# EG60411 Bio-Material Science

Toshiharu Enomae
Professor, PhD, Paper Device and Eco-friendly materials

2G103, 10:10-11:25, Tuesday

## Biomaterial Science （Schedule）

| # | Date | Content |
|---|---|---|
| 1 | 4/15 | History of papermaking |
| 2 | 4/22 | Pulps – Beating and fiber properties |
| 3 | 5/9, Fri | Pulps – Additives and functions |
| 4 | 5/13 | Papermaking processes & interfiber bonding |
| 5 | 5/20 | Paper– Structural properties |
| 6 | 5/27 | Paper– Surface properties |
| 7 | 6/3 | Polysaccharide chemistry by Assoc Prof Akiko Nakagawa |
| 8 | 6/10 | Paper–Wetting and absorption properties |
| 9 | 6/17 | Paper– Mechanical and optical properties |
| 10 | 6/24 | Recent trend of paper science and technology |

## Prospective future with Paper devices and Eco-friendly materials

**Toshiharu Enomae**
Professor
Faculty of Life and Environmental Sciences
University of Tsukuba , JAPAN

## Research topics
Laboratory of Paper Devices and Eco-friendly Materials

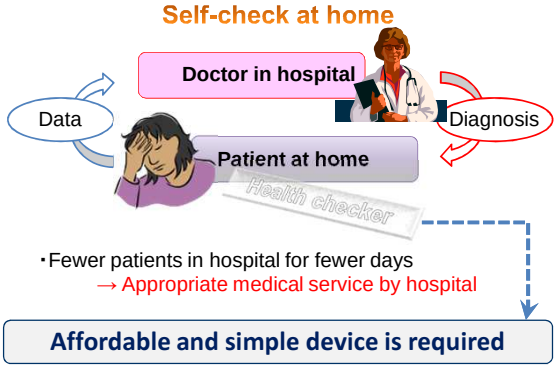
- **Paper device** (Paper in future)
  - Paper electronics
    - Paper–based medical check-up sensor
    - Energy supply device
  - Paper-based bioassay system
- **Paper cultural heritage** (Paper in past)
  - Conservation Science
- **Fundamental papermaking technology** (Paper at present)
  - Paper coating, paper physics and chemistry, etc.

## Development of Paper-based medical check-up sensor and technology of liquid transport in a micro-channel

Yinchao Xu

Kento Maejima
Yinchao Xu
Toshiharu Enomae
筑波大学
University of Tsukuba

## Paper-based medical check-up sensor




・Fewer patients in hospital for fewer days
→ Appropriate medical service by hospital

**Affordable and simple device is required**

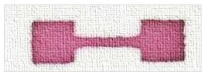
Paper devices

## Paper absorbs water.

Paper substrate

- Capillary force due to porous structure

- Liquid transport
  designed channel



Lab-on-paper as a medical check-up sensor

## Preparation of sensor paper

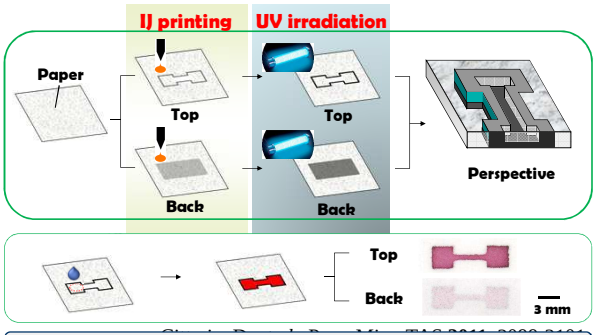
**Advantage of paper and improvement**

- Cheap, disposable, portable, and flexible
- Cotton linter pulp → almost no impurities
- Porous → micro-channel to transport liquid
- Smaller pore size → Less ink bleeding

| # | Beating, revolutions-PFI mill | Density, g/cm³ |
|---|---|---|
| 1 | 10000 | 0.568 |
| 2 | 20000 | 0.622 |
| 3 | 30000 | 0.641 |

