

Yamagata University Organic Thin Film Device Consortium

Greeting

“Yamagata University Organic Thin Film Device Consortium” [*] has developed “Flexible Substrates with Alternative Electrode of ITO (Indium Thin Oxide) for Organic Electronics” by university-industry collaboration.

In this exhibition, the developed technologies and prototype OLED devices are demonstrated.

The next consortium “Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC)” are planned to be started in April 2016 as three years program.

[*] supported by “R&D subsidiary program for promotion of academia-industry cooperation” of Ministry of Economy, Trade and Industry of Japan.

R&D Subjects

“Flexible Substrates with Alternative Electrode of ITO (Indium Thin Oxide) for Organic Electronics”

- * Flexible substrates for organic electronics (ultra-thin glass, stainless steel foil, plastic film)
- * Alternative electrodes of ITO
- * Roll to roll (R2R) technologies

Project term

April 2013 – March 2016

R&D Contents

- ✓ Solution materials
- ✓ Evaporation materials

- ✓ Ultra-thin glass
- ✓ Stainless steel foil
- ✓ Plastic film

Non-ITO transparent electrode
Barrier / Planarization
Flexible substrate

Roll-to-Roll (R2R) process

Original R2R equipment

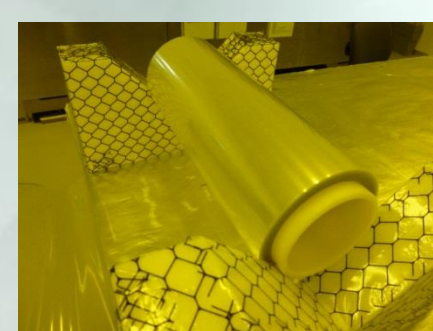
- ✓ Sputtering and CVD (KOBELCO)
- ✓ Screen printing (SERIA)
- ✓ Gravure offset and Flexography printing (Komori Machinery / Taiyo Kikai)
- ✓ Wet clearing (FEBACS)



Ultra-thin glass



Stainless steel foil



Plastic film



Sputtering & CVD (KOBELCO)



Screen printing (SERIA)

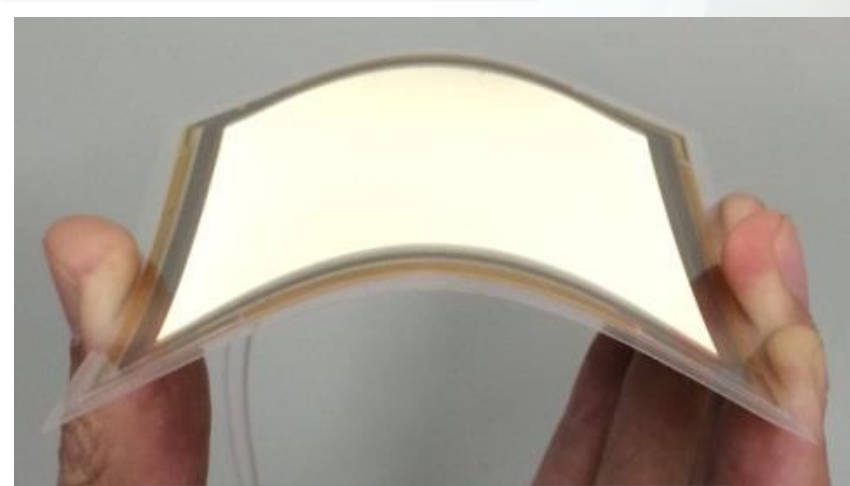


Gravure offset and Flexography printing (Komori Machinery / Taiyo Kikai)

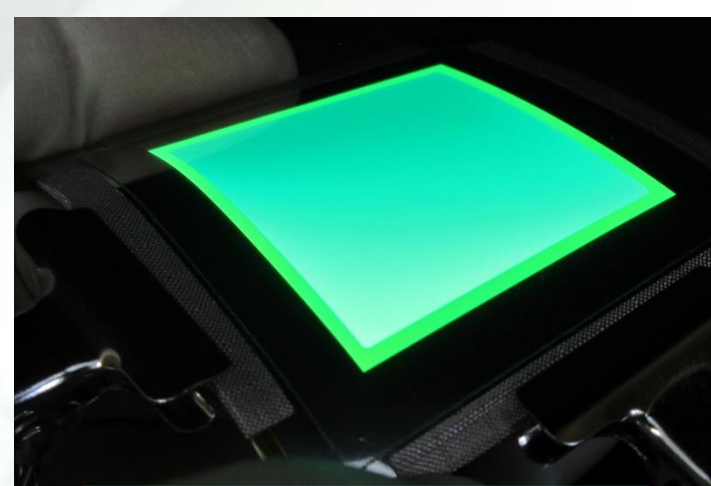


Wet clearing (FEBACS)

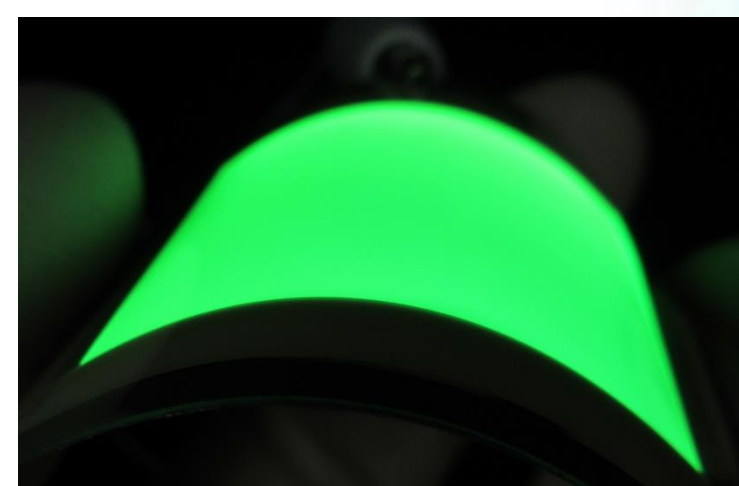
Prototypes



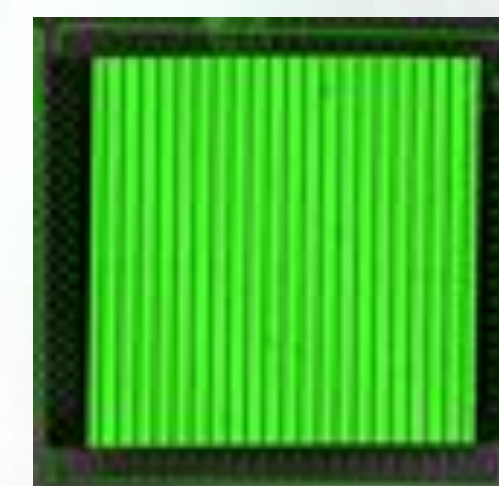
Flexible OLED on ultra-thin glass



Flexible OLED on stainless steel foil



Flexible OLED on barrier film



OLED with non-ITO transparent electrode

Features

- ✓ Technology Integration based on collaboration among companies with various technologies
 - * substrates, materials, printing, equipment, devices, etc.
- ✓ Initiative of Yamagata University
 - * Leaders are experts who left private companies.
- ✓ Introduction of original Roll-to-roll (R2R) equipment
- ✓ Contribution to the revival from 2011 Tohoku earthquake

