NARLabs 國家實驗研究院

台灣半導體研究中心

Taiwan Semiconductor Research Institute

MEMS Fabrication & Sensors developed in TSRI

Han-Ting Hsueh

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www.narlabs.org.tw
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Gas Sensor

Ambient air monitoring

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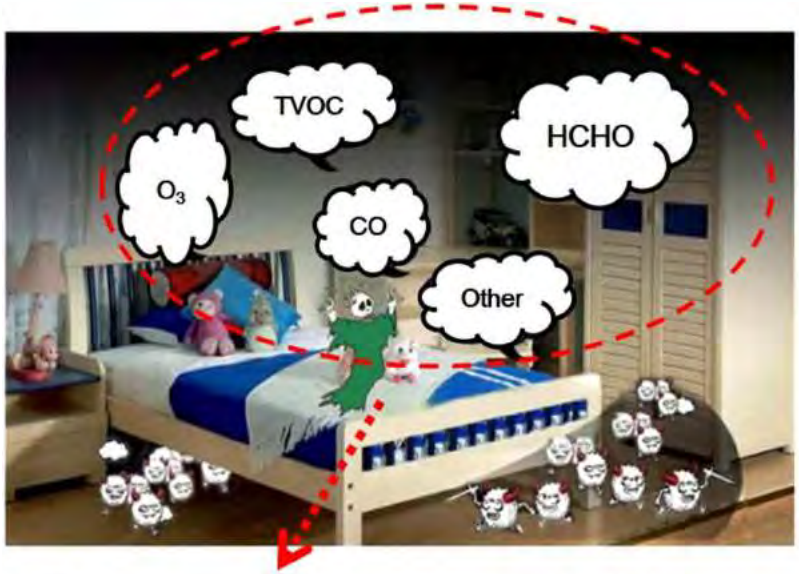
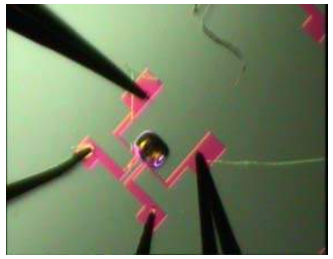


Metal Oxide Semiconductor MEMS Gas Sensor

1. Micrographics
2. Low Power Consumption.
3. Multi-Gas Sensor Improve Accuracy.

Device Application:

1. Wi-Fi、Bluetooth for Personal Safety.
2. Environment Safety for Smart Home.
3. Air Quality for Air Freshener.



TSRI MEMS Gas Sensor

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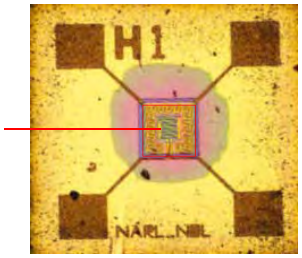
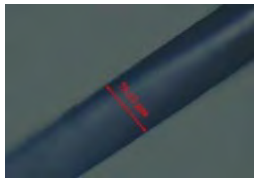
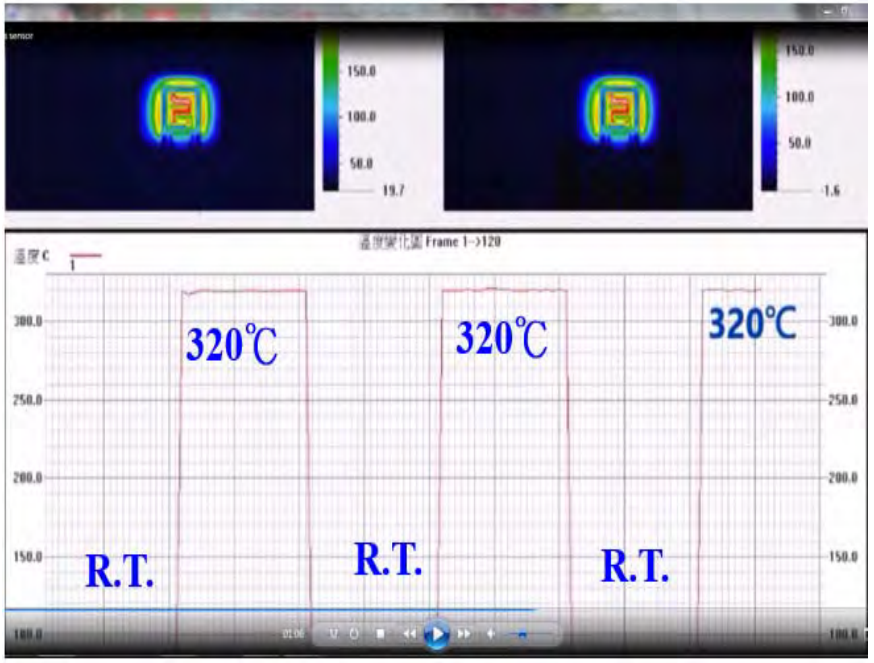
Micro-Heating Zone 120 um



Hair's Width : 75-76 μm





- ✓ **MEMS Technology(Miniaturization)：** The sensing chip is miniature to pinhole size and the micro-heated area has only one hair width.
- ✓ **Low Stress Membrane & Micro-heater Technology (Rapid Heating)：** It takes about milliseconds(ms) heating to 320°C.
- ✓ **Nanotechnology(Energy Saving)：** Improve Response, Sensitivity and Low power consumption with Sensor.

Stability of the Micro-Heater

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6" gas sensor Structure

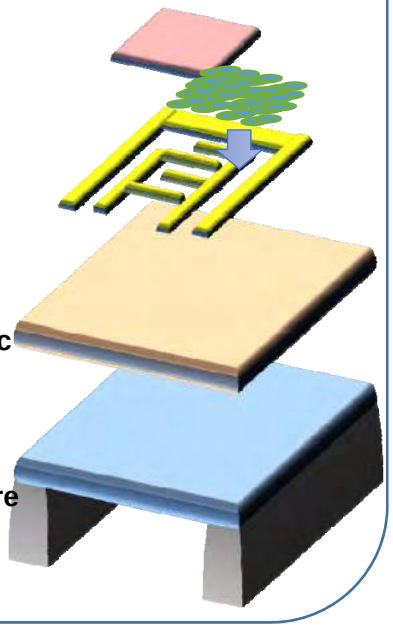
Nano particles
or
Nano porous

Sensing Film

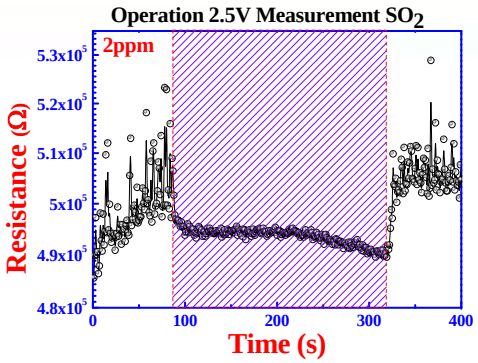
Micro Heater
& IDE

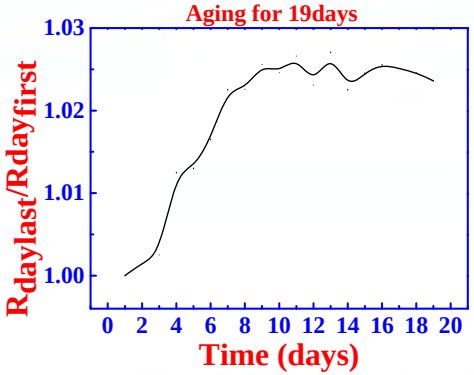
Low Stress Dielectric Layer

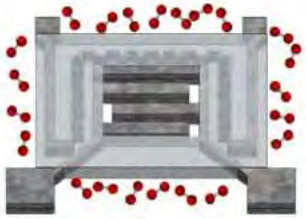
Suspension Structure



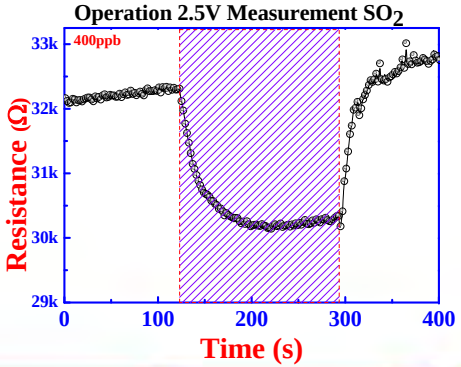
In metal oxide gas sensors, micro-heater is used as a hot plate which controls the temperature of the sensing layer.

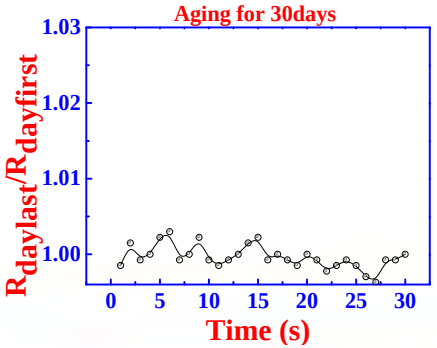






Prevent Oxidation of Metal Electrodes





Gas Sensors Characteristics

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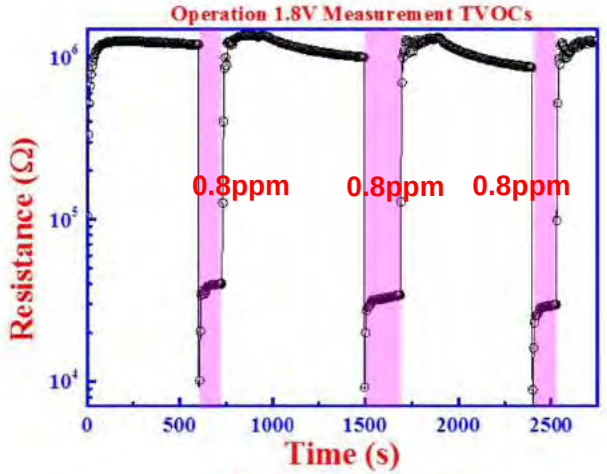
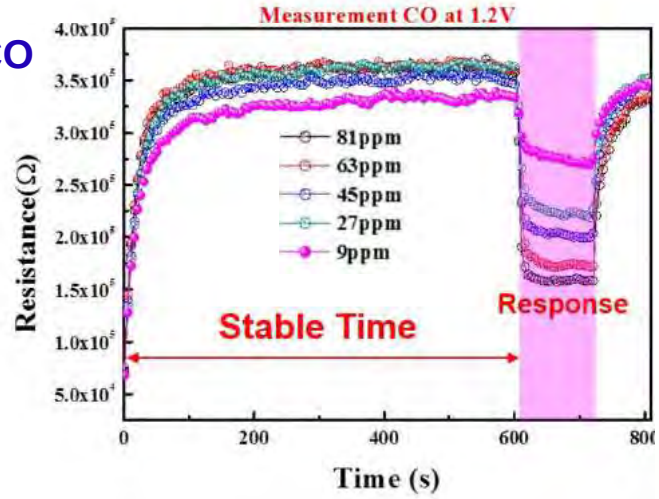
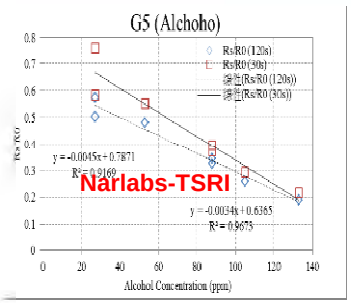
TVOCs

