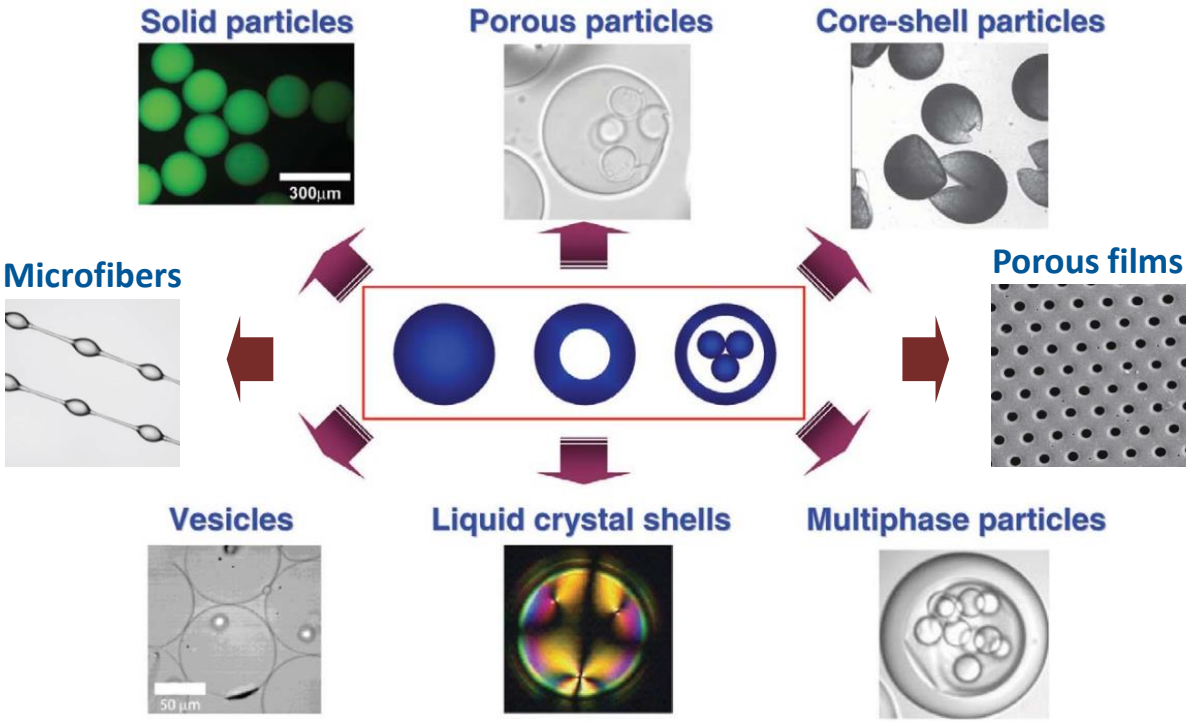
Bio-inspired design resolves effectively the conflict between mechanical stability and liquid repellency: interconnectivity endows the surface with enhanced mechanical stability; re-entrant structure yields robust liquid repellency.