Main members



Prof.
Dr. M. Koden
(Project leader)



Prof.
H. Nakada
(Technical fellow)



Associate Prof.
T. Furukawa
(R2R technologies, printing)



Associate Prof.
Dr. T. Yuki
(Non-ITO technologies)



Associate Prof.
Dr. H. Kobayashi
(Flexible substrates)

(Contact)

Prof. M. Koden

koden@yz.yamagata-u.ac.jp

Prof. H. Nakada

nakada@yz.yamagata-u.ac.jp

URL : <http://inoel.yz.yamagata-u.ac.jp/F-consortium/index2.htm>

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Yamagata University Organic Thin Film Device Consortium

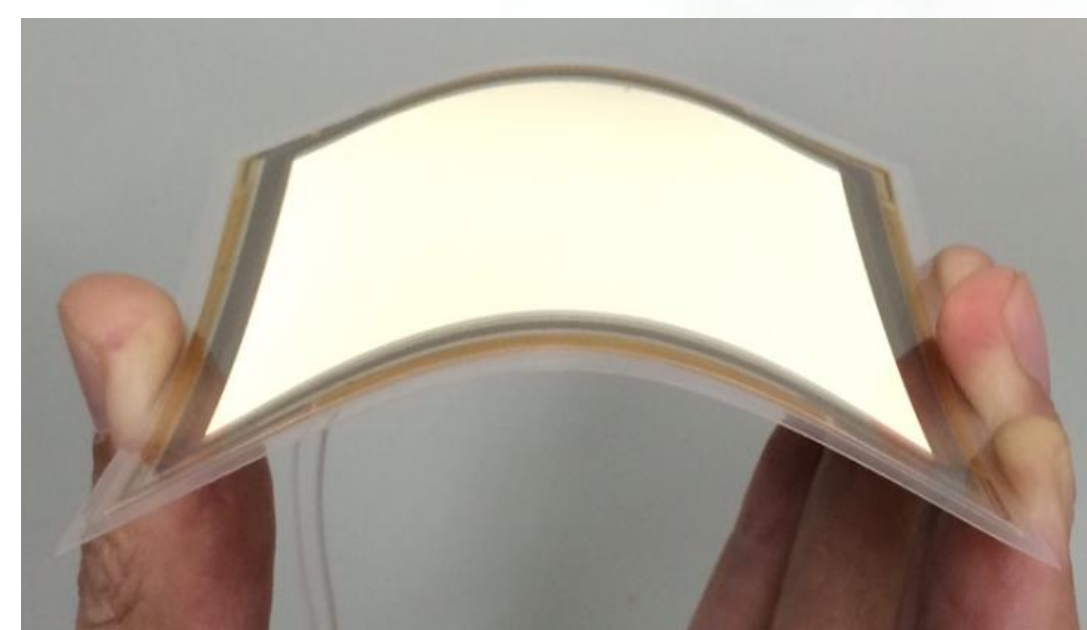
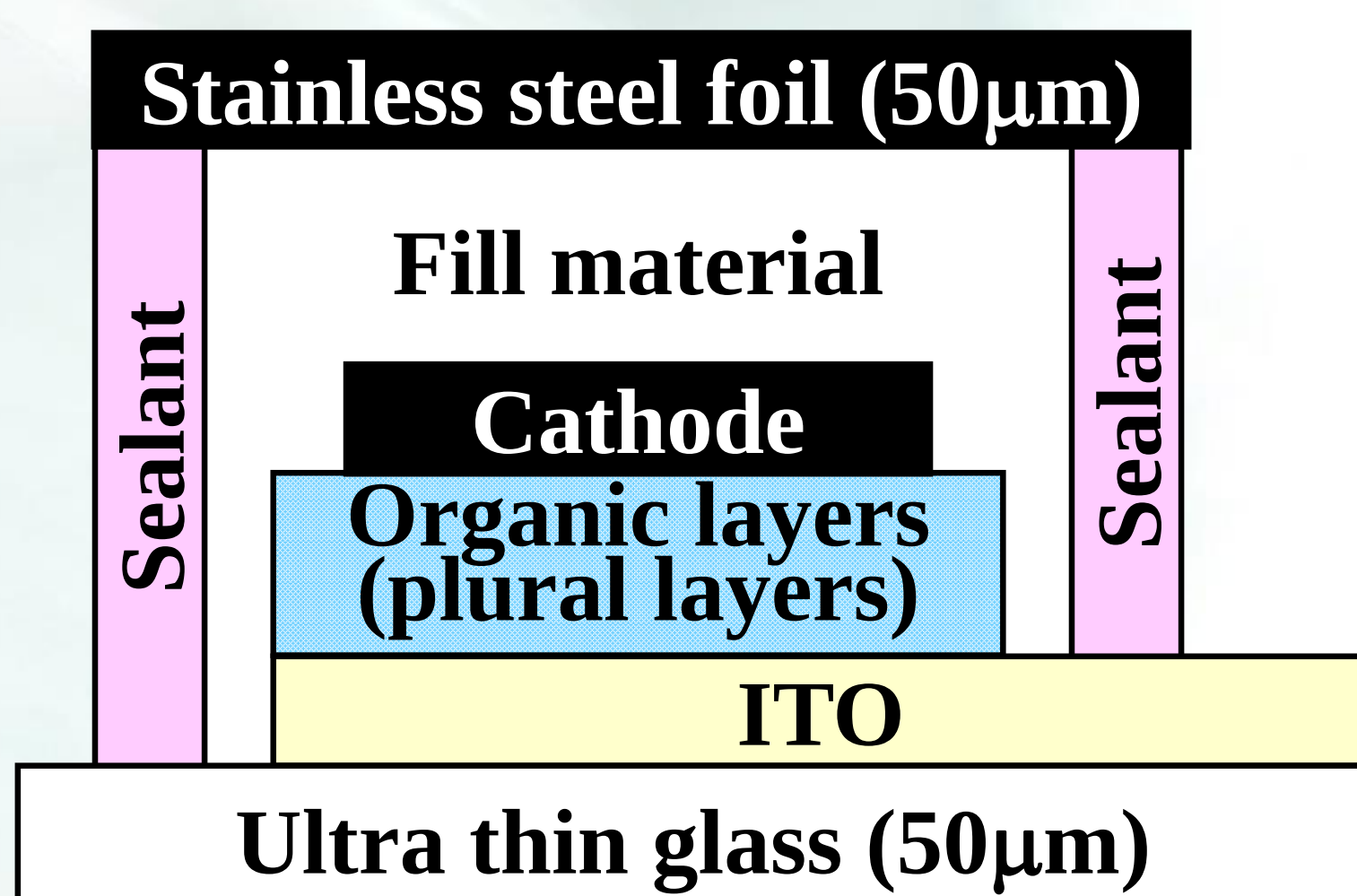
Flexible OLED lighting devices with ultra-thin glass

