

Ink-jet Printing

Recently, ink-jet printings are actively applied to printed electronics.

We are studying applications of ink-jet to organic electronics devices (OLEDs, OPV, etc.).

Using these technologies, we collaborate with industrial companies, aiming at practical developments for actual products.

This material reviews our ink-jet technologies applied to flexible organic electronics devices (OLEDs, OPV, etc.).

Yamagata University

Innovation Center for Organic Electronics (INOEL)

Research Group for Flexible Technologies (Nakada/Furukawa/Yuki/Koden)

<http://inoel.yz.yamagata-u.ac.jp/F-consortium/home.html>

(Contact) Prof. H. Nakada nakada@yz.yamagata-u.ac.jp

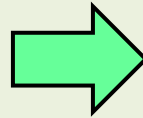
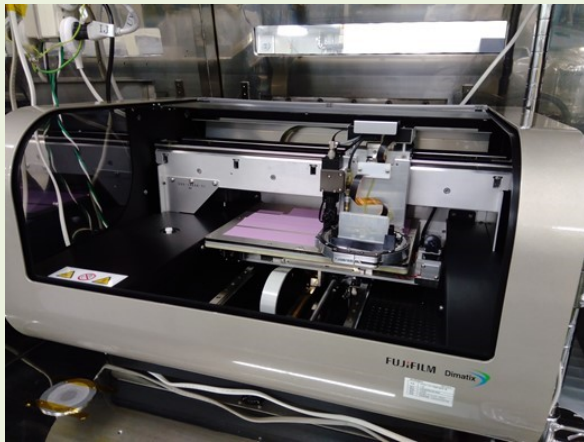
Prof. M. Koden koden@yz.yamagata-u.ac.jp

Technologies and equipment

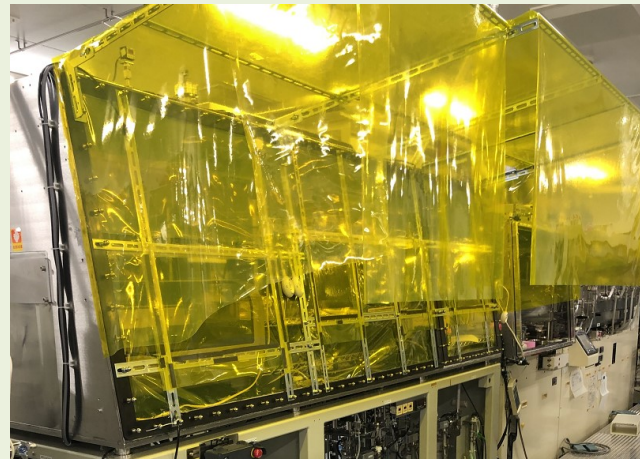
Equipment

Clean room

**Dimatix Materials Printer
DMP-2850 (FUJI FILM)**



**Glove-box with UV-cut film
(N₂ or dry air)**



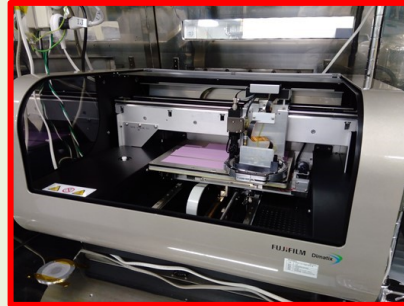
- **LED exposure equipment is set.
wavelength: 365nm and 395nm
exposure area: 300 × 300mm**
- **Hot-plate is set.
(~300°C)**

Ink-jet and relating apparatuses

Clean room



Vacuum deposition
(300mm square)



Ink-jet printer



Sputtering
(SiN_x, SiO_xN_y, IZO, etc.)



Wet cleaning
(Brushing, atomizing spray, US)



Plasma treatment
(O₂, N₂, Ar, CF₄)



ALD
(Al₂O₃, TiO₂, etc.)

Application of ink-jet to TFE (Thin Film Encapsulation)

Collaroration

TOYO INK SC HOLDINGS CO., LTD.