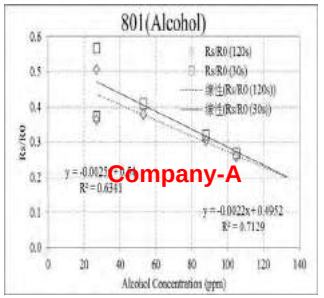


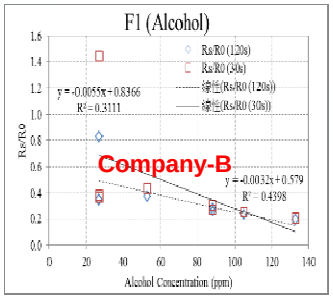
CO



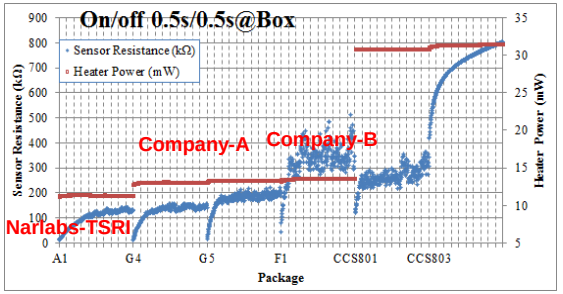
Performance and power consumption







Stability



Power Consumption

	Narlabs-TSRI	Company-A	Company-B
Chip size (mm^2)	0.65 x 0.65	0.75 x 0.5	NA
Package (mm^3)	~3.2 x 2.35 x 1	~3.2 x 2.5 x 1	~3 x 2 x 1
Power consumption	10~15 mW	15 mW	~30mW

Gas sensing: Alcohol, CO, TVOCs, NO_x, NH_3, C_4H_{10}

Gas Sensors Characteristics

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Cross-Sensitivity

CO /C_2H_5OH

Gas sensor	CO	C_2H_5OH
Operating Voltage	V_H:1.2V (~150℃)	V_H:3V (~330℃)

CO /C_4H_{10}

Gas sensor	CO	C_4H_{10}
Operating Voltage	V_H:1.2V (~150℃)	V_H:3V (~330℃)

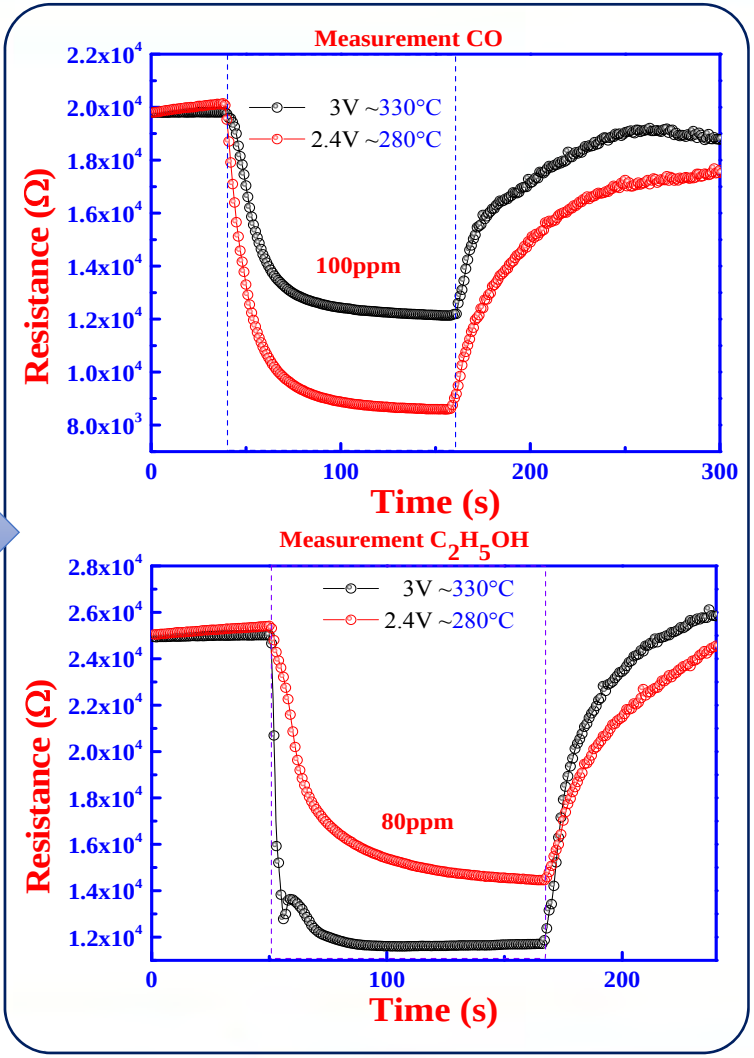
NO_X /SO_X

Gas sensor	NO_X	SO_X
Operating Voltage	V_H:1.2V (~150℃)	V_H:3.5V (~350℃)

Cross Sensitivity-Control Micro-Heater Temperature

Temperature↑ Response ↑ : TVOCs、SO_2

Temperature↑ Response ↓ : CO、NO_x



Narlabs-TSRI'S Gas Sensing Chip-Module-System

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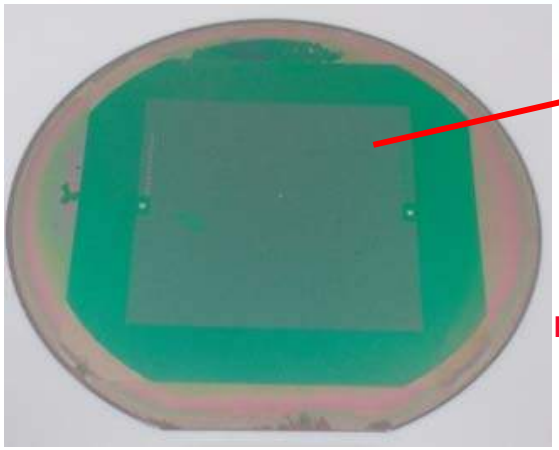
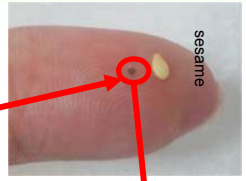
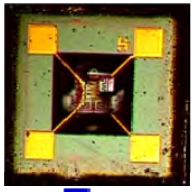


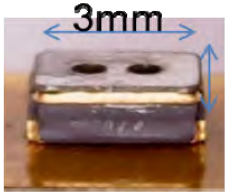


Micro-Heating Zone 120 um

Ten thousand gas sensor pieces on one 6" wafer

Package





Prototype of CO Sensor Embedded Smart Phone

Breath Sensing

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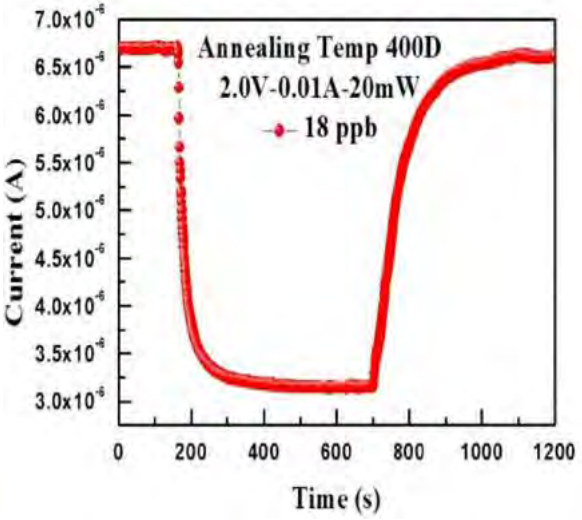
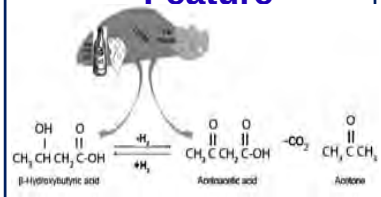
Asthma



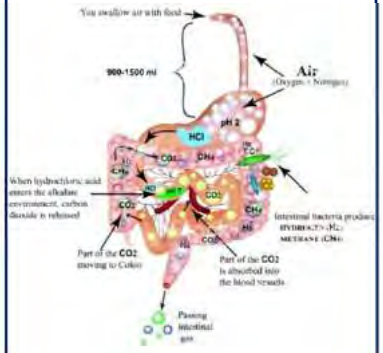
	Adults		
NO (ppb)	<25	26 - 49	50+
Range	Low	Intermediate	High

	Children (<12 years of age)		
	<20	21 - 44	45+
	Low	Intermediate	High

Feature



Diabetes→Acetone(gas)



Gastrointestinal tract

↓

Hydrogen

Vibration Sensor

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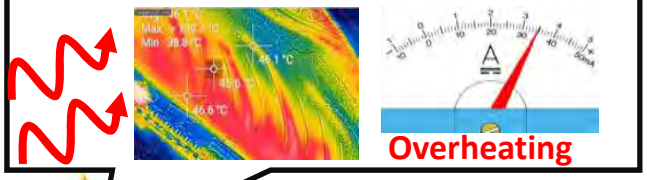
- **Real-time Failure Investigation ?**

- Temperature
- Vibration
- Noise

Abnormal Vibration Detection

Remote Overheating Investigation



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- **Magnetic Induction Vibration Sensor**

Ref. J. Micromech. Microeng. 19 (2009) 035001

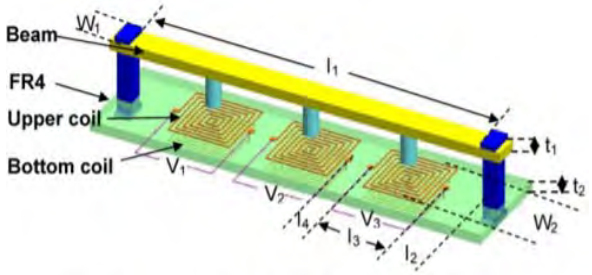


Figure 1. Schematic drawing of the FR4 energy harvester.

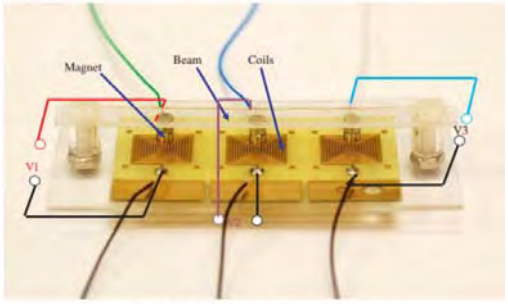
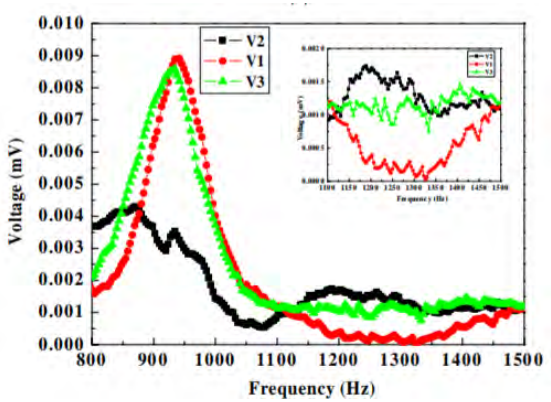


Figure 5. Photograph of the whole device.



