

Multiscale Architecturing

Bio-mimetics

Multiscale Fuel cell (PEMFC)

Microfluidic devices

Flexible Electronic Devices

Selected papers



The Multiscale Architecturing Laboratory, directed under Prof. Sang Moon Kim, uses conventional and unconventional lithography technology to create 3D architecture. Also research for multiscale fuel cell and flexible device are ongoing.

With broad networking with domestic and oversea research groups, our laboratory is intensively researching multiscale energy devices.

We welcome mechanical engineering students who wants to join our group, especially students with multidisciplinary knowledge!

Advisor: Professor Sang Moon Kim

✓ Career

- 2016. 3 – present : Assistant Professor, Department of mechanical engineering, Incheon National University
- 2015. 3 – 2016. 2 : Post-Doc, Global Frontier Center for Multiscale Energy System

✓ Education

- 2010. 3 – 2015. 2 : Ph.D., School of mechanical and aerospace engineering, Seoul National University
- 2006. 3 – 2010. 2 : B. S., School of mechanical and aerospace engineering, Seoul National University



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Please visit us!

## Multiscale Architecturing

### Nature-inspired Multiscale Architecturing

**Functional surfaces in Nature**

- Gekko lizard
- Lotus leaf
- Cactus spine

**Bio-mimetics**

**Applications**

- Dry adhesive
- Self cleaning surface
- Directional wetting

### Flexible polymer membranes with Micro/Nano-apertures

UV exposure PUA → Demolding → Free-standing multiscala membrane

Permeable PDMS with micro-pillars | Permeable PDMS with nano-pillars | Multiscala membrane with nano-holes

### Multiplex lithography

(a) Permeable mold (800 nm in diameter) → (b) Spin UV exposure → (c) Demolding → (d) UV exposure → (e) Drop-casting of pre-polymer → (f) Sequential stacking and curing → (g) Replication → (h) Demolding → (i) Bonding

A hole-patterned back (800 nm in diameter)

**Multiscale, multilevel LEGO-like structures**

### Creep-assisted lithography

1) Nanopatterned PUA mold →  $T_1 > T_2$ ,  $P_1 = 1\text{MPa}$ ,  $t = 5\text{min}$  → Nanopatterned Nafion membrane

2) Micro-patterned PUA mold → Creep behavior of Nafion →  $T_1 < T_2$ ,  $P_1 = 200\text{kPa}$ ,  $t = 20\text{min}$  → Multiscala patterned Nafion membrane

3) PET film → UV exposure → Replicated multiscala PUA mold

## Microfluidic devices

### Flexible polymer membranes with Micro/Nano-apertures

Line mask → Dry mask → Asymmetric ratchet array in microchannel

UV curable prepolymer → Spin coating → UV exposure → Patterned → Laser trim → Washing → Integrated microfluidic devices

**On-chip timers**

Region 1, Region 2, Region 3

0 sec, 50 sec, 100 sec, 200 sec

Glass substrate with Chrome mask → Asymmetric Prism → Guided light transmission

### Thermoresponsive switching of liquid flow direction

**Railroad junction**

Soft Matter

**Step flow**  
Flow upward while overcoming gravity  
10 sec

**Thermo-responsive switching system**

Thermo-responsive Valves in Multi-layered microfluidic system

## Flexible Electronic Devices

### Ultrasensitive pressure sensor

(a) Fabrication process: (i) Spin coating, (ii) UV exposure, (iii) Demolding, (iv) UV exposure, (v) Drop-casting of pre-polymer, (vi) Sequential stacking and curing, (vii) Replication, (viii) Demolding, (ix) Bonding.

(b) Sensor characteristics: (i) High on-off ratio, (ii) High sensitivity.