Publication

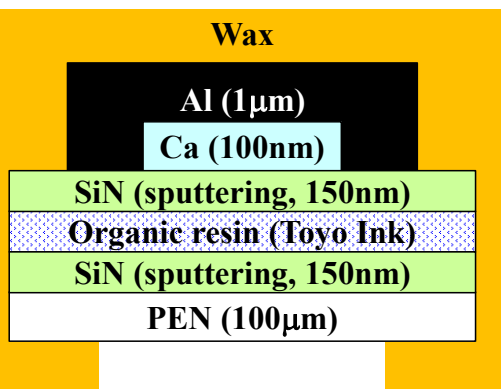
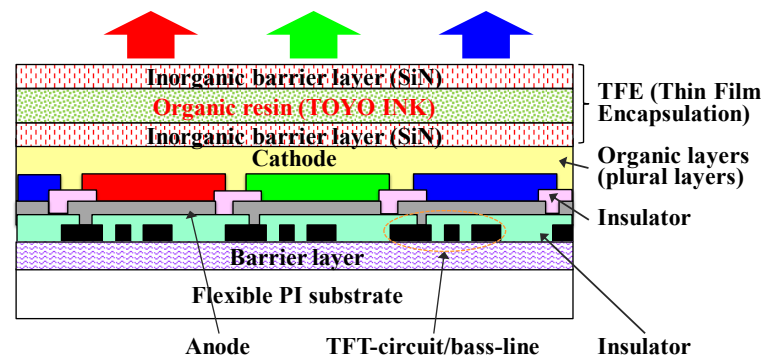
● Yamagata University ; “JFlex2020” (Jan. 2020 / Tokyo); “JFlex2019” (Jan. 2019 / Tokyo).

TFE technologies with TOYO INK's organic resin

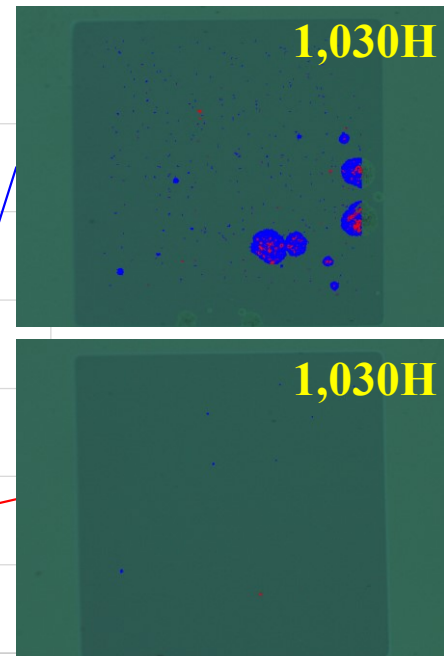
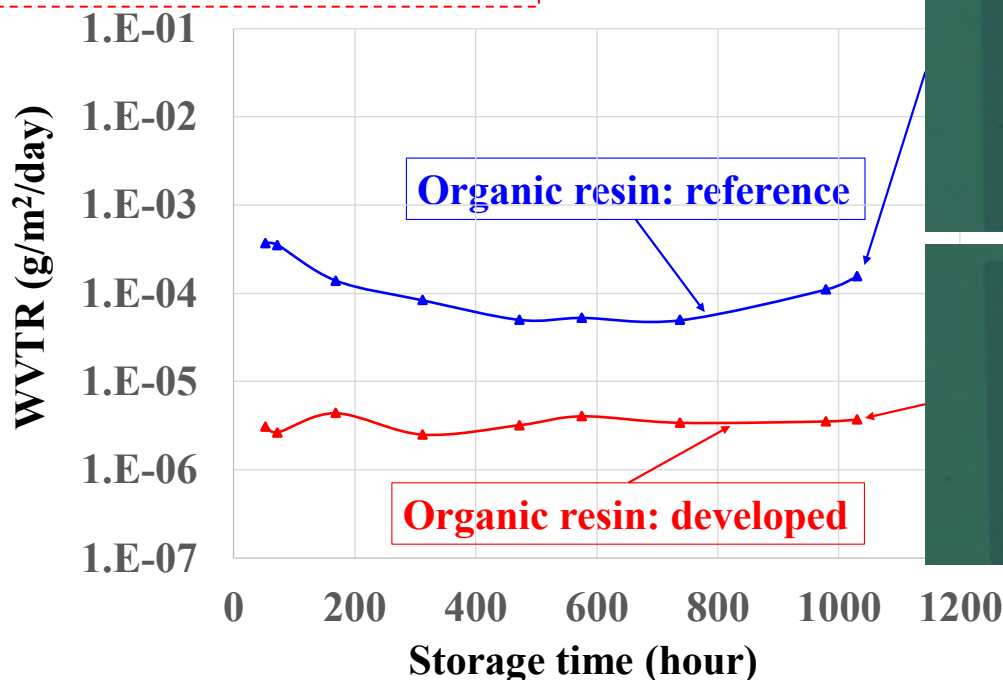
High gas barrier property was achieved by TOYO INK's organic resin sandwiched by SiN barrier