仿生學設計有效地解決了強韌度和防水防油性之間的矛盾：互相連接提高強韌度；凹角特點加強疏液性能。

Background 背景

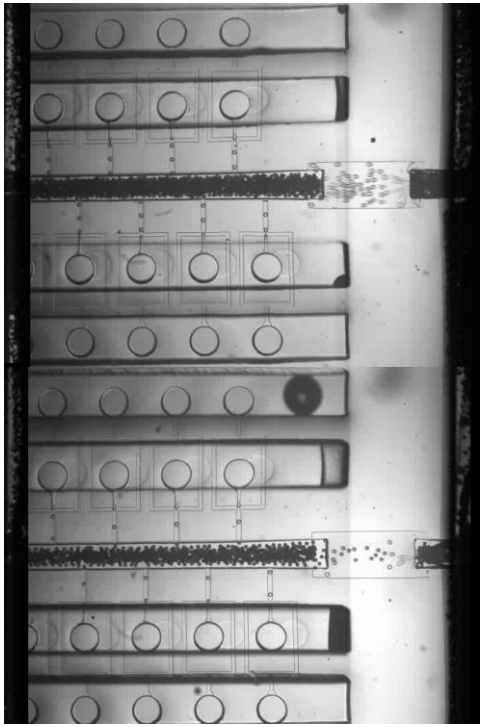
Droplet microfluidics 液滴微流控技術

Fabrication of functional materials 製備功能材料



Mater. Today, 2008, **11**, 18

High-throughput droplet generation (~ 1.5 L h^{-1}) 量產液滴（1.5升/小時）



Lab Chip, 2015, **15**, 4387

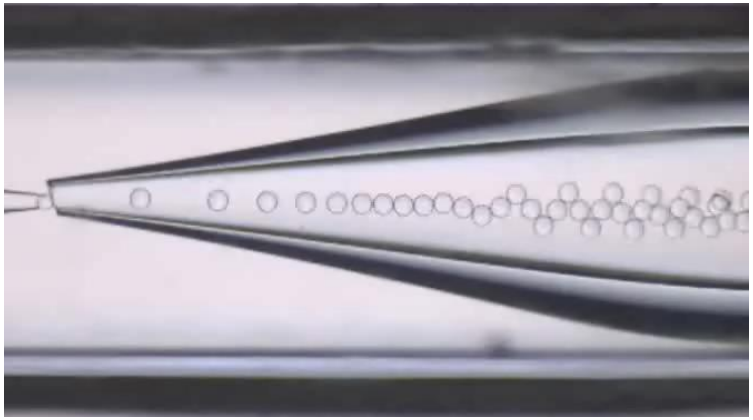
Droplet microfluidics enables low-cost fabrication of large-scale surface structures with high precision and controllability.