【Features of ultra-thin glass】

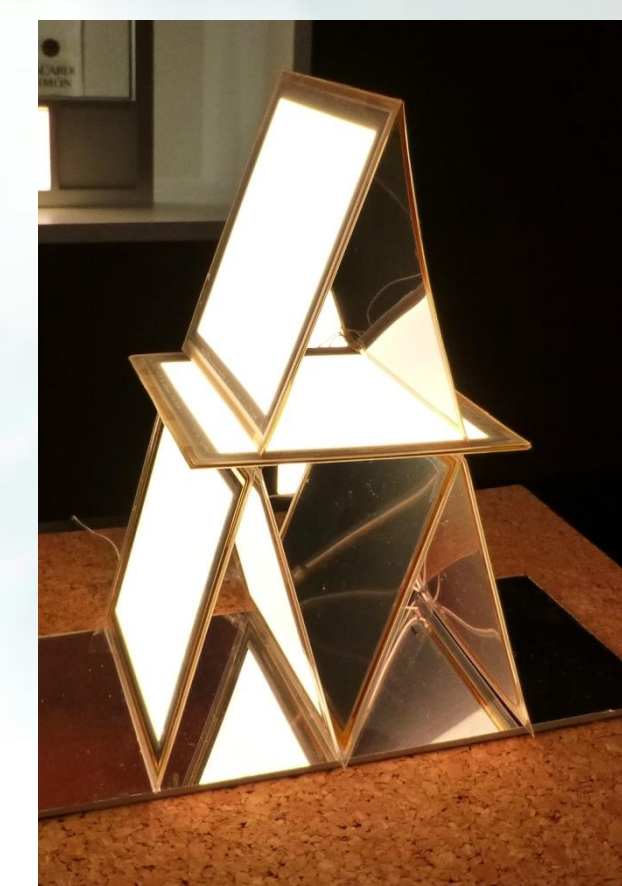
- ✓ Flexibility (applicable to R2R)
- ✓ Excellent gas barrier property, excellent temperature resistance, excellent chemical resistance, smooth surface, low thermal expansion, etc.



Flexible OLED lighting device (92mm□) with ultra-thin glass (fabricated by NEC Lighting)



Substrate size : 92mm X 92mm
Emission area : 75mm X 75mm



Lighting Fair 2015
(NEC Lighting Booth)
(March 2015)

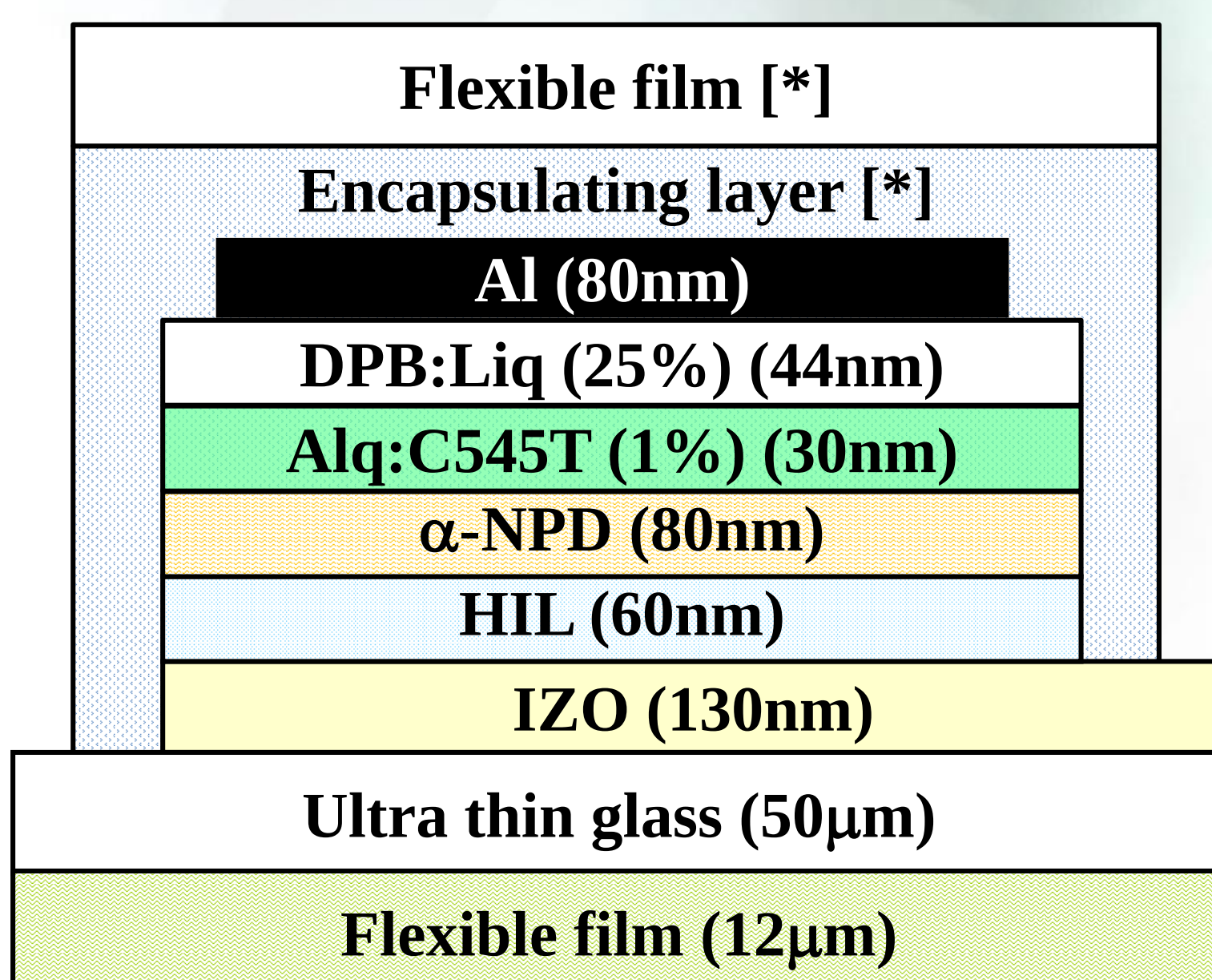
*OLED panel : fabricated by NEC Lighting Ltd.

UniversalPHOLED® Phosphorescent OLED Technology and Materials from Universal Display Corporation

*Ultra-thin glass: Nippon Electric Glass Co., Ltd.