* No actual damage after storage test of 1,000 hours under 40°C/90%RH

* WVTR (Water Vapor Transmission Rate): order of 10^{-6} g/m²/day (40°C/90%RH)



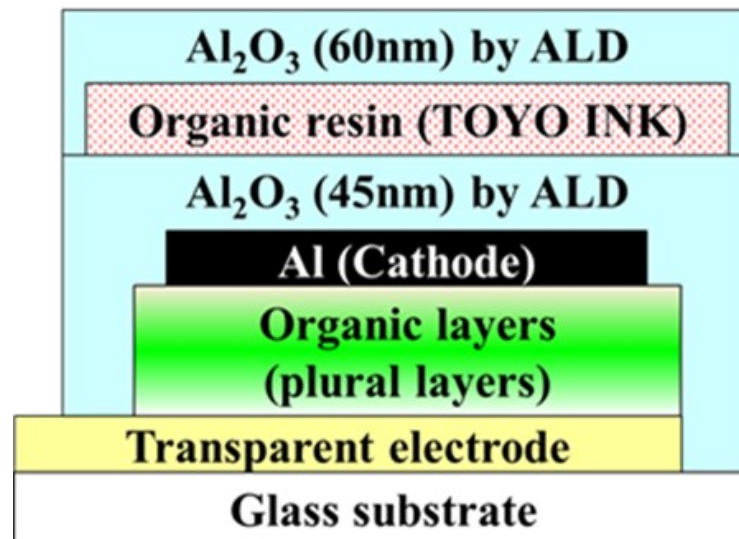
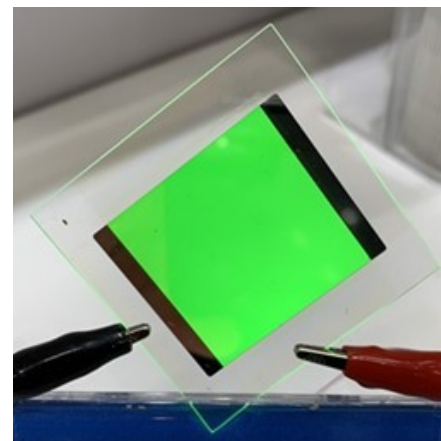
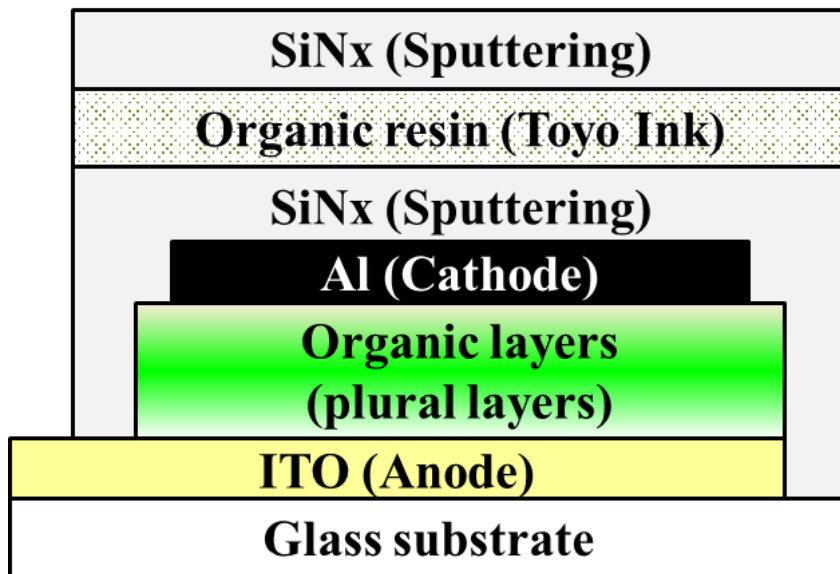
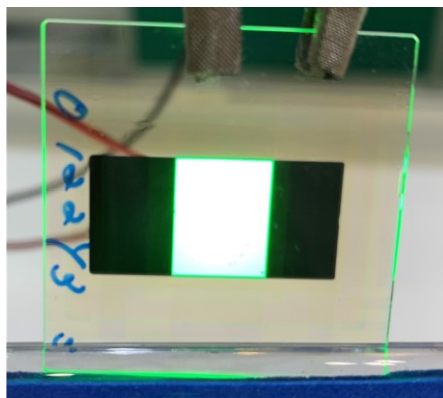
Ca corrosion test
40°C/90%RH