液滴微流控技術可實現低成本大面積並具有精確結構的表面製備

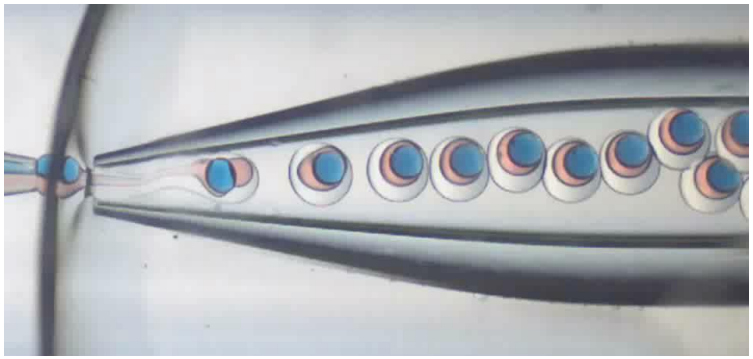
Microfluidic Droplet Generation
生產微流控液滴

Microfluidic droplet generation 生產微流控液滴

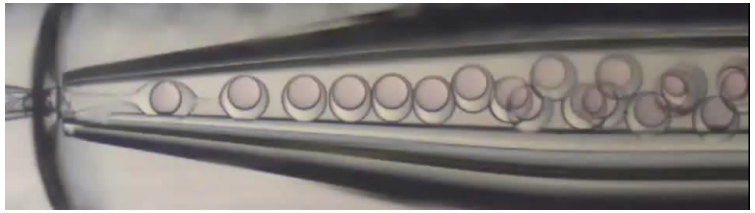
Single emulsion 單乳液



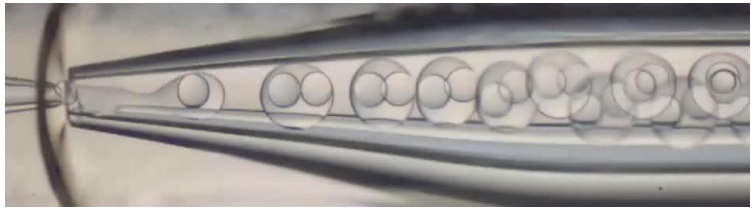
Triple emulsion 三重乳液



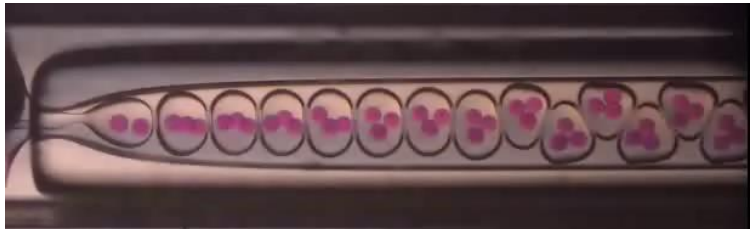
Double emulsion (single-core)
雙重乳液（單核）