*Stainless steel foil: NIPPON STEEL & SUMITOMO METAL CORPORATION Group

Flexible OLED device with ultra-thin glass (supported with protecting film)



[*] Laminate encapsulation (Kaneka)



Substrate size : 50mm X 50mm
Emission area : 32mm X 32mm

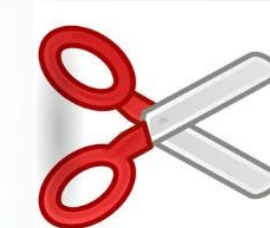
Flexible ultra-thin glass (Nippon Electric Glass)

- Ultra-thin glass roll (thickness: 50mm)
- Excellent gas barrier
- Excellent thermal stability
- Excellent chemical stability
- Smooth surface

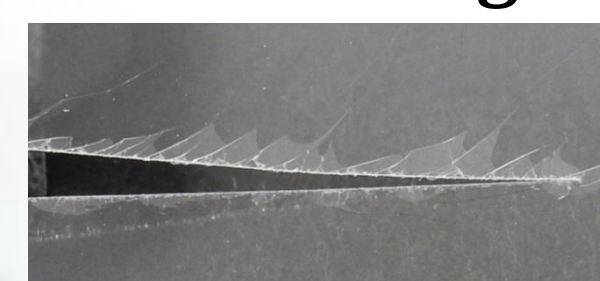


Novel protecting film for ultra-thin glass (Mitsubishi Plastics)

Cutting by scissors

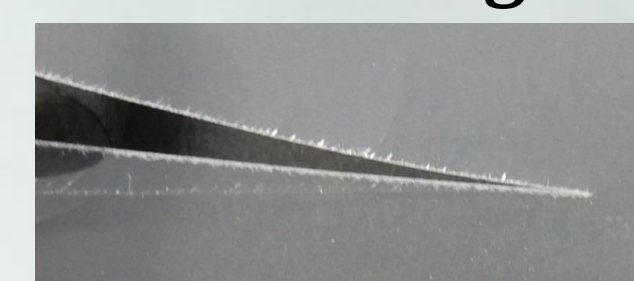


【Common protecting film with ultra-thin glass】



⇒large cracks

【Novel protecting film with ultra-thin glass】



⇒Small cracks

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Prof. H. Nakada

nakada@yz.yamagata-u.ac.jp

URL : <http://inoel.yz.yamagata-u.ac.jp/F-consortium/index2.htm>

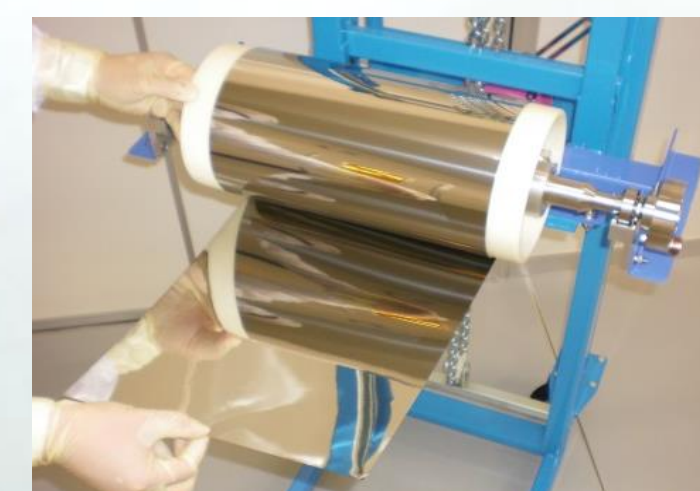
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Yamagata University Organic Thin Film Device Consortium

Flexible OLED lighting devices with stainless steel foil

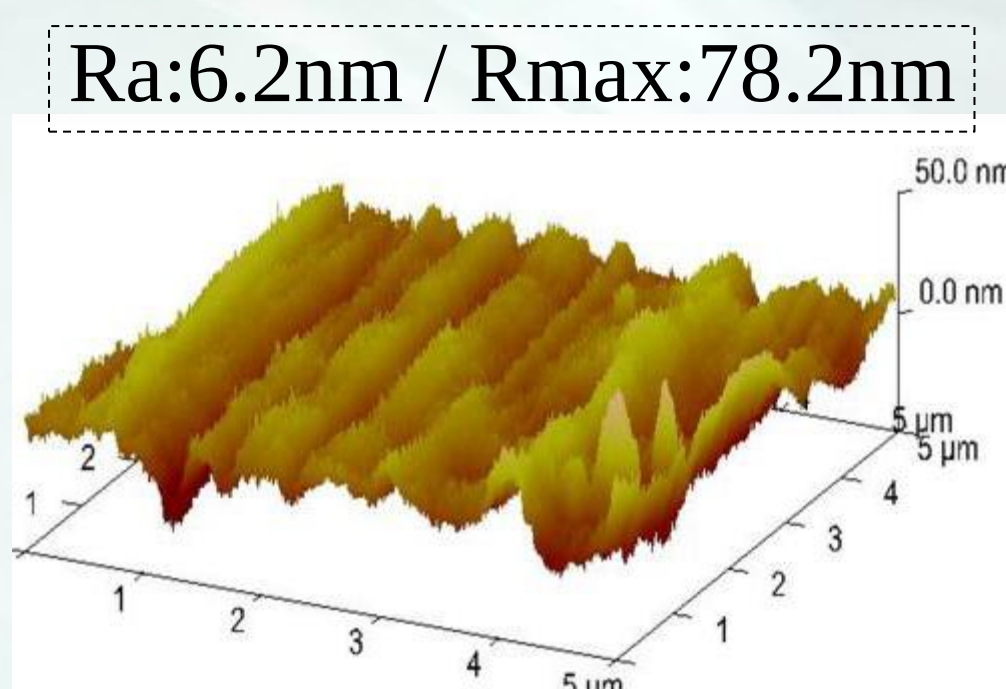
【Features of stainless steel foil】

- Flexibility (applicable to R2R)
- Excellent gas barrier property, excellent temperature resistance, excellent chemical resistance, low thermal expansion, etc.
- Smooth surface with novel planarization layer developed by NIPPON STEEL & SUMITOMO METAL CORPORATION Group