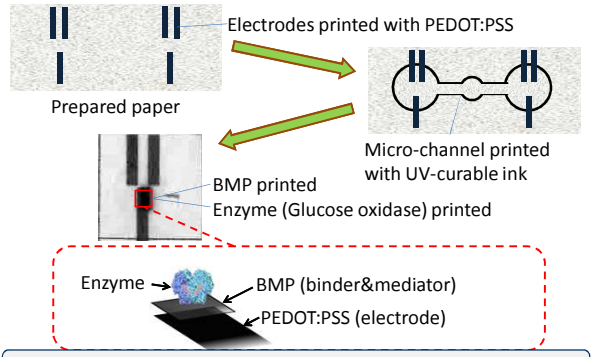
193

## Microchannel Fabrication




Microchannel was successfully fabricated

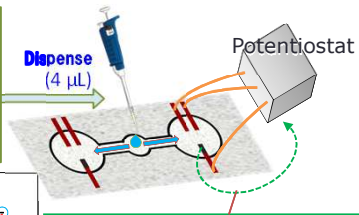
## Fabrication Processes of electrodes

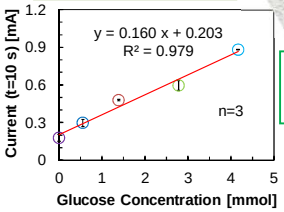



Lab-on-Paper was successfully fabricated

## Quantification of glucose

**Sample solution**
- 0.5 M KCl
- 2 mM $K_3[Fe(CN)_6]$
- 15 U/mL HRP
- Glucose Conc. (0-4.16 mM)

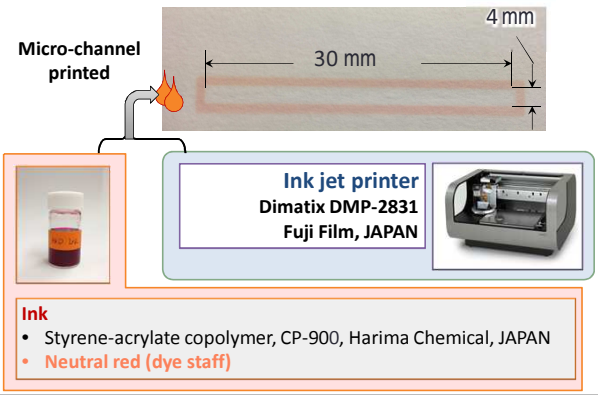



Glucose + $O_2$ → Gluconic acid + $H^+$ + $e^-$

**Glucose concentration quantified successfully**

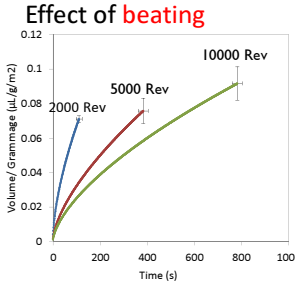
## Technology of liquid transport



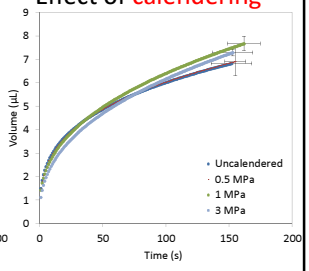

**Ink**
- Styrene-acrylate copolymer, CP-900, Harima Chemical, JAPAN
- Neutral red (dye staff)

## Results and discussion

Effect of beating




Effect of calendering




Lucas-Washburn's equation: $V \propto \sqrt{r_p}$

Beating → $r_p$ ↓

Calendering → $r_p$ ↓

Water transport

$r_p$ ↗ Irreversible

$r_p$ ↗ Reversible

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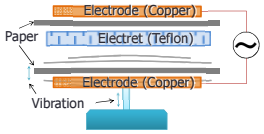
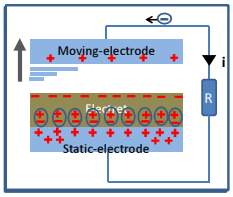
Laboratory of **Paper Devices and Eco-friendly Materials**
Prof. Toshiharu Enomae, University of Tsukuba

**Conversion of vibration energy of paper to electric energy**

Evi Oktavia

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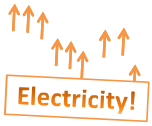
Paper-made Electric Power Generator




Application to:
Voice-activated posters

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## Bacterial culture system using paper substrate and ink jet printing

Tithimanan Srimongkon
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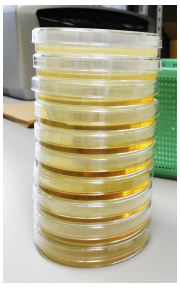
## Background



Stack of Petri dishes for different conditions!!

Ink jet printer dispenses

- **constant number of cells,**
- **same patterns**, and
- **a few environments in one medium**.