Vibration Sensor

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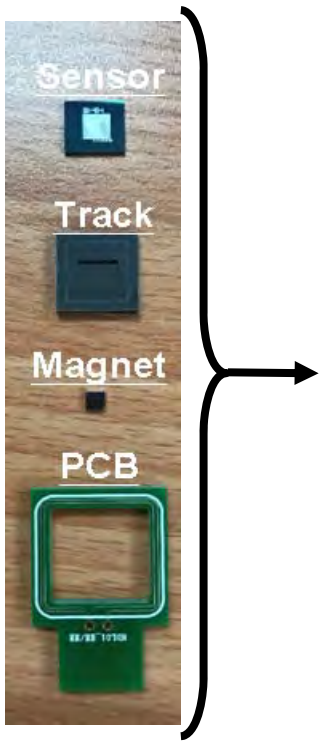
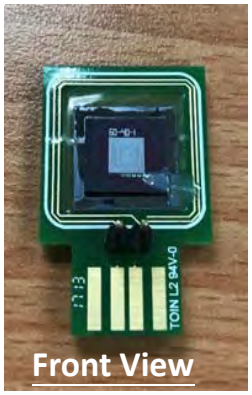
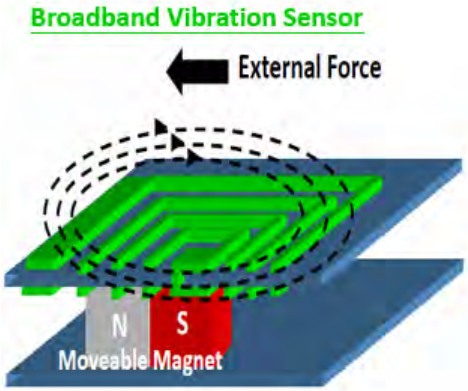
● Device Fabrication

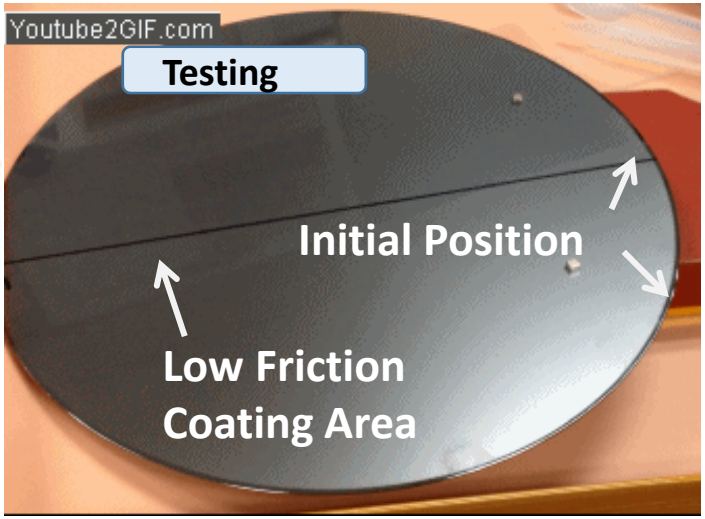
Vertical Heterogeneous Assembly







~ 2g
~ 0.16 mm² (sensor part)
Frequency Detection: 20 ~ 2000Hz
Self-powered Device (Bias-free)



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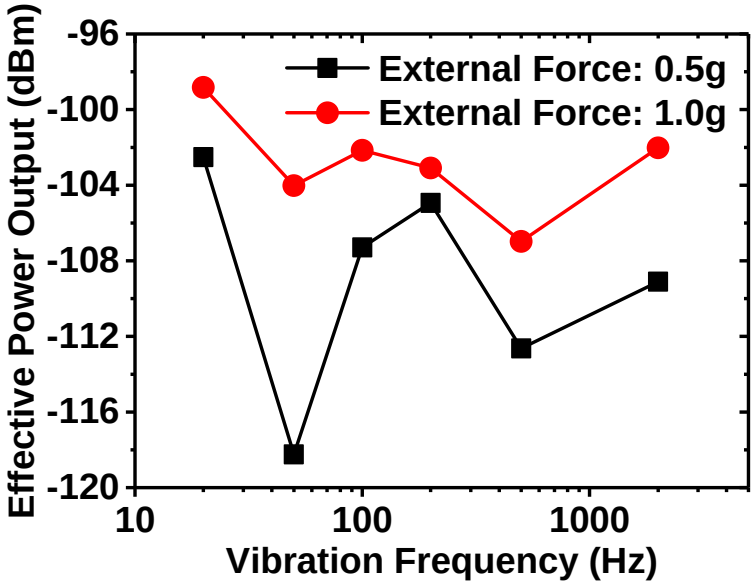
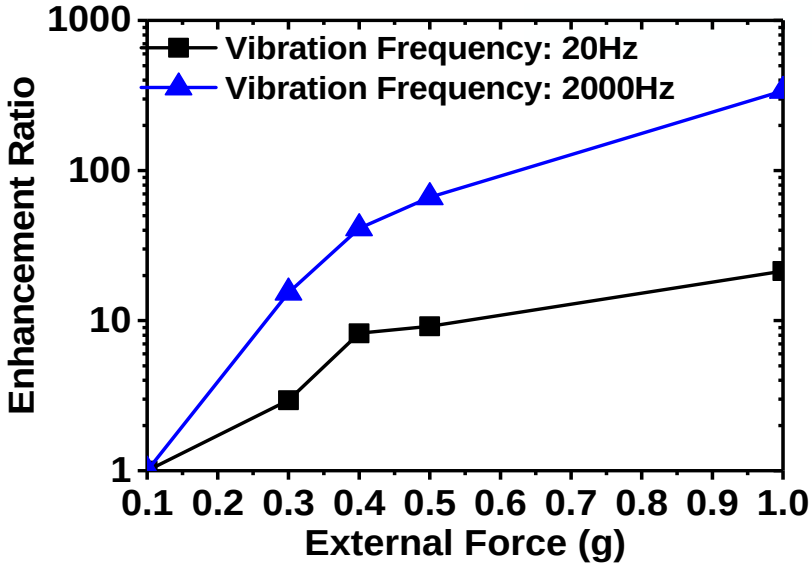
● Device Characterization



Bias-Free Operation



Low g Vibrating Detection

Broadband Vibrating Detection

Vibration Sensor

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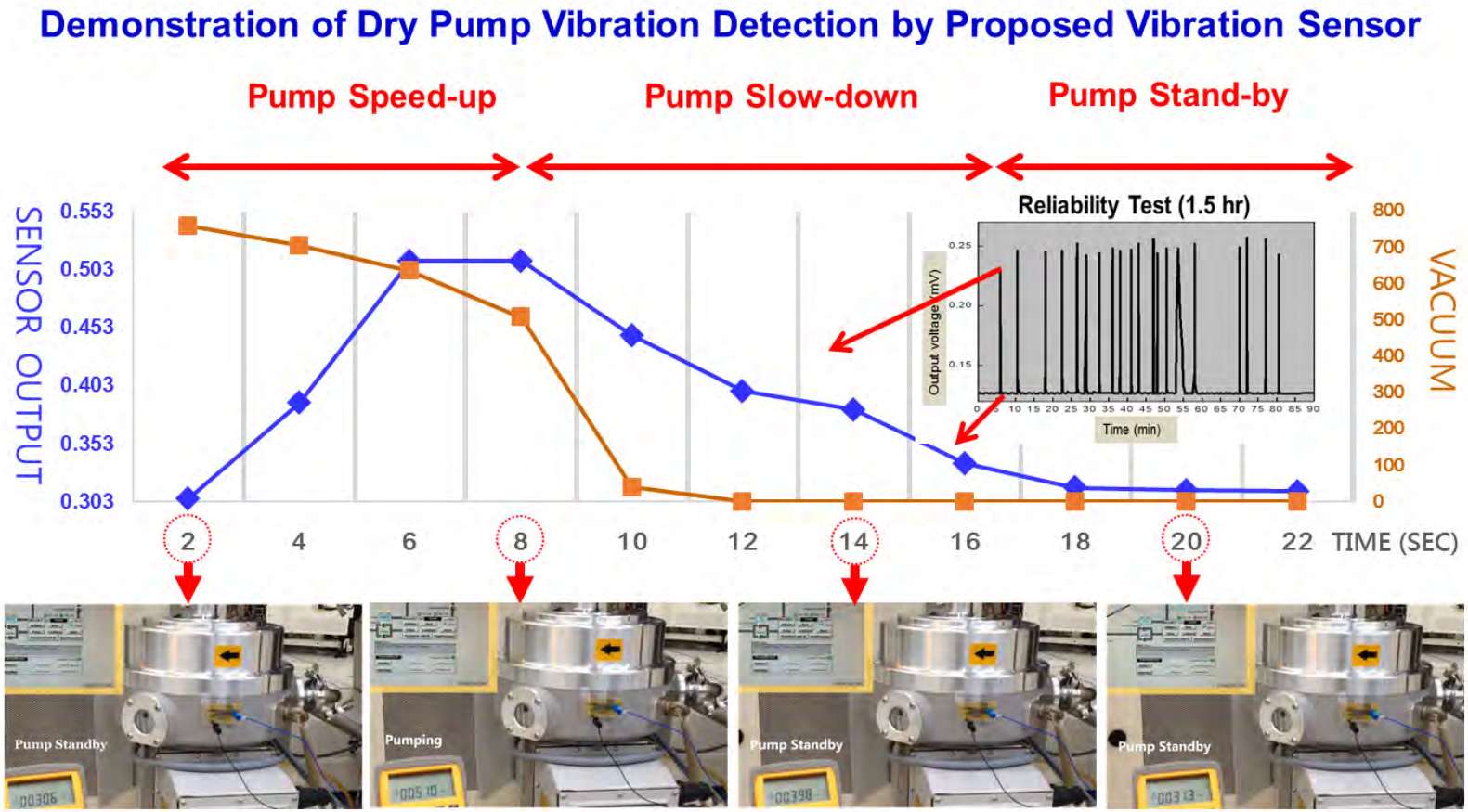
- **Demonstration for Smart Factory**