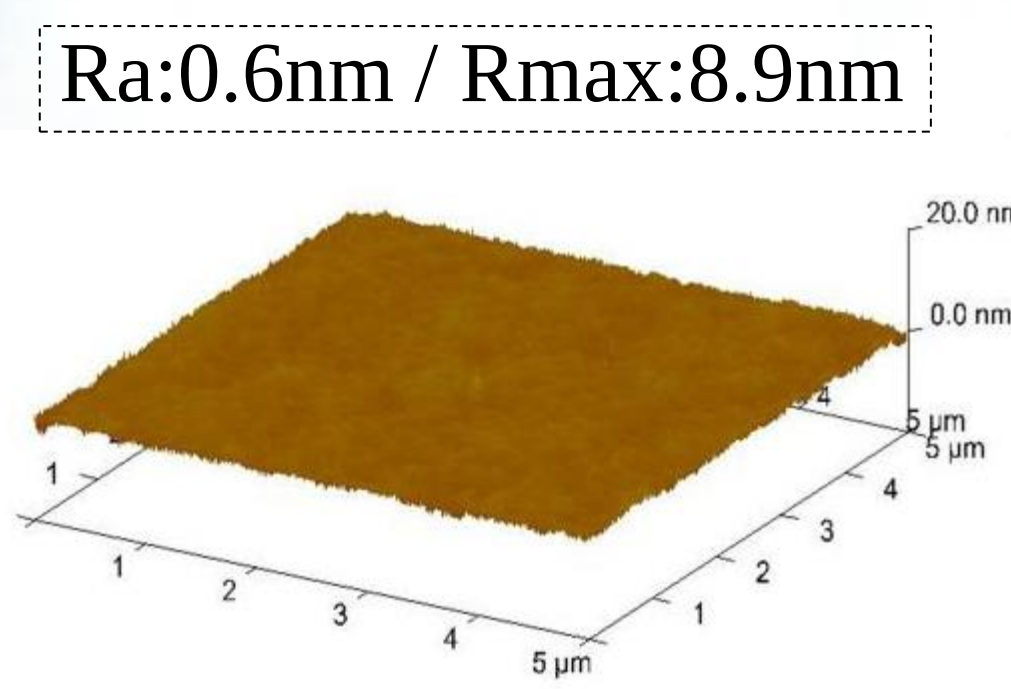


Flexible OLED panel fabricated on stainless steel foil

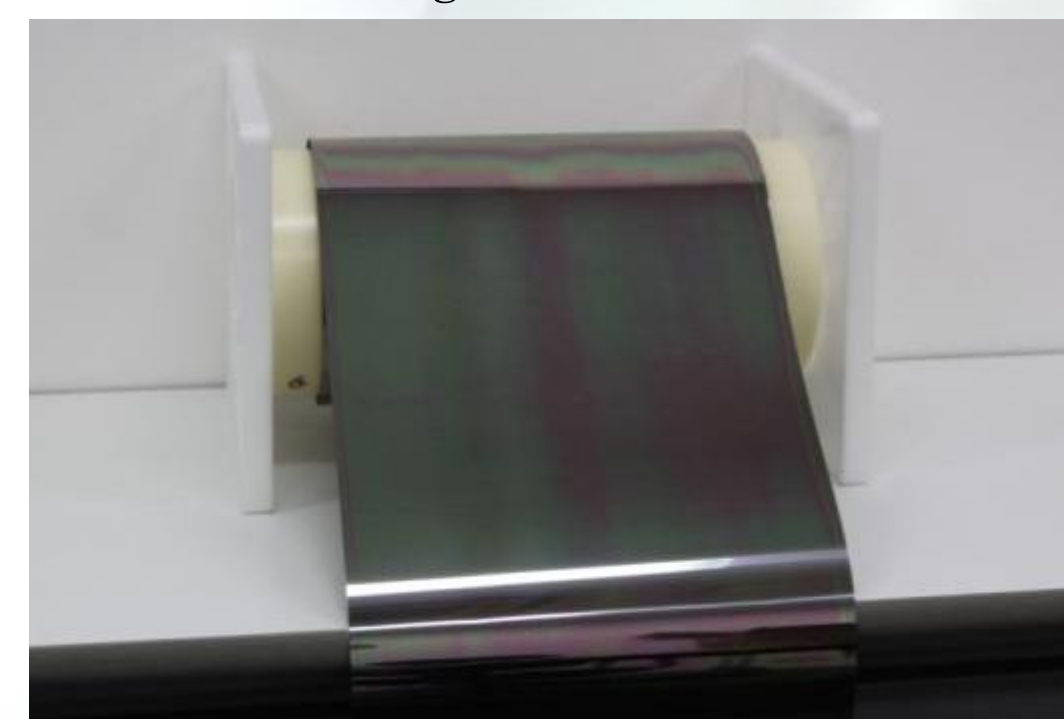
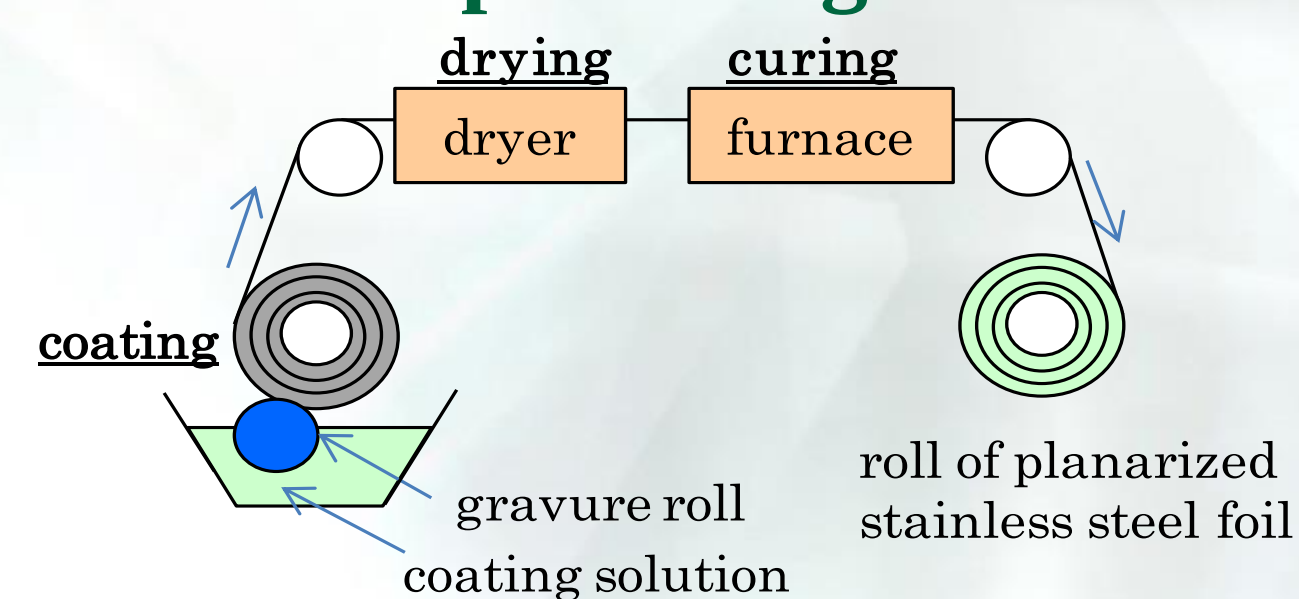
(NIPPON STEEL & SUMITOMO METAL CORPORATION Group / Yamagata University)