Related program

- Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016~Mar. 2019]
- NEDO: Strategic technological innovation program for energy saving "Development of high efficient OLED materials" (Collaboration with CEREBA) [Aug. 2017~Mar. 2020].

Flexible OLEDs with TFEL



Collaroration

TOYO INK SC HOLDINGS CO., LTD.

Publication

● Yamagata University; “JFlex2020” (Jan. 2020 / Tokyo); “JFlex2019” (Jan. 2019 / Tokyo).

OnDemand patterning of OLEDs by ink-jet printed insulators

On-demand patterning of insulators was developed using on-demand ink-jet printing, aiming at applications to OLED lighting devices with certain design patterns.

Such OLED devices can be applied to various products such as direction indicators, emergency signs, labels, packaging, advertisements, souvenirs, name plates, name tags, etc.

Collaroration

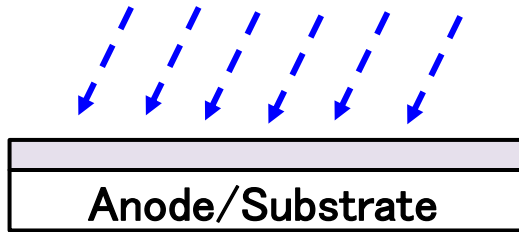
TOYO INK SC HOLDINGS CO., LTD.

Publication

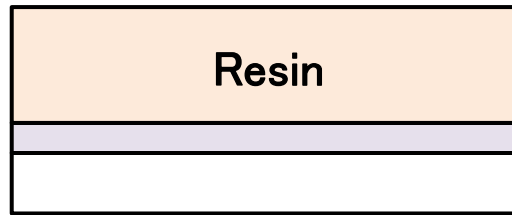
● M. Sugimoto, Y. Fukuchi, H. Tsuruta, M.Koden, H. Nakada, T. Yuki, A-COE 2021, PA-17 (2021).

■ General processes of Insulator (Photolithographic patterning)