Double emulsion (double-core)
雙重乳液（雙核）



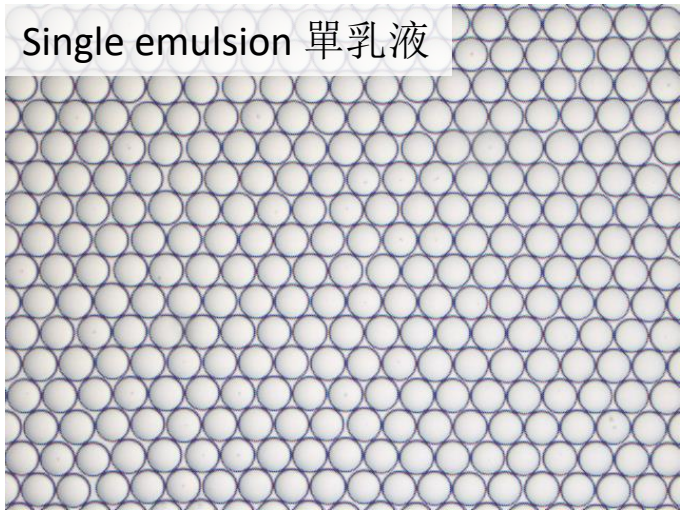
Double emulsion (triple-core)
雙重乳液（三核）



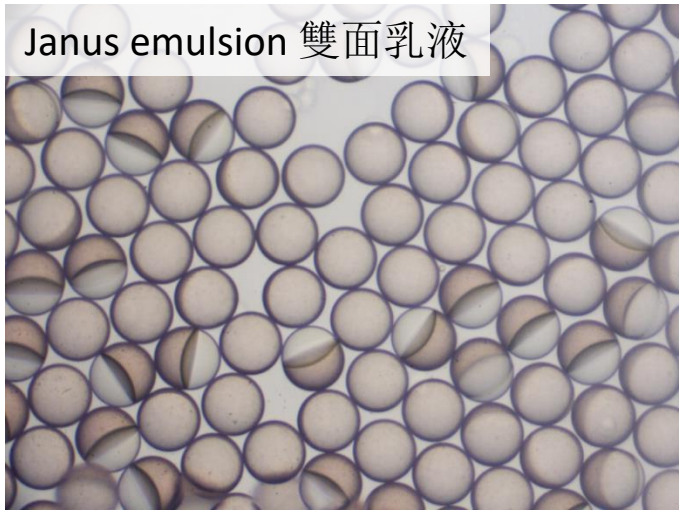
Microfluidic Droplet Generation
生產微流控液滴

Diverse microfluidic emulsions 多種微流控乳液

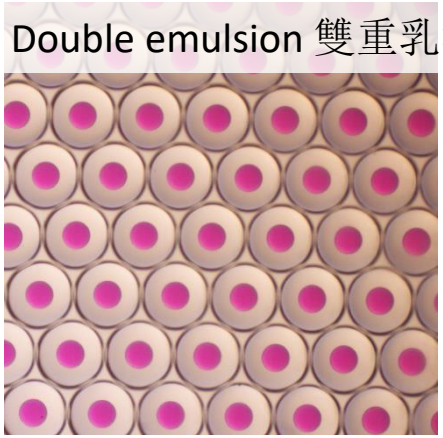
Single emulsion 單乳液

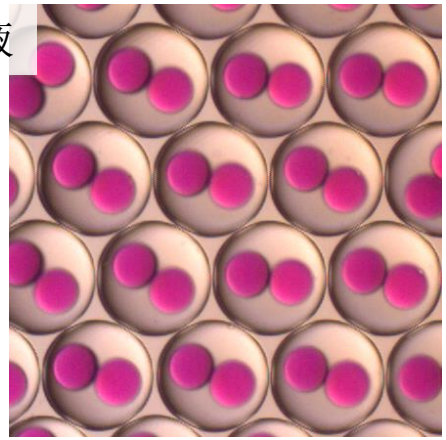