Vibration Sensor

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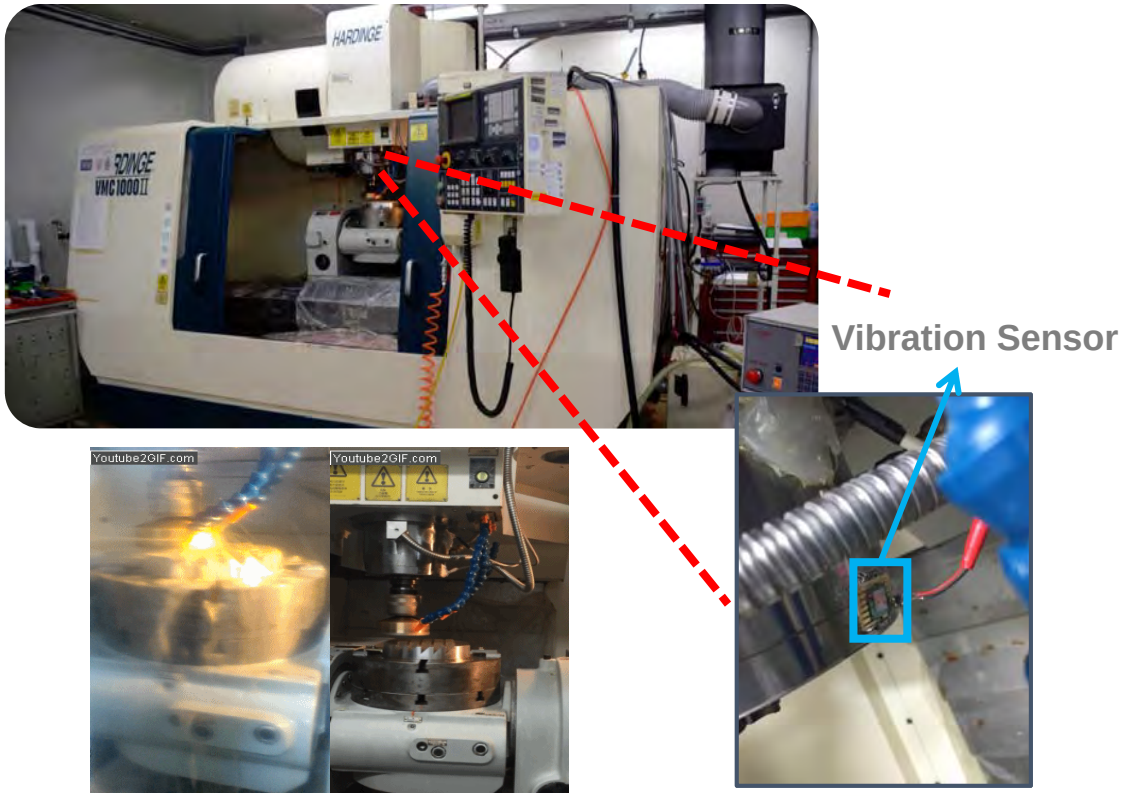
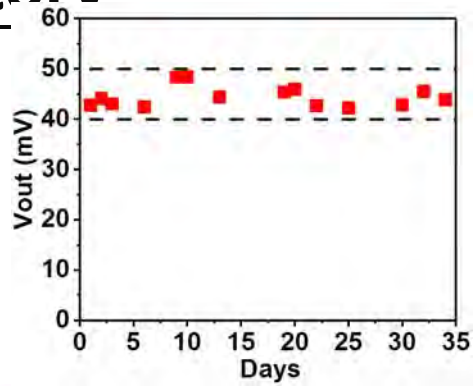
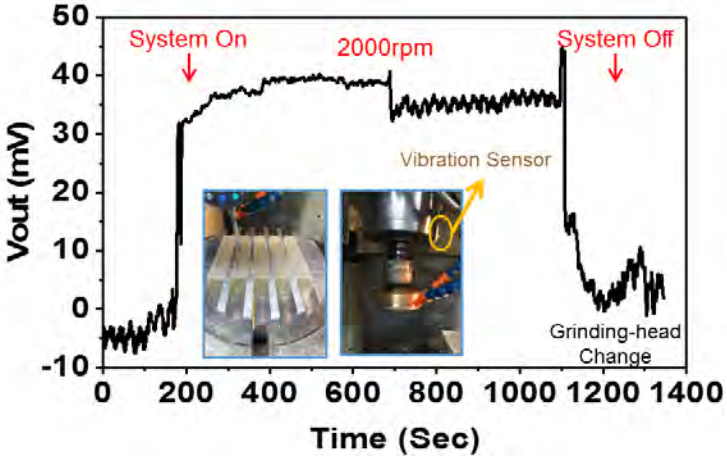
- **Demonstration for Conventional Factory**







Microfluidics and Biosensing Researches in TSRI

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1. Microfluidic chip fabrications and their applications

2. Micro/nano-manipulation and concentration in a biochip

3. Label-free and whole cell diagnostic assay

Standard PDMS-based Microchannel Fabrication and Microfluidic Chip with Functional Electrodes

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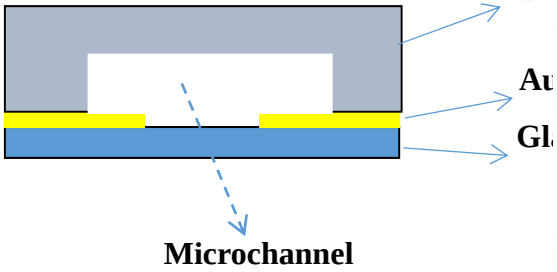
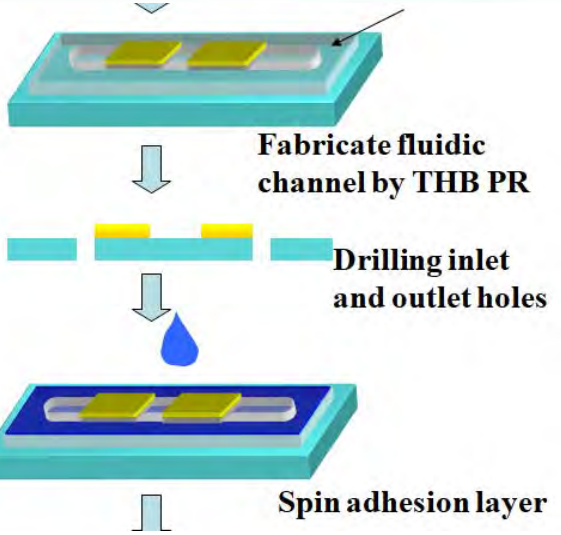
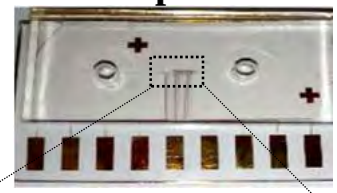
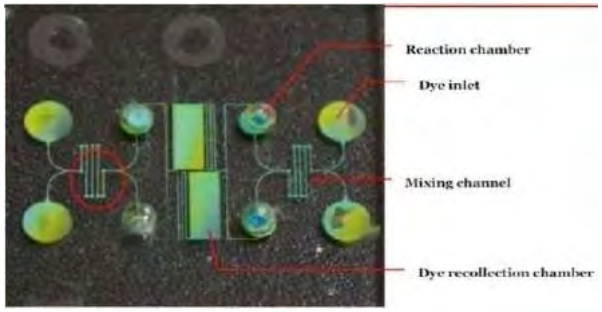
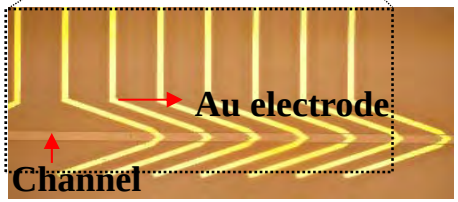


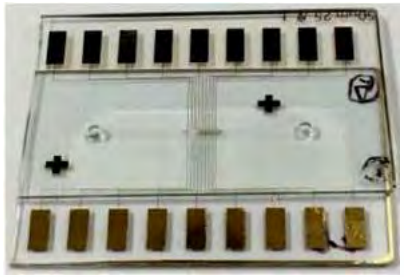


Microchip









Microfluidic Gray-Scale Photolithography through the Generation of Concentration Gradient

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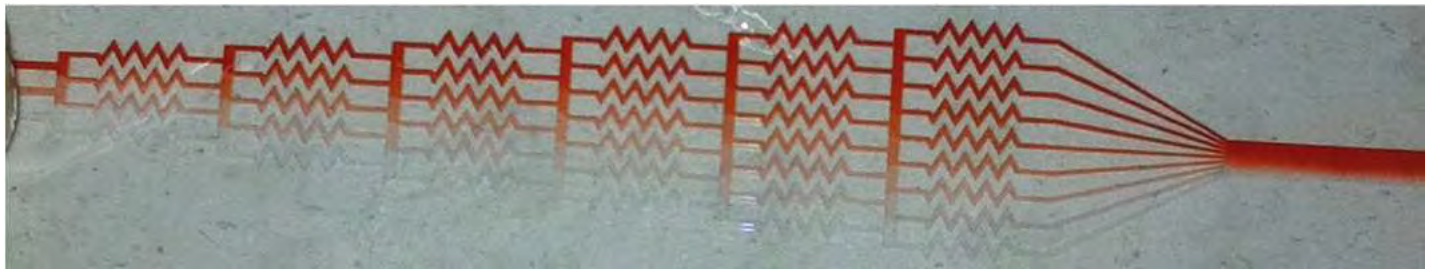

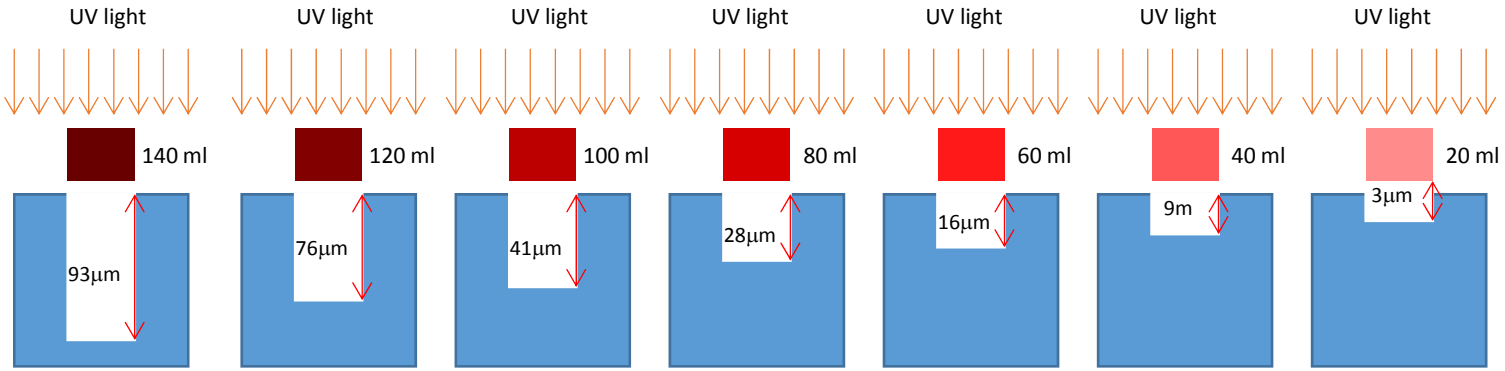

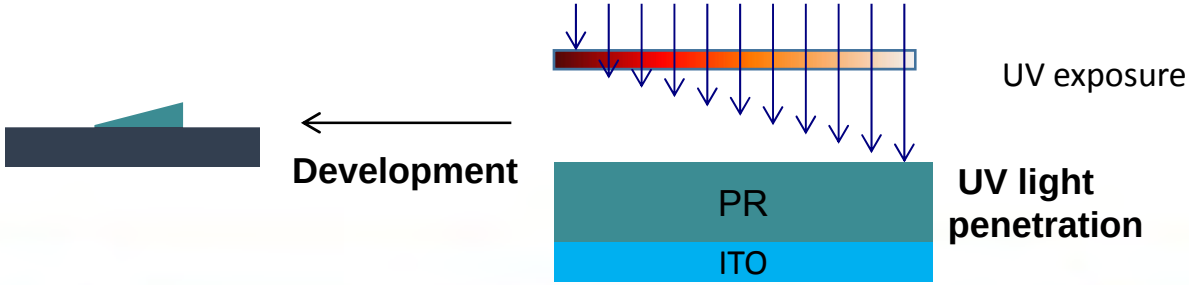

Current state of Gray-scale Lithography

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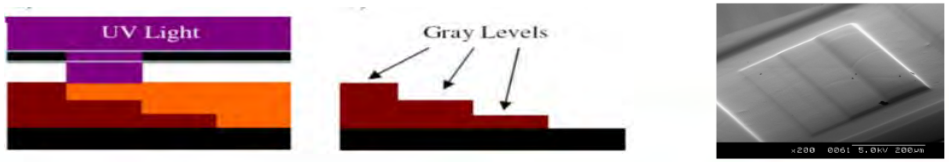
Heidelberg Instruments GmbH