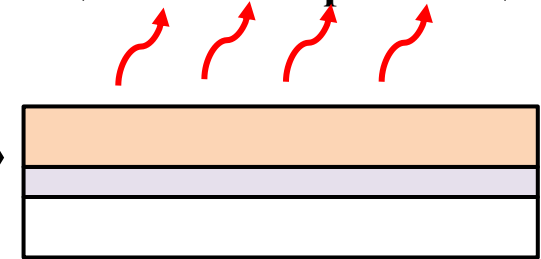
Cleaning/Pre-treatment



**Printing of resin
(Die coating, Spin coating)**

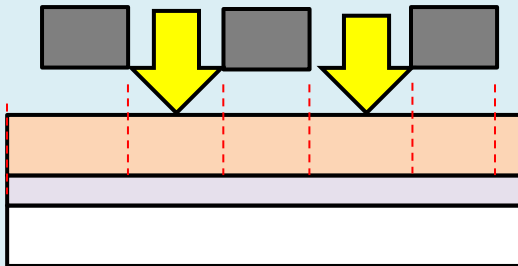


**Pre-Bake
(Solvent evaporation)**



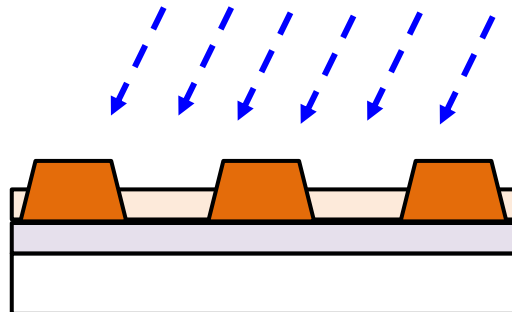
exposure

Photo mask

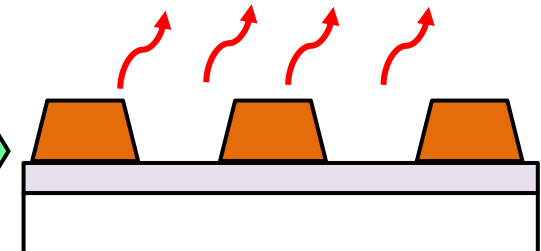


Patterning with Photo mask

Development/Washing

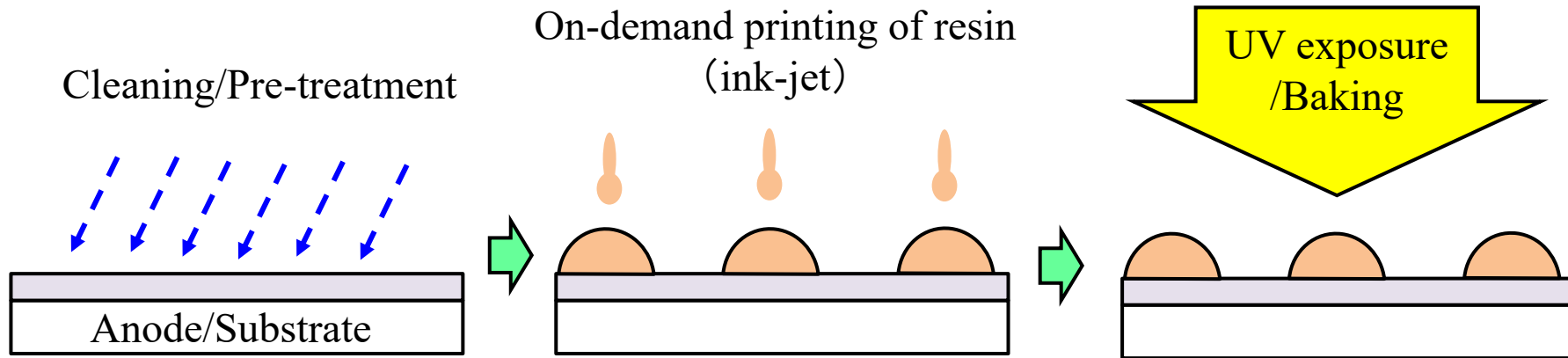


**Post-bake
(Water removal, Crosslinking)**



● **Complex processes**

■ *IJ Patterning processes*



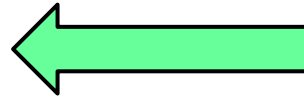
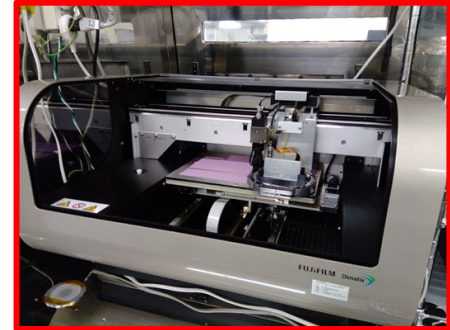
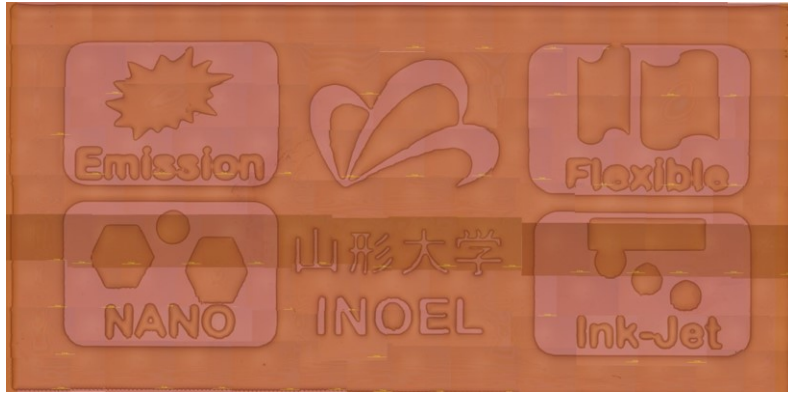
Advantage of ink-jet printing (IJ)