### Metal-elastomer bilayered switches

Switch system with deepening of crack depth

Expressing number by simple figure gesture

High on-off ratio

Fabrication of Logic Gates

### Rollable electronic devices

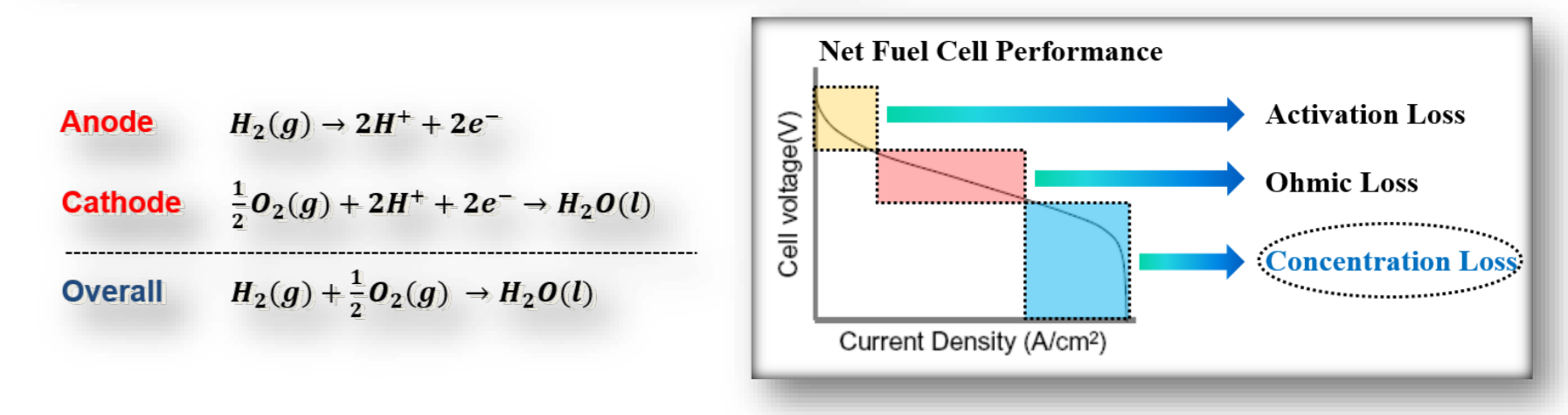
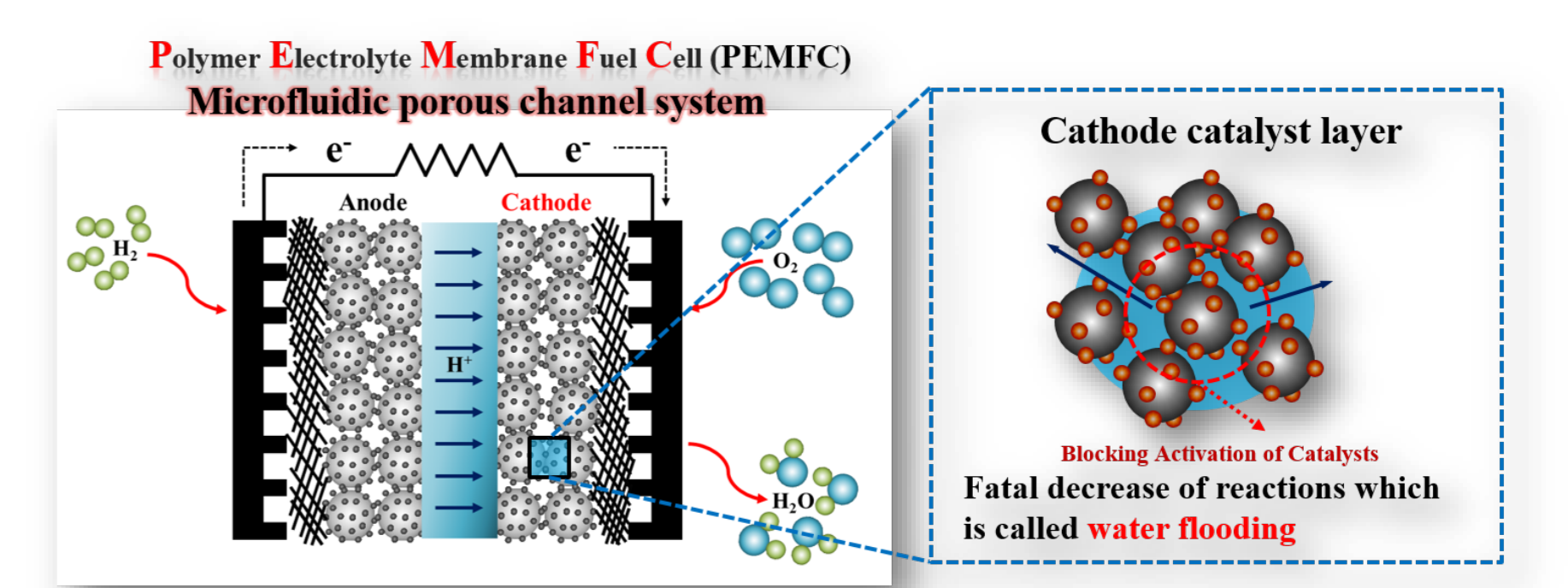
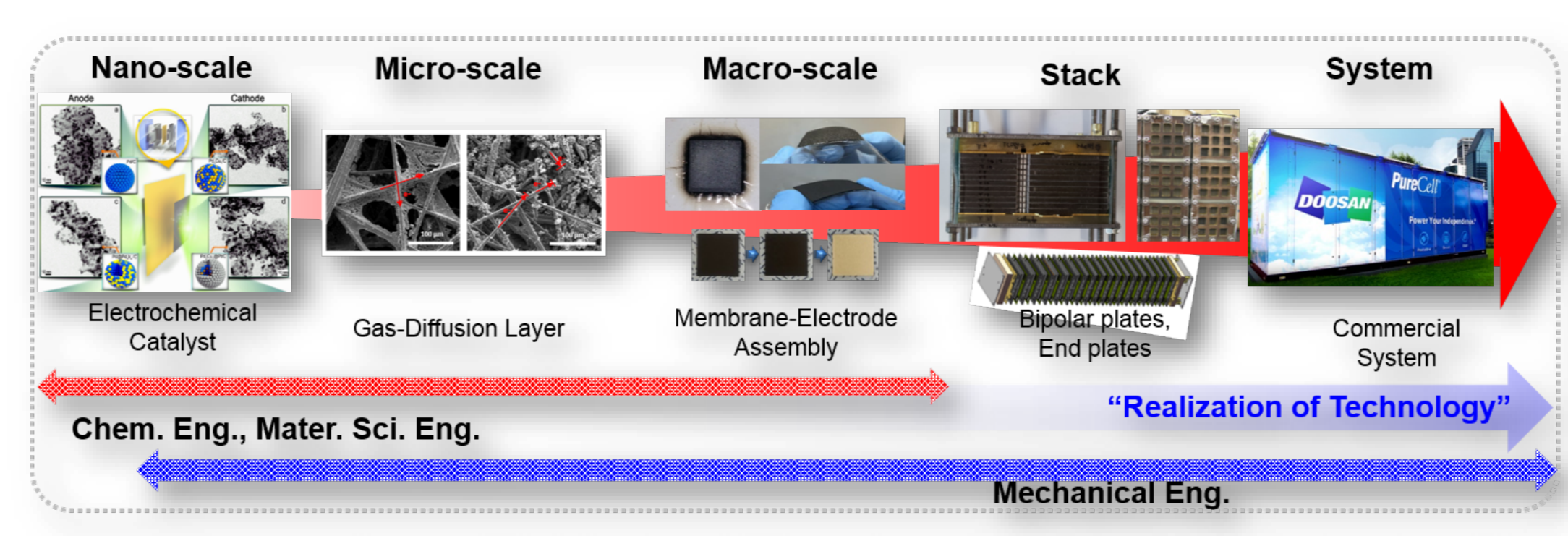
**Rolling mechanism**

**Rollable electronics and soft grippers**

**Controlled rollability**

**Cell sheet transfer with Rollable platform**

## Multiscale Polymer Electrolyte Membrane Fuel cell (PEMFC)



### High performance fuel cell with multiscale membrane

$O_2$ ,  $H_2$ ,  $H_2O$

Nafion 211, Multiscala Nafion

Proton conductivity vs Pattern diameter (thickness)

Electrochemical active surface area vs Voltage (V)