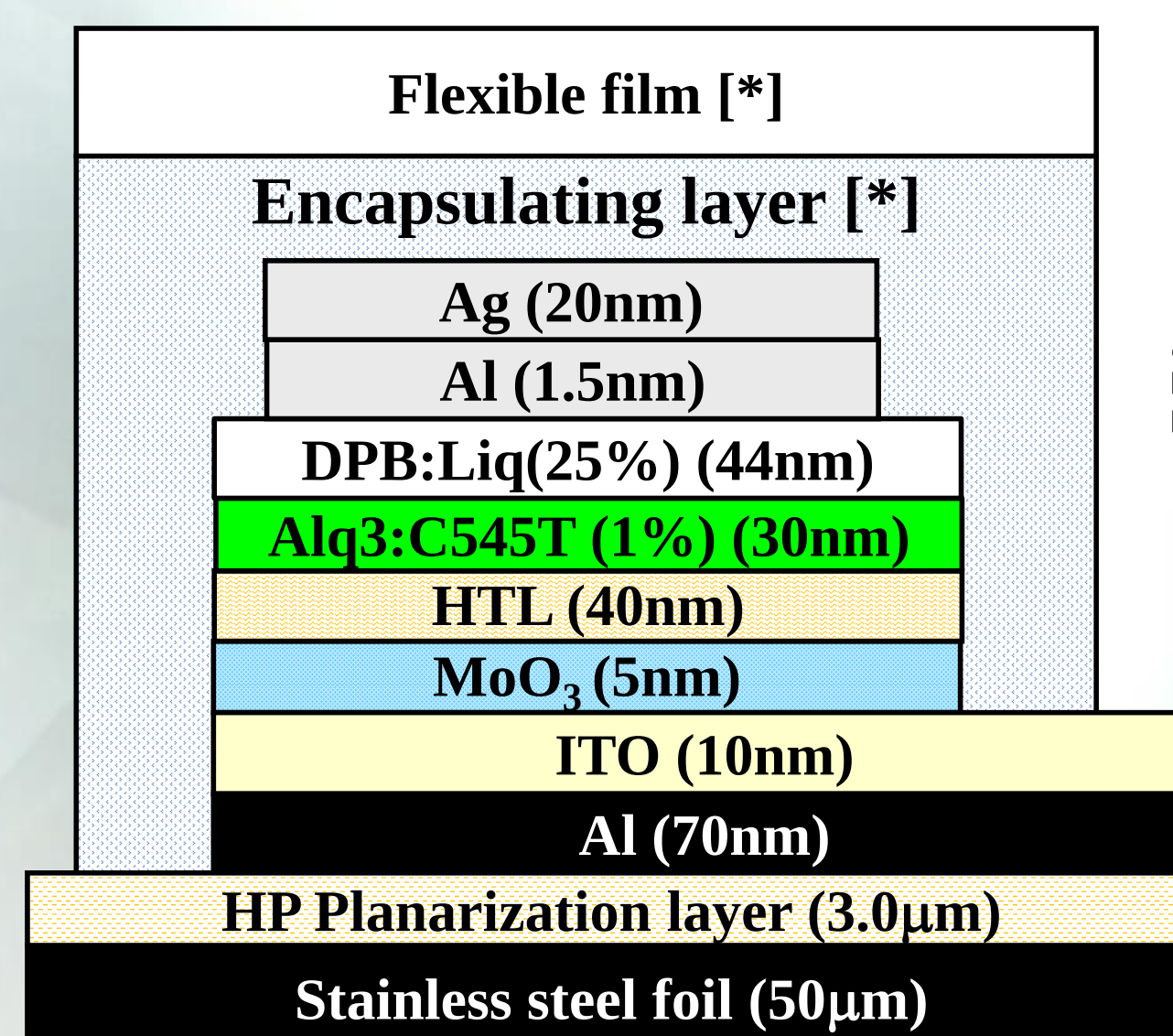
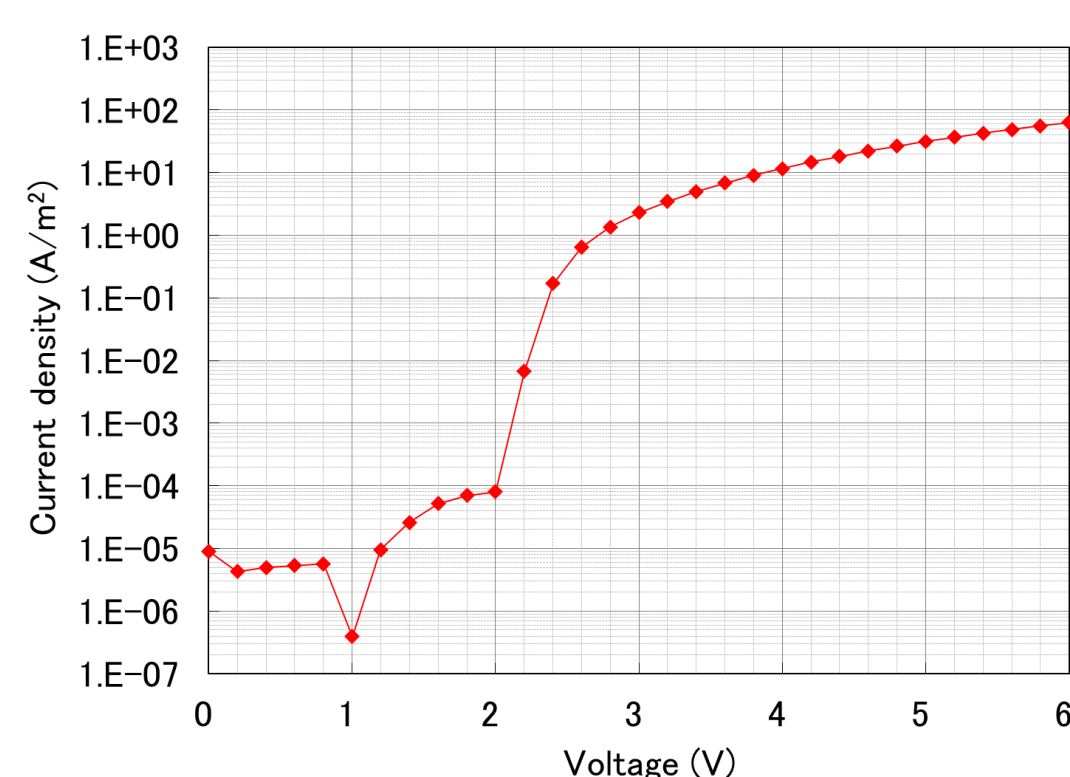
(a) Without planarization layer