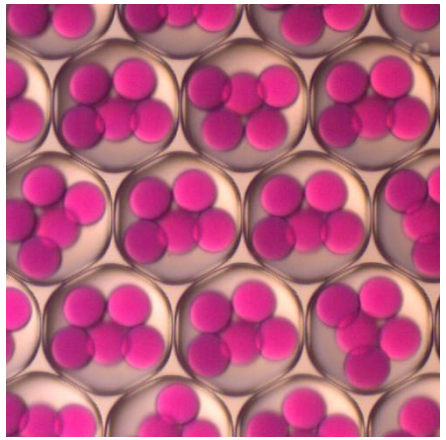
Janus emulsion 雙面乳液



Double emulsion 雙重乳液

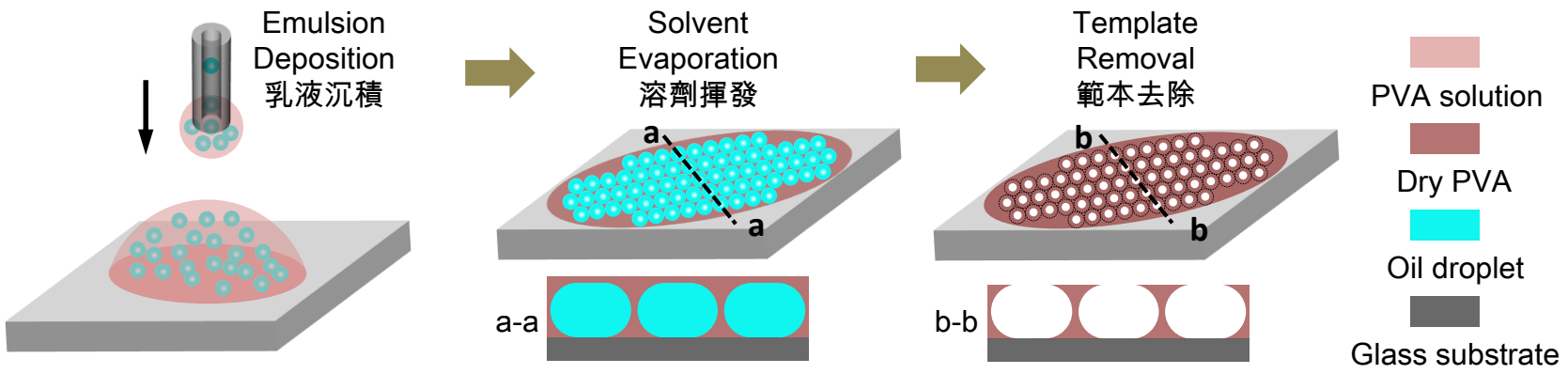




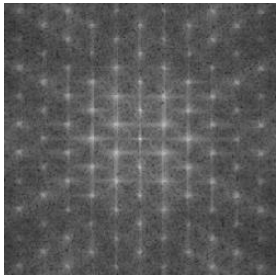


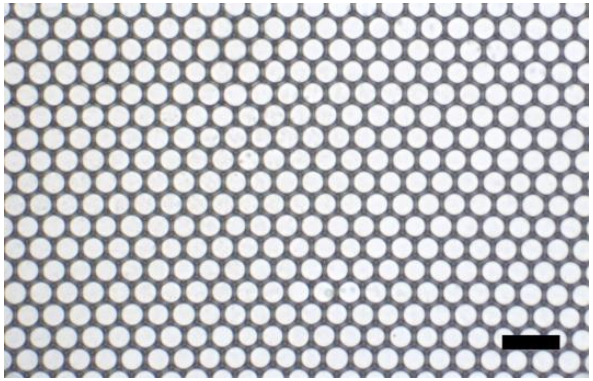
Self-assembly of Micro-droplets
微液滴自動組裝

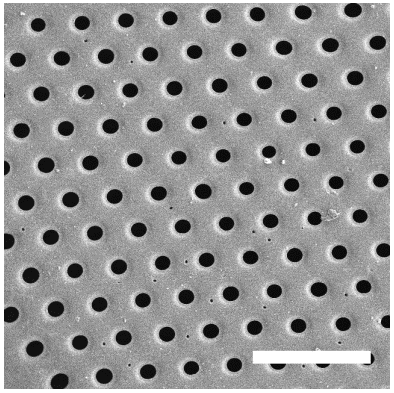
Fabrication process 製備過程

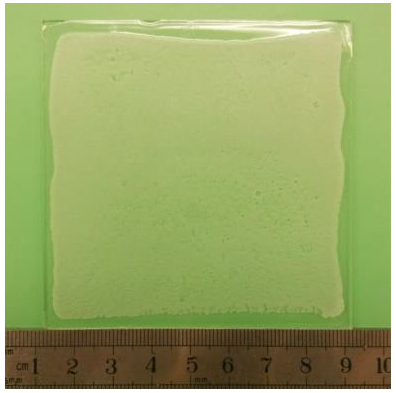