http://www.himt.de/en/technology/gray-scale-lithography.php



Flow Rate Effect

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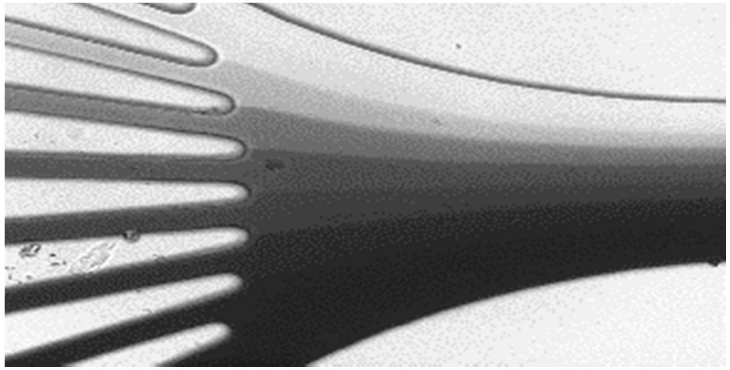

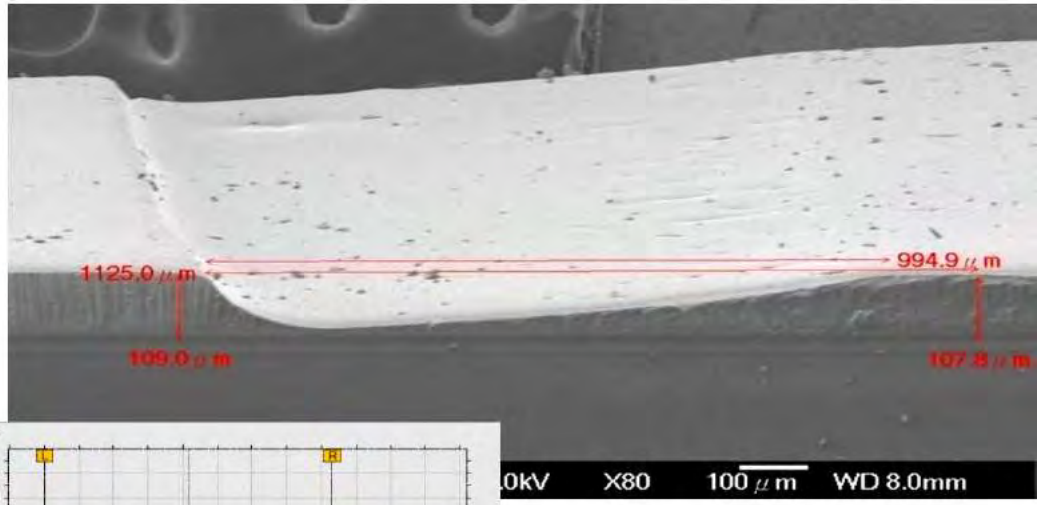

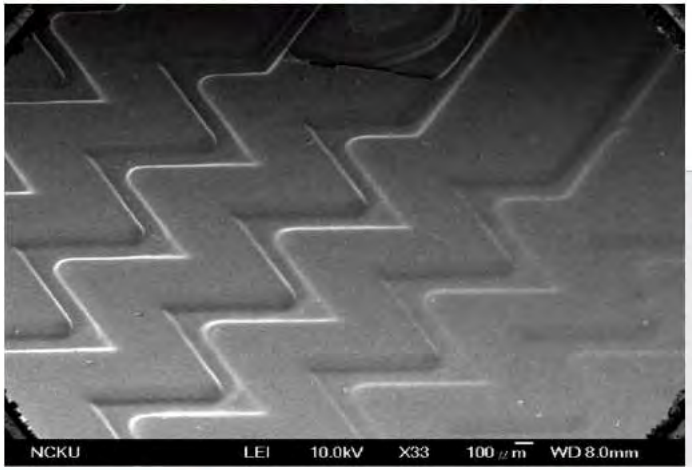

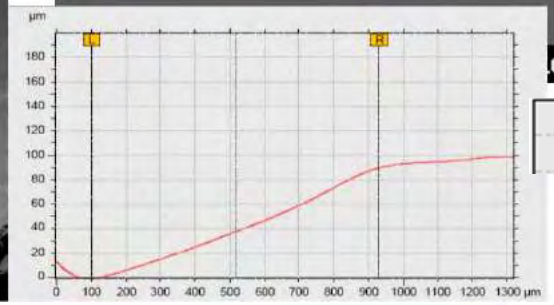

Width	825.15 μm
Height	90.411 μm

Light-induced Dielectrophoresis for Passive and continuous Separation of Microparticles

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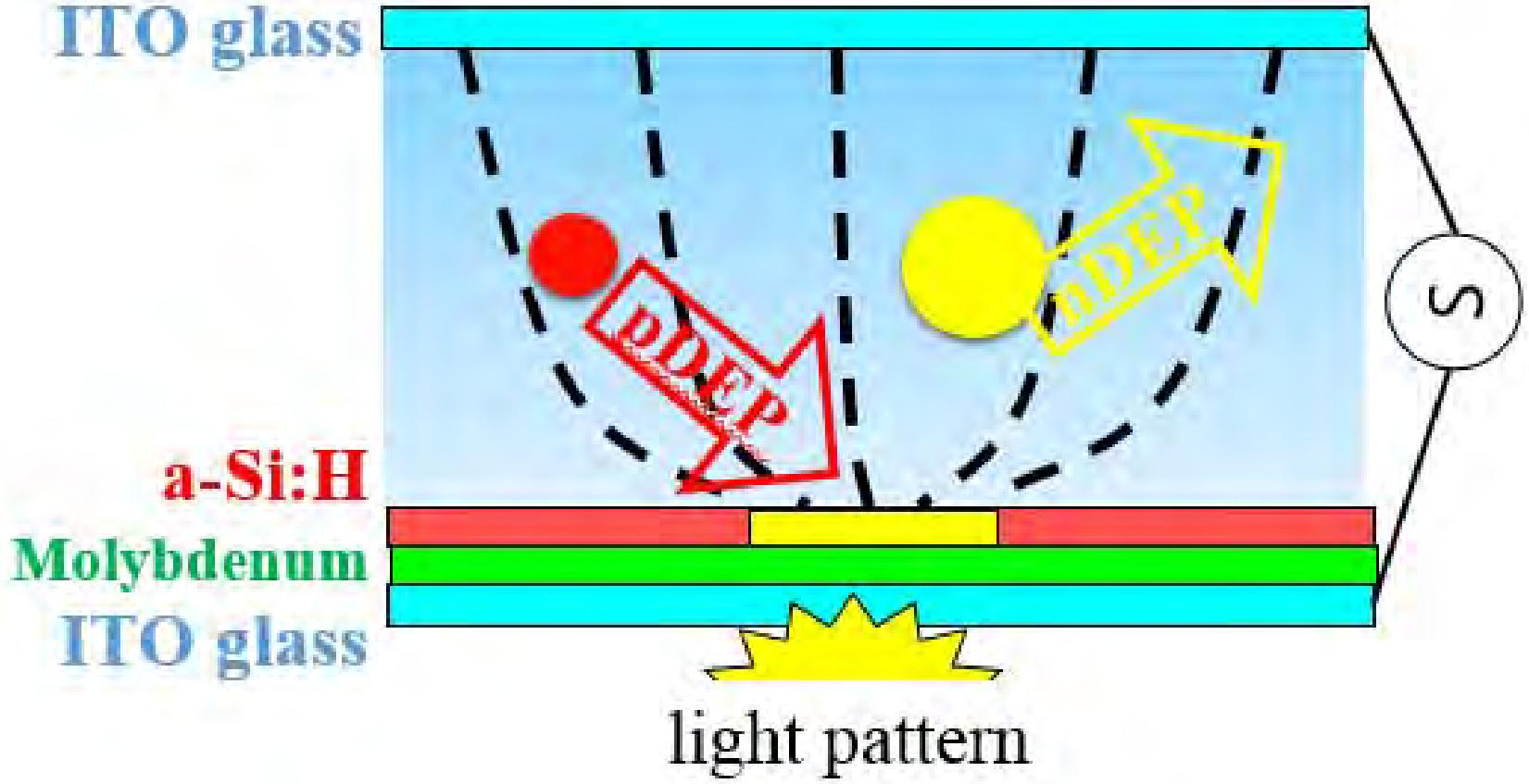