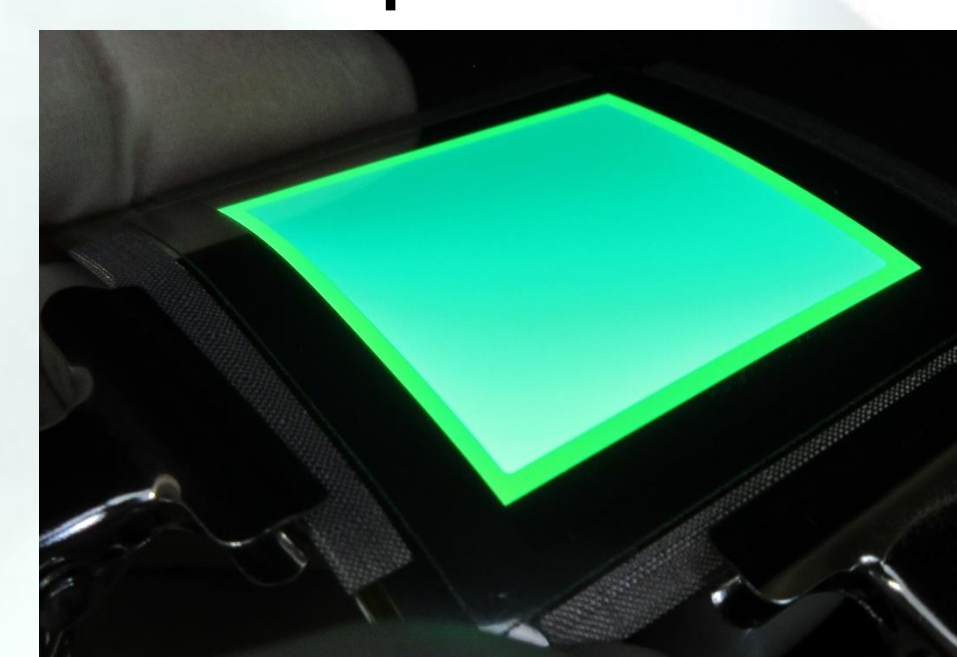
(b) With Planarization layer



Planarization layer coated by Roll-to-roll process



[*] supplied from Ajinomoto Fine-Techno



Substrate size :50mm X 50mm

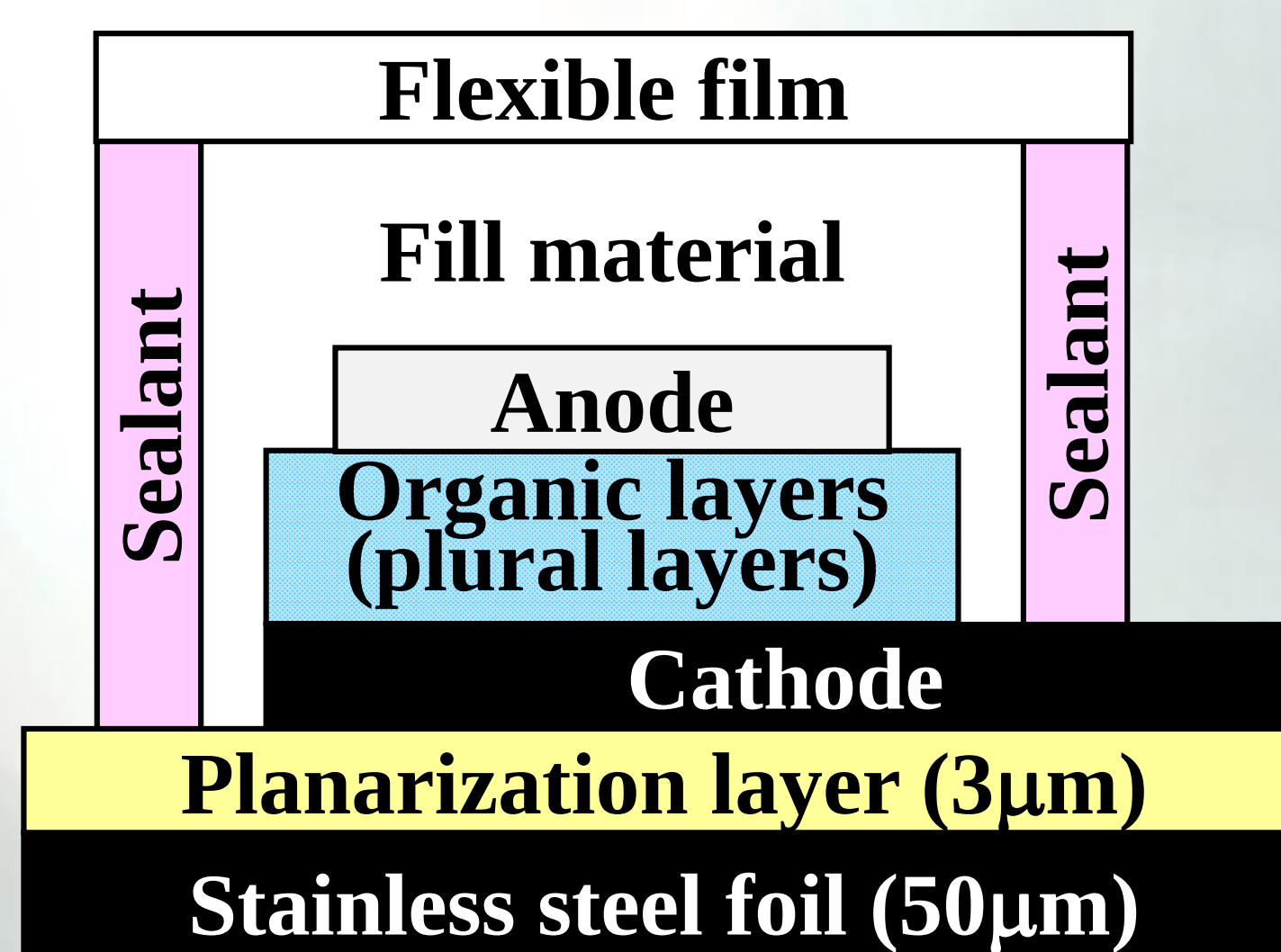
Emission area : 32mm X 32mm

- N. Yamada, H. Kobayashi, S. Yamaguchi, J. Nakatsuka, K. Nose, K. Uemura, M. Koden, H. Nakada, IDW'14, FLX6-4L (2014).
- N. Yamada, S. Yamaguchi, J. Nakatsuka, Y. Hagiwara, K. Uemura, IDW'15, FMC3-1 (2015).

Flexible OLED lighting device (92mm□) with stainless steel foil
(fabricated by NEC Lighting)

Substrate size : 92mm X 92mm

Emission area : 75mm X 75mm



*OLED panel : fabricated by NEC Lighting Ltd.