- Simple process
- Easy correspondence for low-volume and multi-design production (Without photo mask)
- Eco-friendly (A small amount of waste liquid)
- Non-contact of materials, masks, etc. in un-coated areas

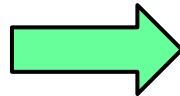
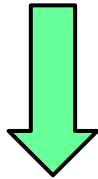
Ink-jet printing is ideal for on-demand OLEDs

OLED device fabrication

Ink-jet printing on a glass with



OLED device fabricaitn

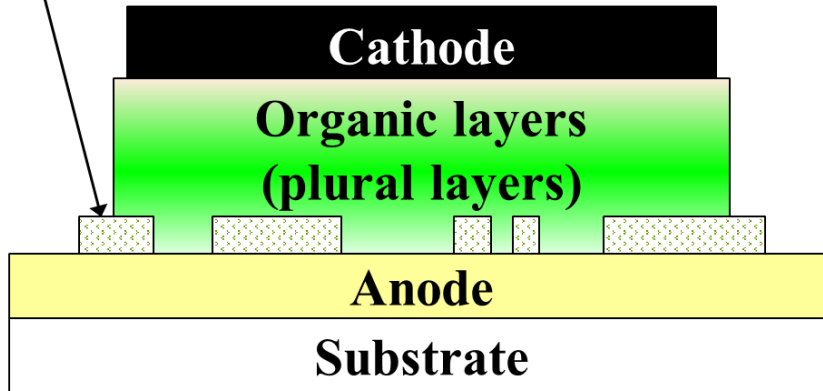


OLED Prototype
Size : 100mm × 60mm
(YU-FLEC)

OLED with insulator patterns printed by ink-jet

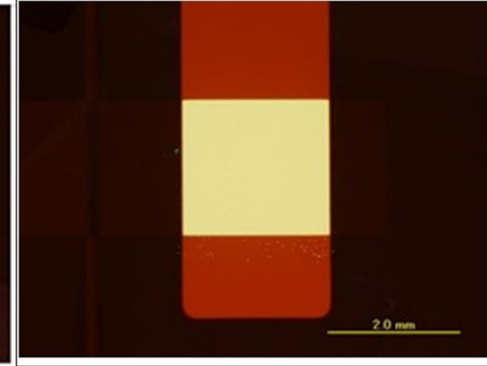
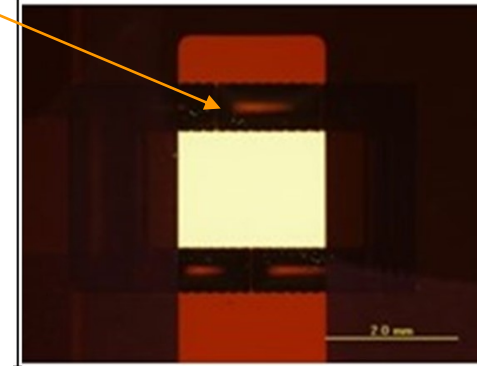
Insulator (by IJ)