FFT image







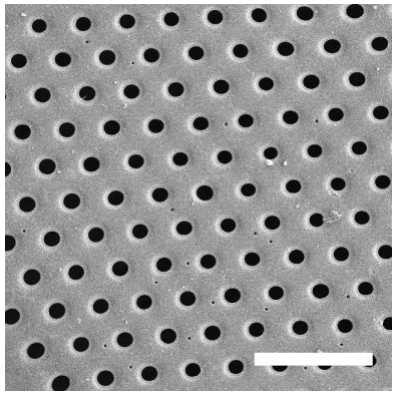


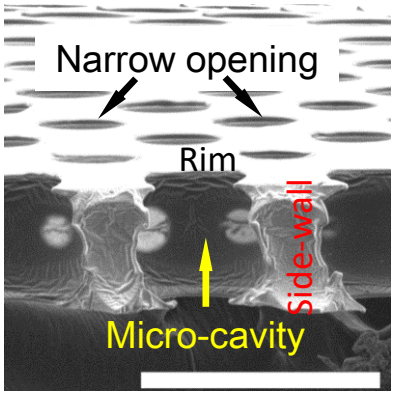
Large-scale well-ordered porous surface
具有均勻結構的大面積多孔表面

Liquid-repellent Surfaces
防水防油表面

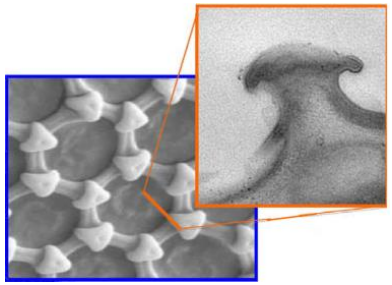
Robust liquid repellency 良好的防水防油性

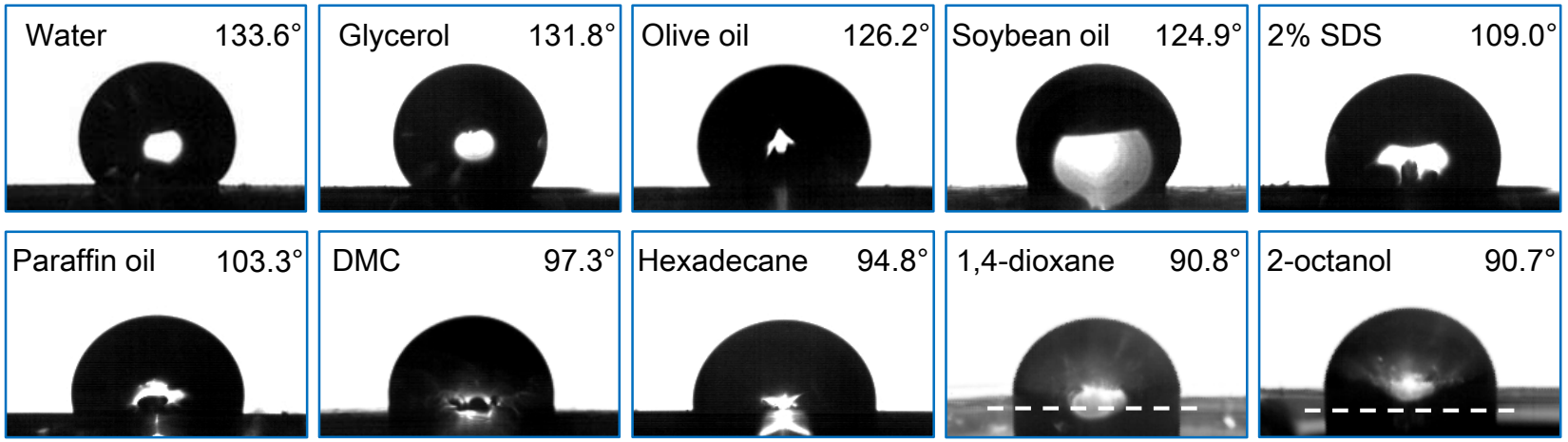
Contact angle >90˚for both water and oils 水和油的接觸角均高於90˚