Dynamic Separation

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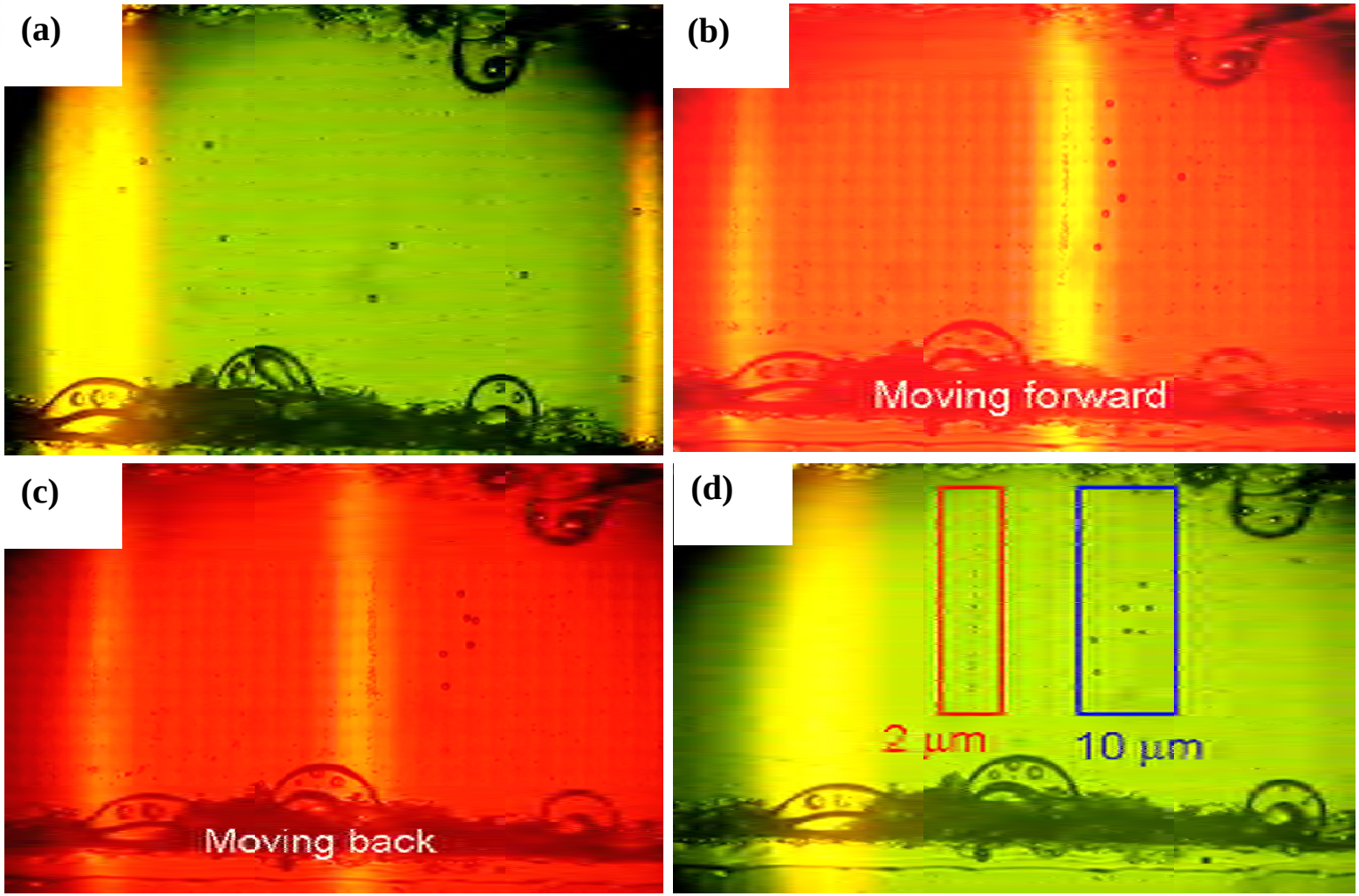

Electrokinetics Enhanced Sensitivity and Selectivity for DNA Hybridization/Immunoassay

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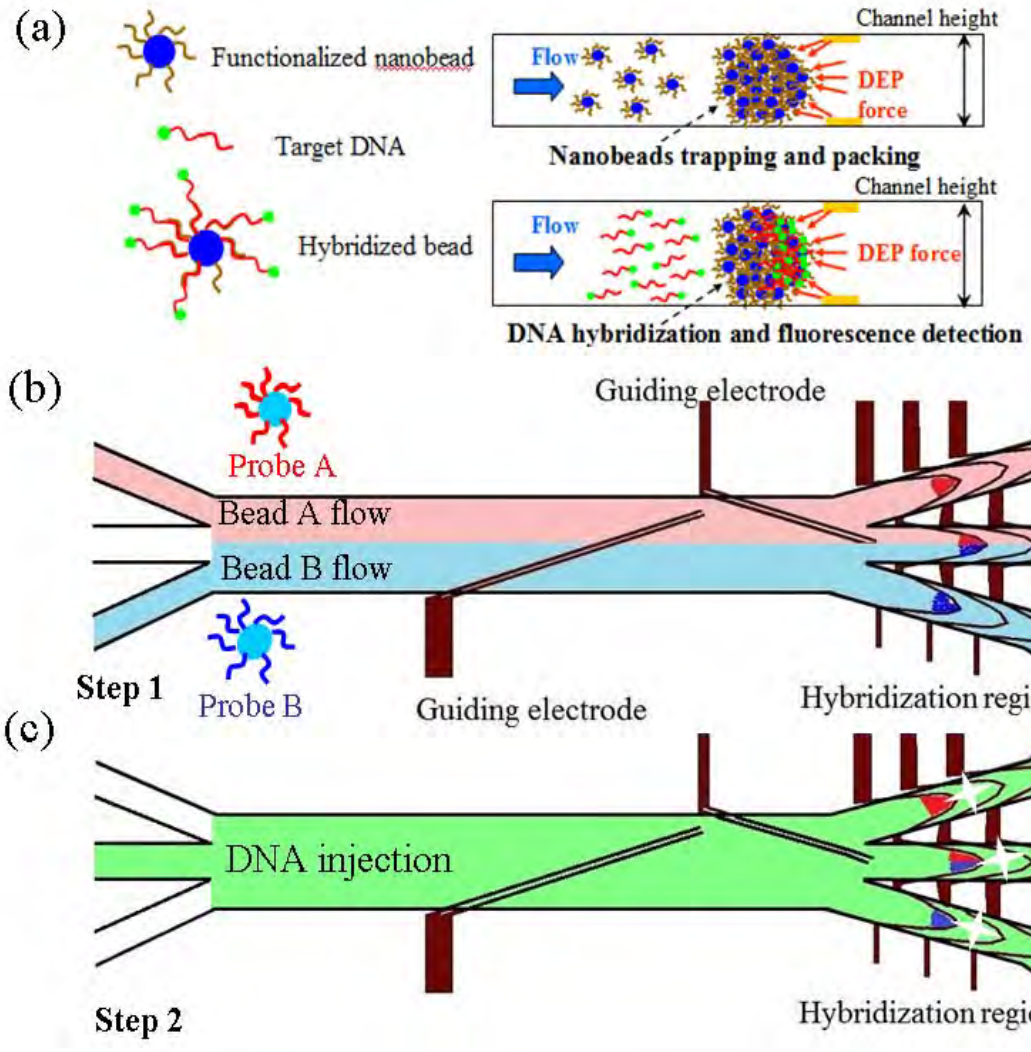
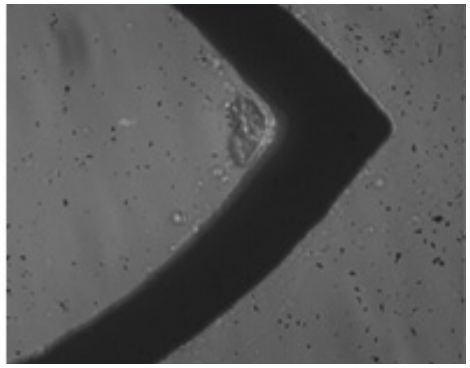
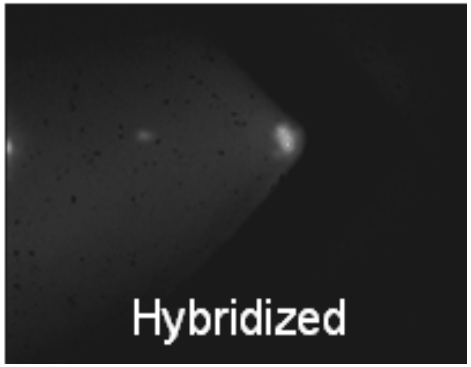
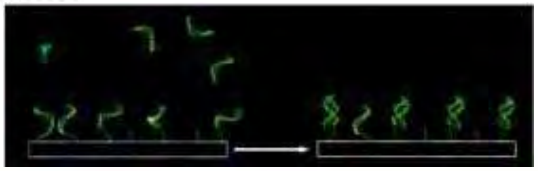






Hybridized Fluorescence



Shear Force Enhanced Specificity

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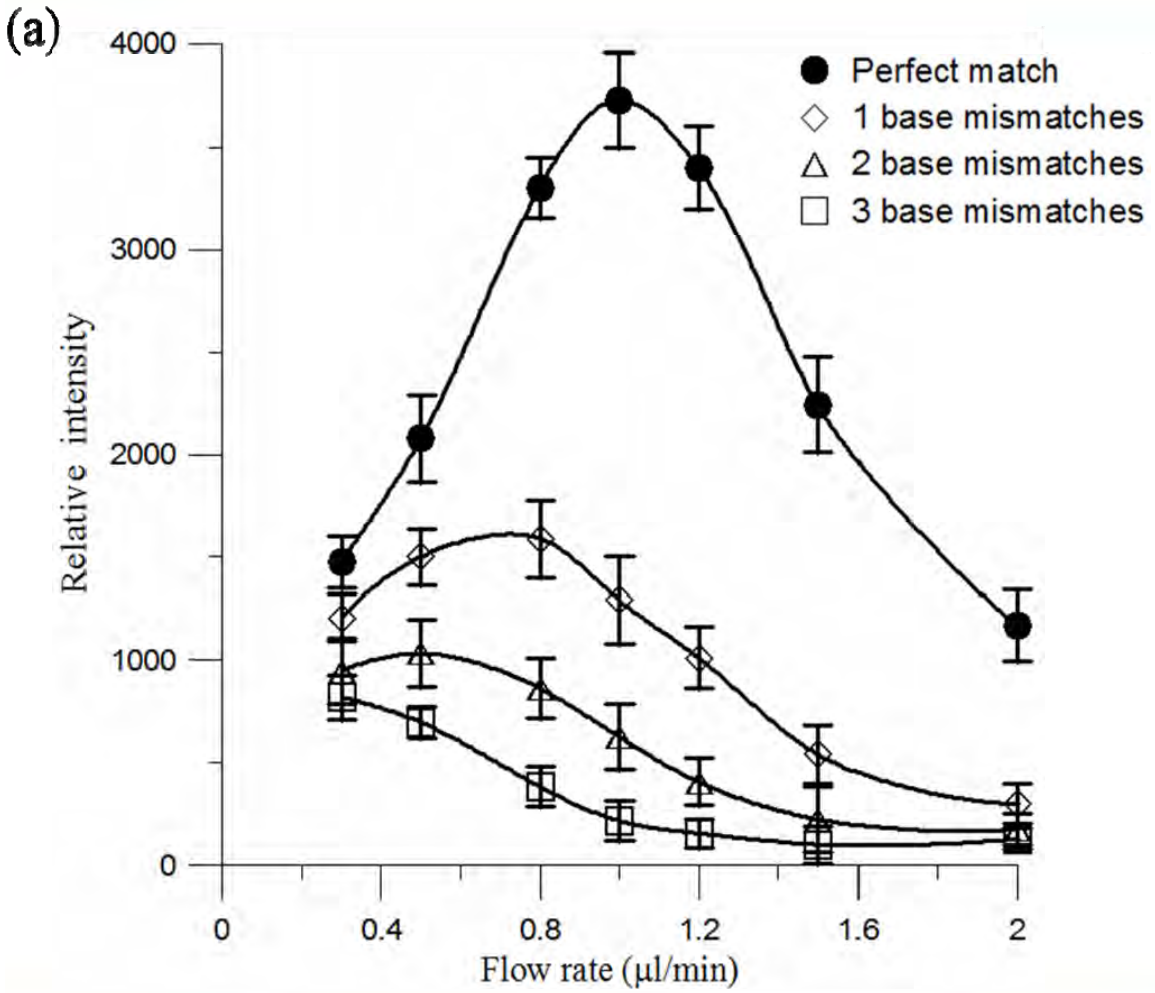