Insulator

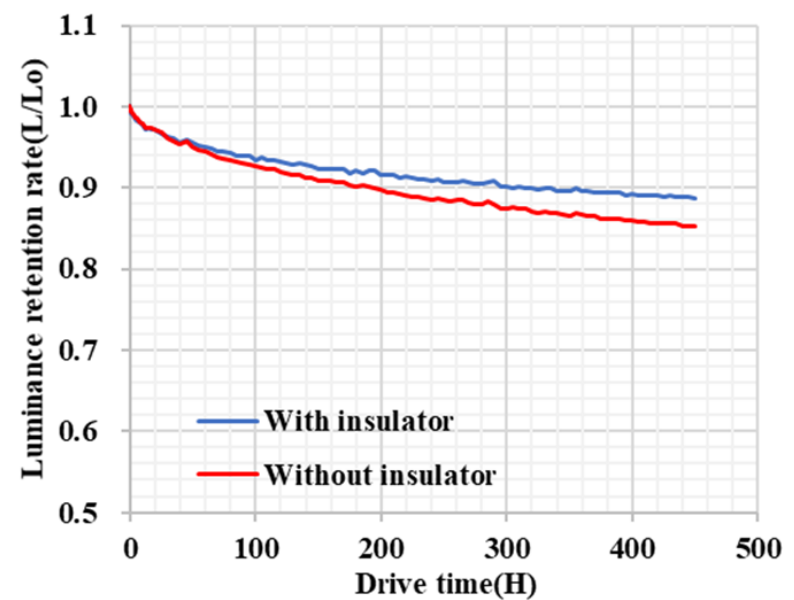
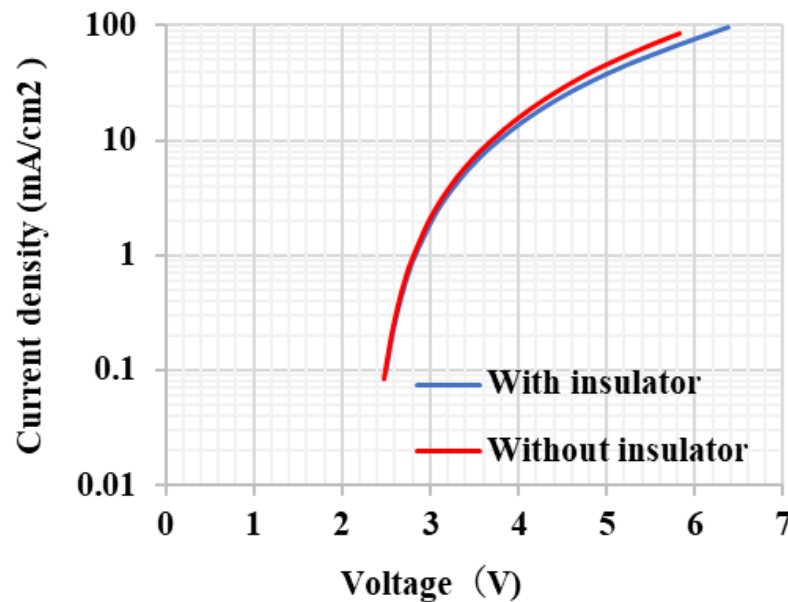


With insulator

Without insulator



(Uniform emission)



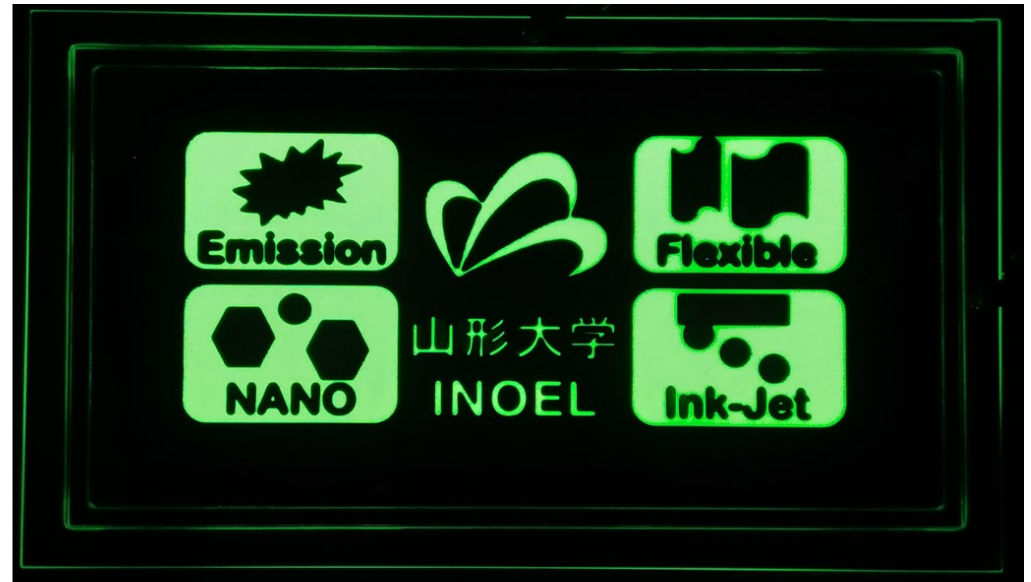
Equivalent initial characteristics and lifetime

Prototype samples of OLED devices

The developed technology achieved fine patterns with $L/S=61/62\mu\text{m}$, which is almost comparable with 400dpi.



Substrate size: 50mm × 50mm



Substrate size: 60mm × 100mm

Summary

Our ink-jet technologies contribute practical R&D in industrial companies by collaborations using our rich knowledge and skills.

Please do not hesitate to contact with us.

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Research Group for Flexible Technologies

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