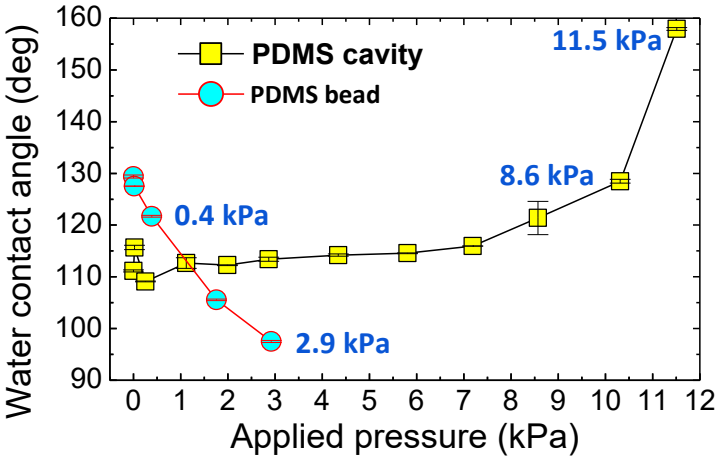
Bio-inspired structure

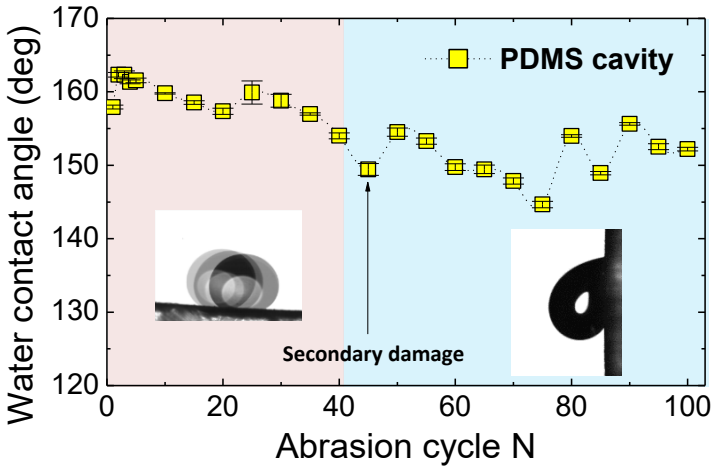




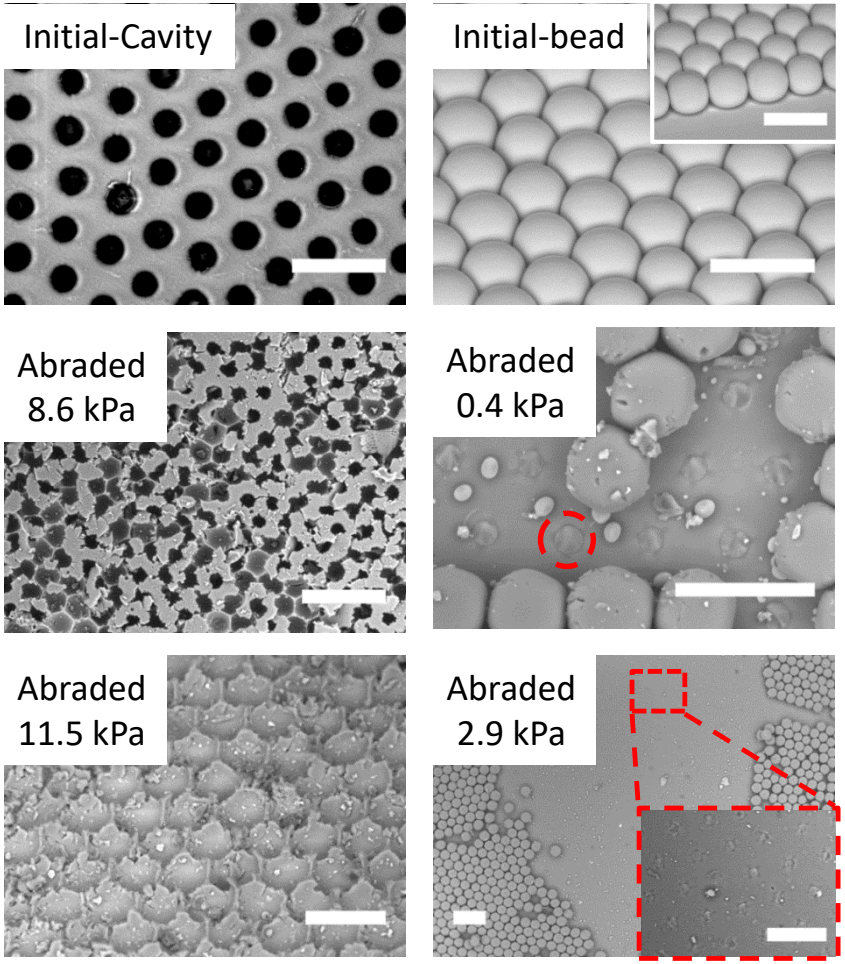
Liquid-repellent Surfaces
防水防油表面

Enhanced mechanical stability
強韌度被增強



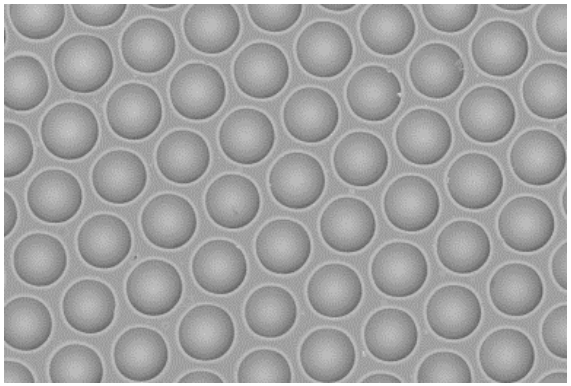


Abrasion test (over 21-fold enhancement)
摩擦測試結果（強韌度增強至少21倍）



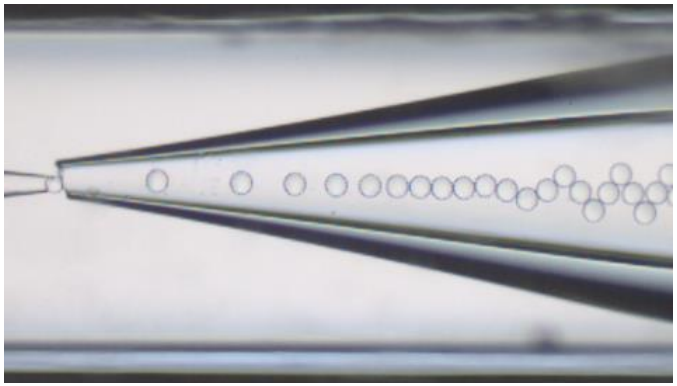
Concluding Remarks 總結

Design 設計



- **Bioinspired design resolves effectively the conflict between the liquid-repellency and the mechanical stability**
- 仿生學設計新型結構解決了疏液性和耐用性的矛盾

Fabrication 製造



- **Microfluidic-droplets-based fabrication offers low-cost and scalable production of well-defined structures with precision and controllability**
- 微流控液滴技術實現低成本大面積製備結構控制的表面

Many Thanks

謝謝