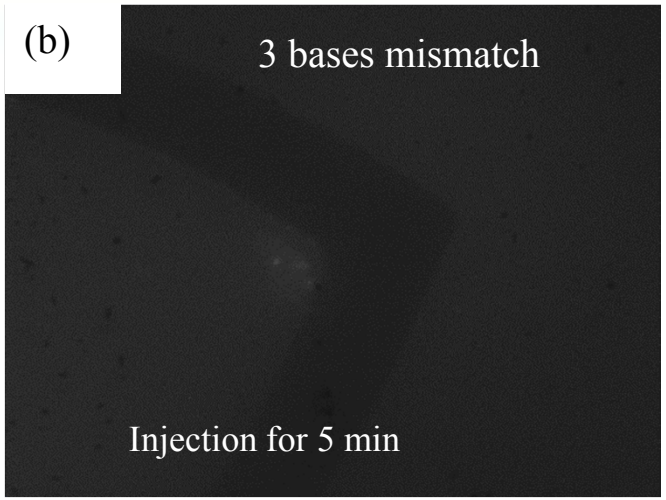

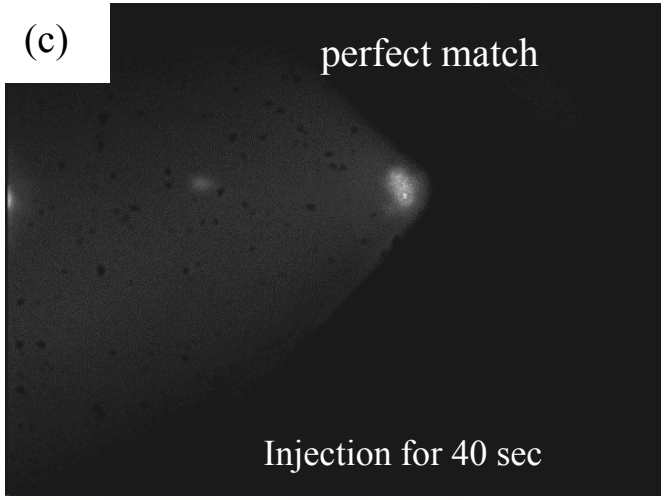

Whole Cell Diagnosis!

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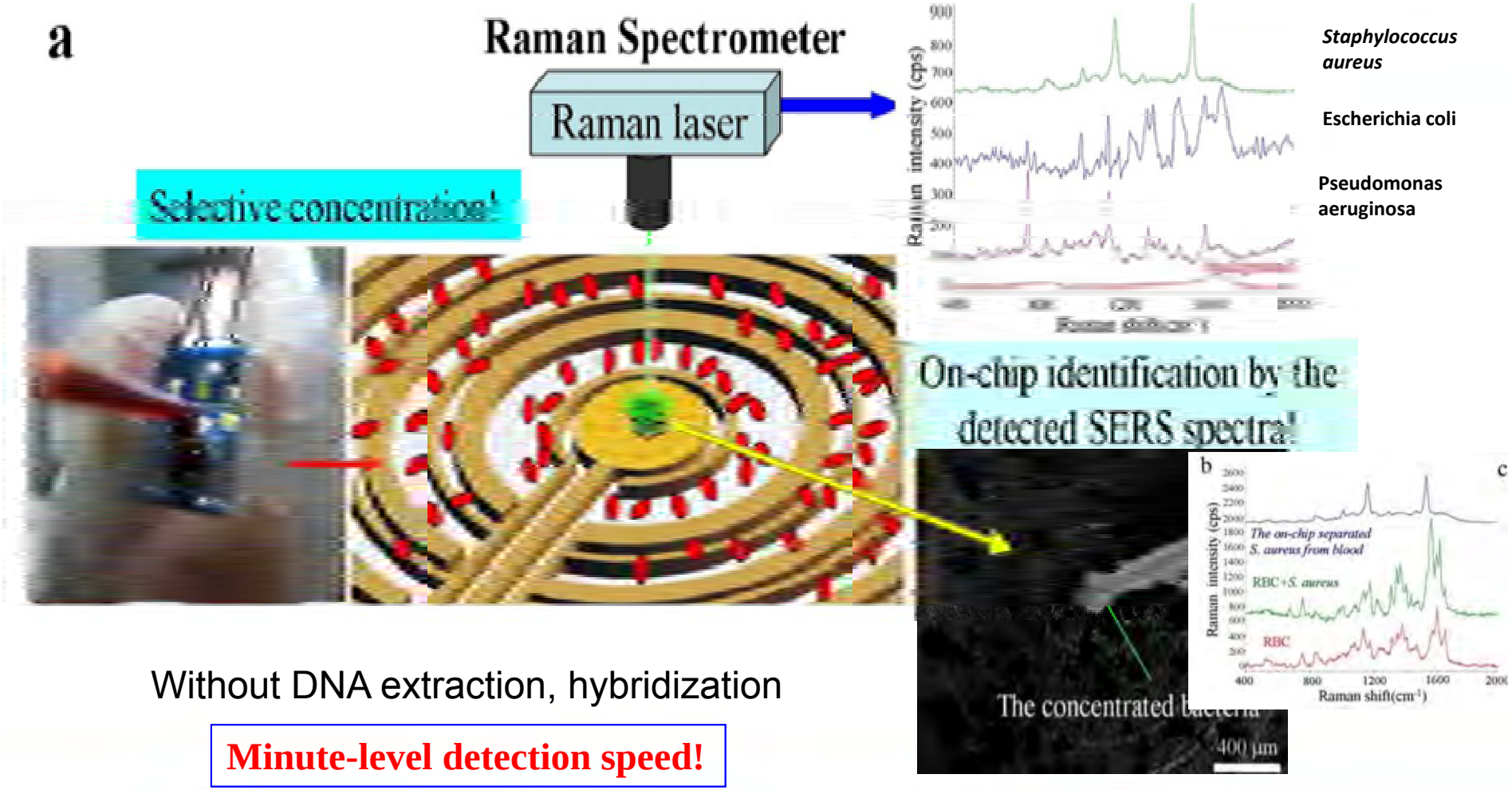
Rapid On-Chip SERS Identification of Bacteria



Without DNA extraction, hybridization

Minute-level detection speed!

Comparing to Current Protocol in General Hospital

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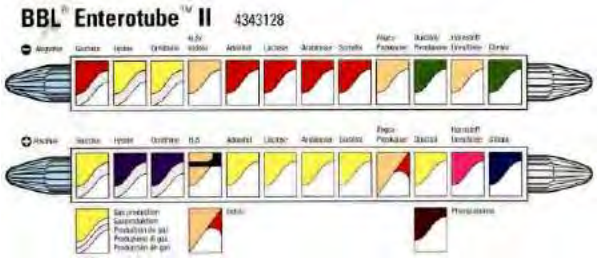
Bacteria detection in hospital

Positive Blood Culture

Plate culture

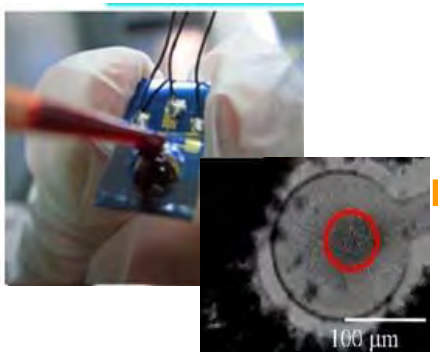
24 hr



Biochemical Detection (Enterotube II)

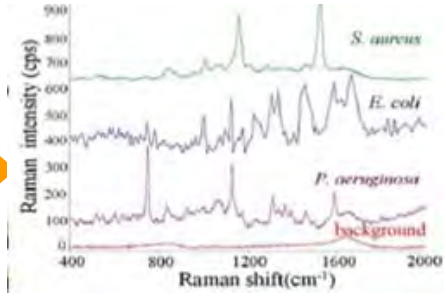
16-24 hr

Positive Blood Culture



Electrokinetically trapping

5 min



Raman Spectroscopy

~30 sec

Conventional Turbidimeter and AST Application

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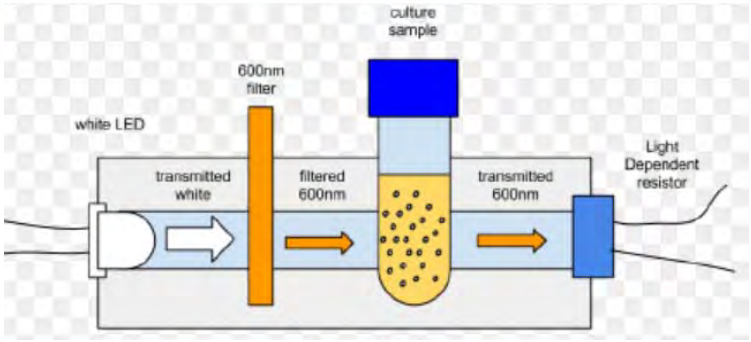