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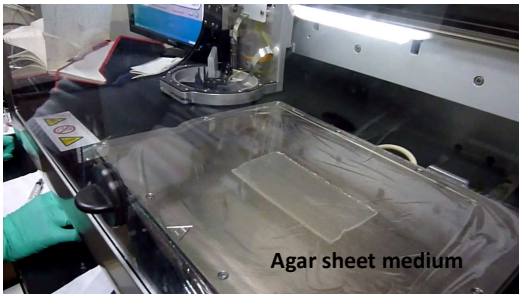
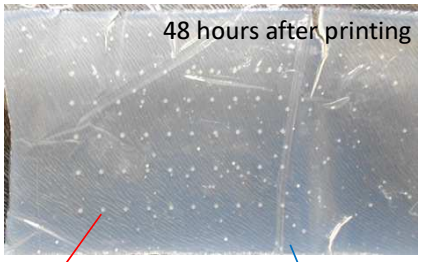
## *E. coli* printing



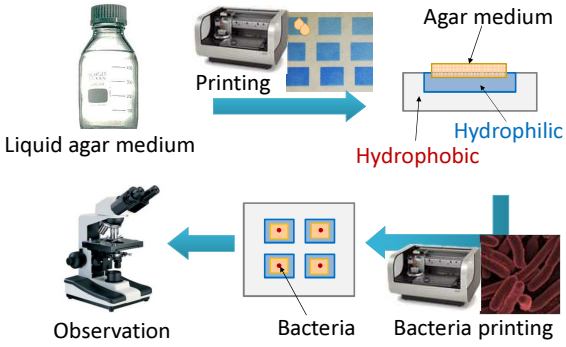
## *E. coli* printing



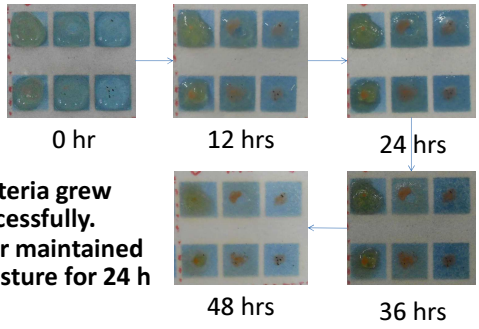

Dot of *E. coli* colony

Agar sheet medium

## Printing of agar and bacteria




## Bacterial culture test




- **Bacteria grew successfully.**
- **Agar maintained moisture for 24 h**

## Influence of saltwater immersion on properties of flood-damaged paper

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Akiko Nakagawa-Izumi
Toshiharu Enomae

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## Save flood-damaged paper

**Flood-damaged paper and books**

Mold grows and

- **Characters cannot be read due to color**
- **Bad smell**
- **Health hazard**
- **Artistic value lost**

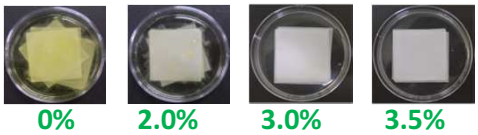
To inhibit mold growth

Washing → Drying → Restoration

… **Speedy action is difficult!**

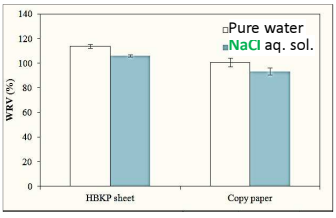
**Immersion in saltwater** **was proposed.**

## Saltwater inhibits mold growth

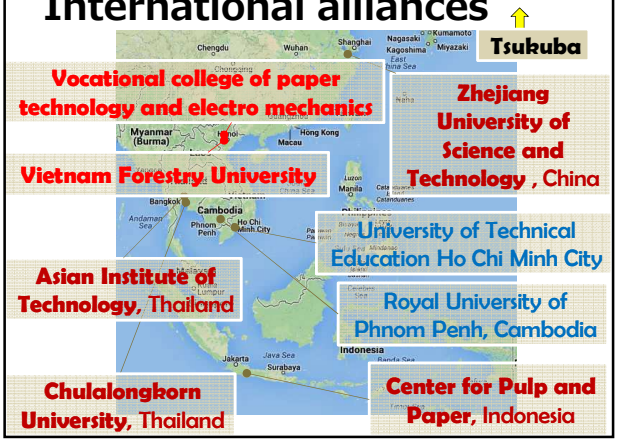


**0%** **2.0%** **3.0%** **3.5%**

- **As NaCl concentration increases, bacteria grew less (top), and**
- **fibers swelled less (right).**



## International alliances




Thank you for attention.

Your questions are welcome.
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