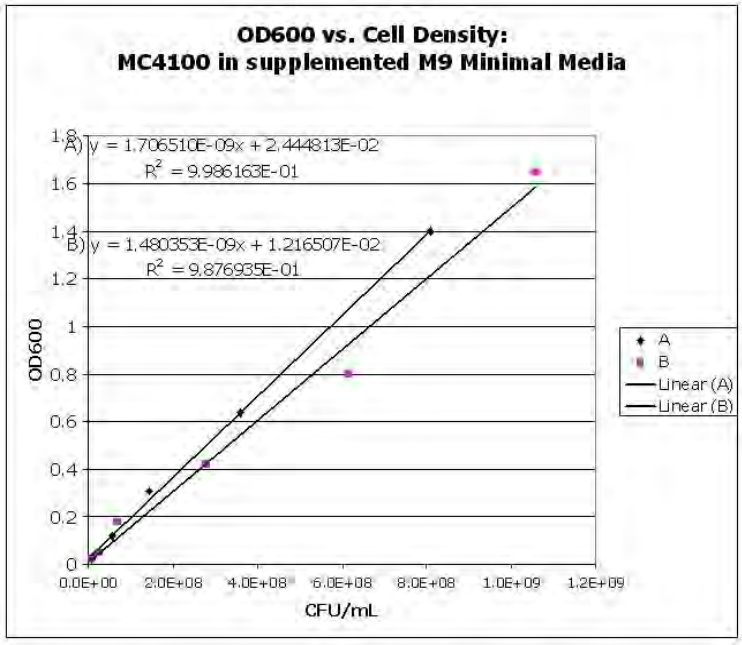

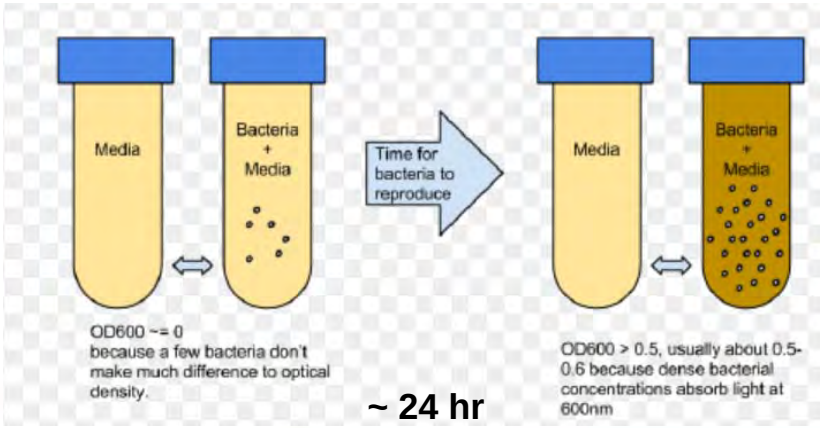

Pre-Concentration Enhanced Sensitivity

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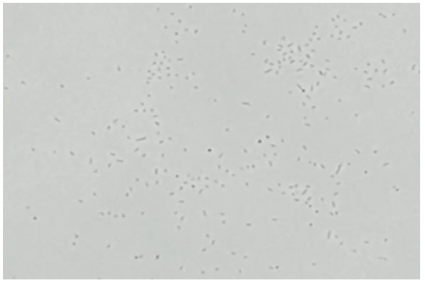
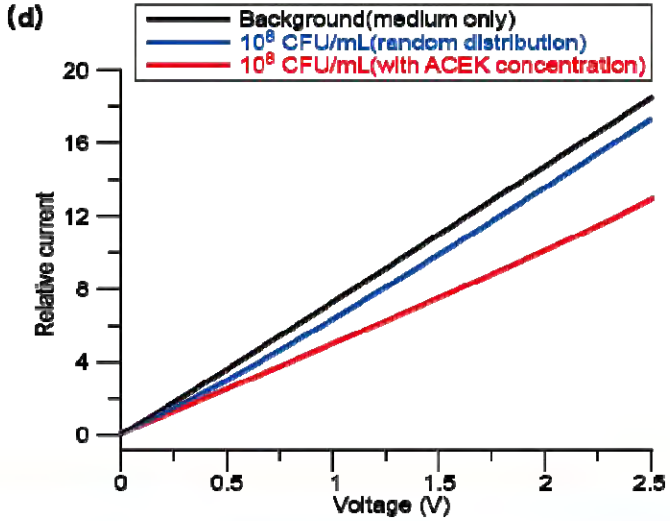
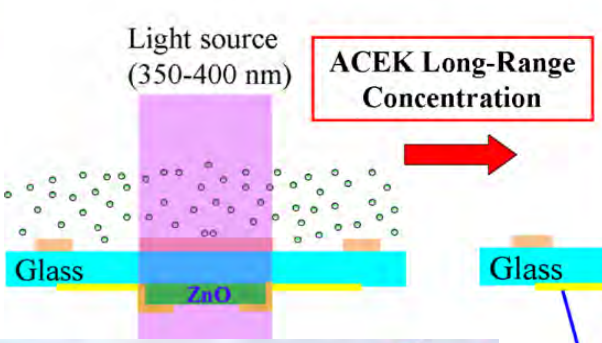
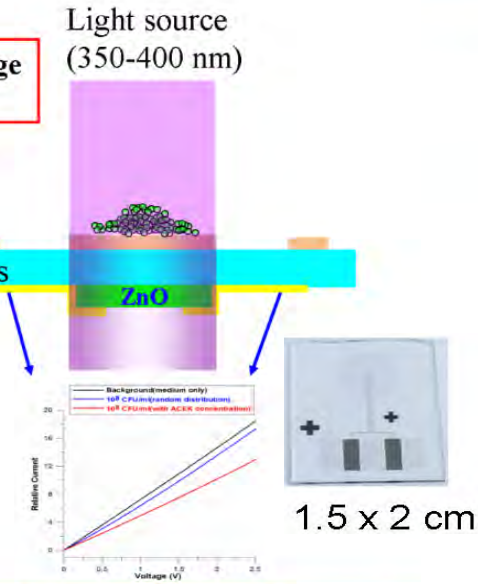
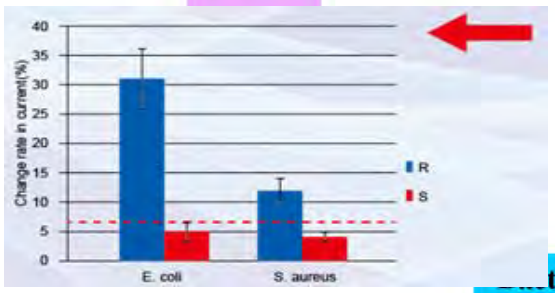


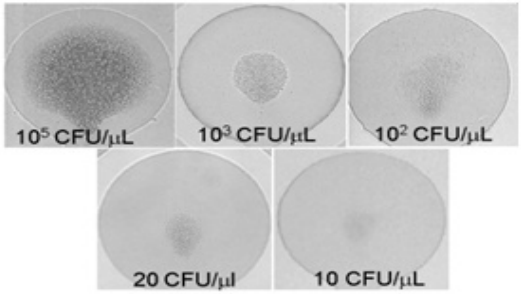


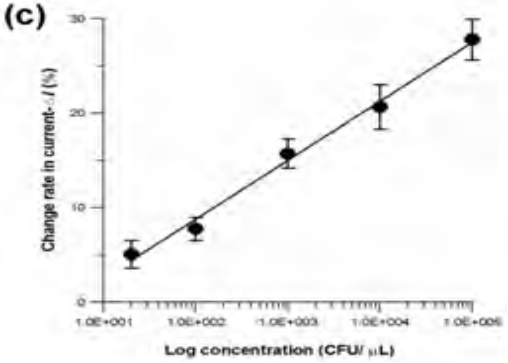






Bacteria Quantification via Measuring the Change in I-V Response





3.5 Hours Antimicrobial Susceptibility Testing Assay

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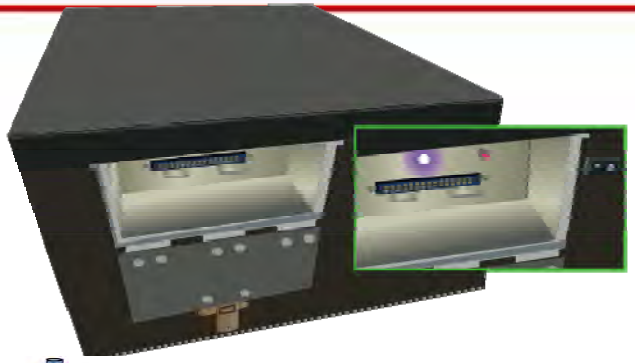
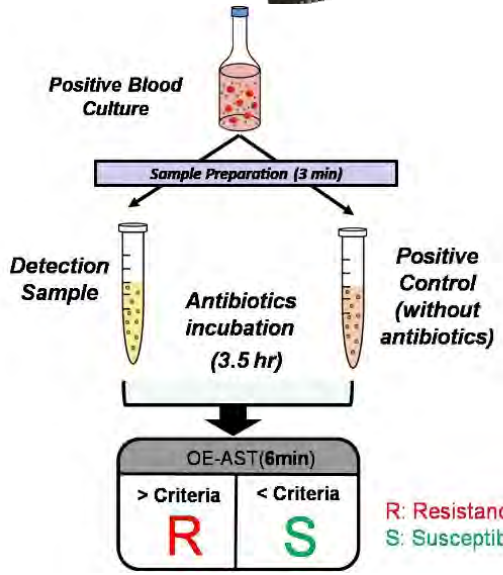
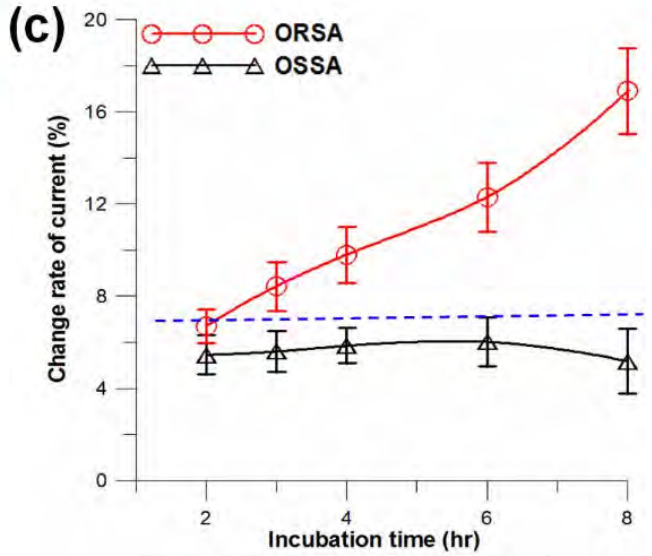


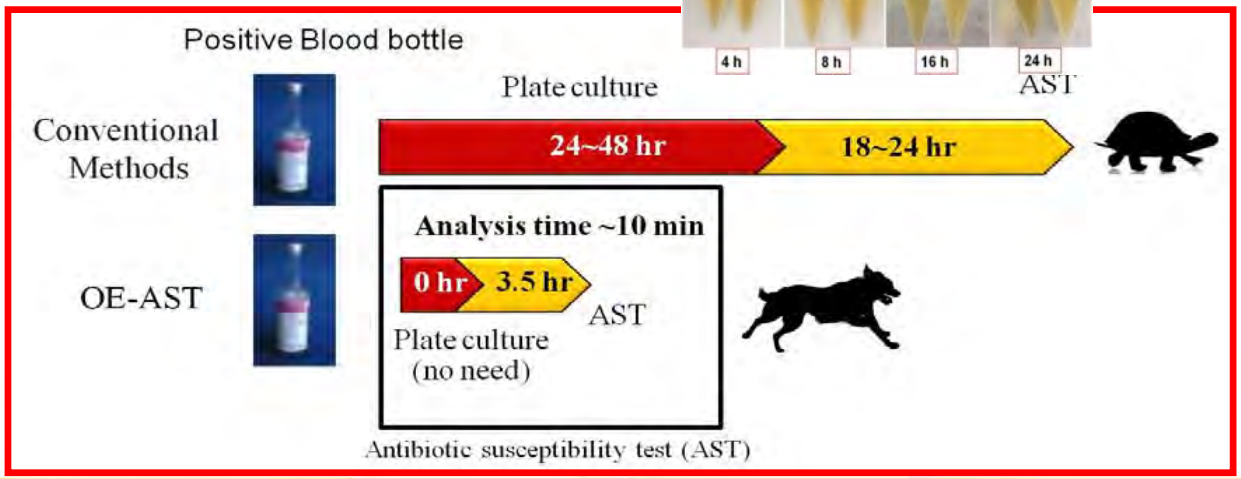


*Rapid AST of Septicemia and Urethritis
*Culture Free
*44 hr shorter than current methods
*Simple and User Friendly Detection Protocol
•Major error < 2% (3/151)



Tree-steps only!

Simple and User Friendly



Thanks for Your Attention!