UniversalPHOLED® Phosphorescent OLED Technology and Materials from Universal Display Corporation

*Stainless steel foil: NIPPON STEEL & SUMITOMO METAL CORPORATION Group

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

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

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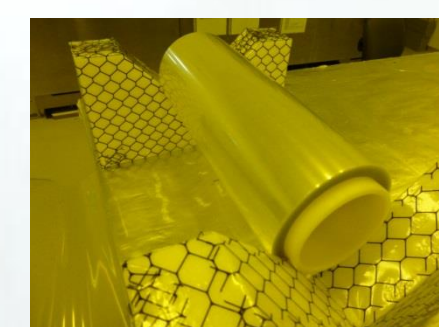
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Yamagata University Organic Thin Film Device Consortium

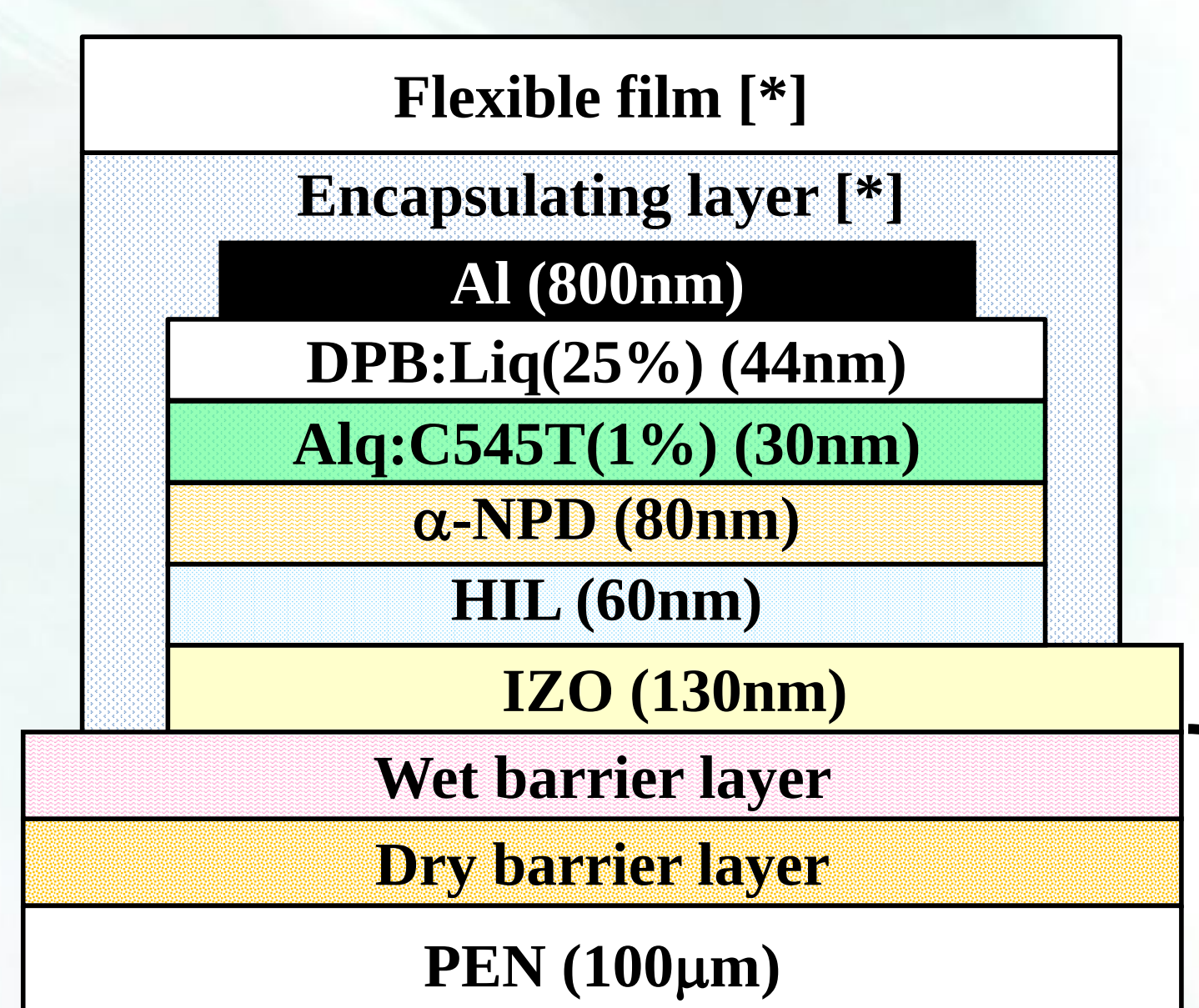
Flexible OLED lighting devices with novel barrier film

【Feature of novel barrier film】

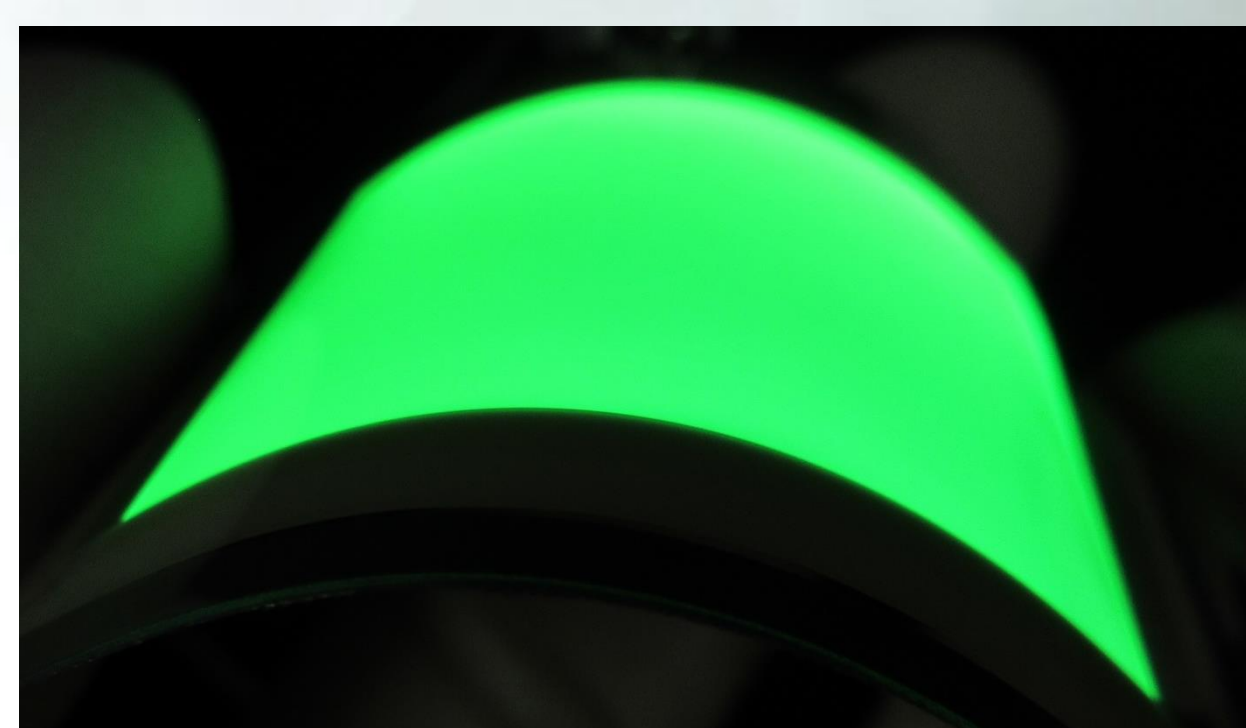
- Novel barrier layer with only 2 layer consisting of one vacuum deposited and one wet coated layers (Teijin, KOBELCO, Merck PM-M, Yamagata University)



OLED device with novel barrier film consisting of only two barrier layers (Teijin, KOBELCO, Merck PM-M, FEBACS, Yamagata University)

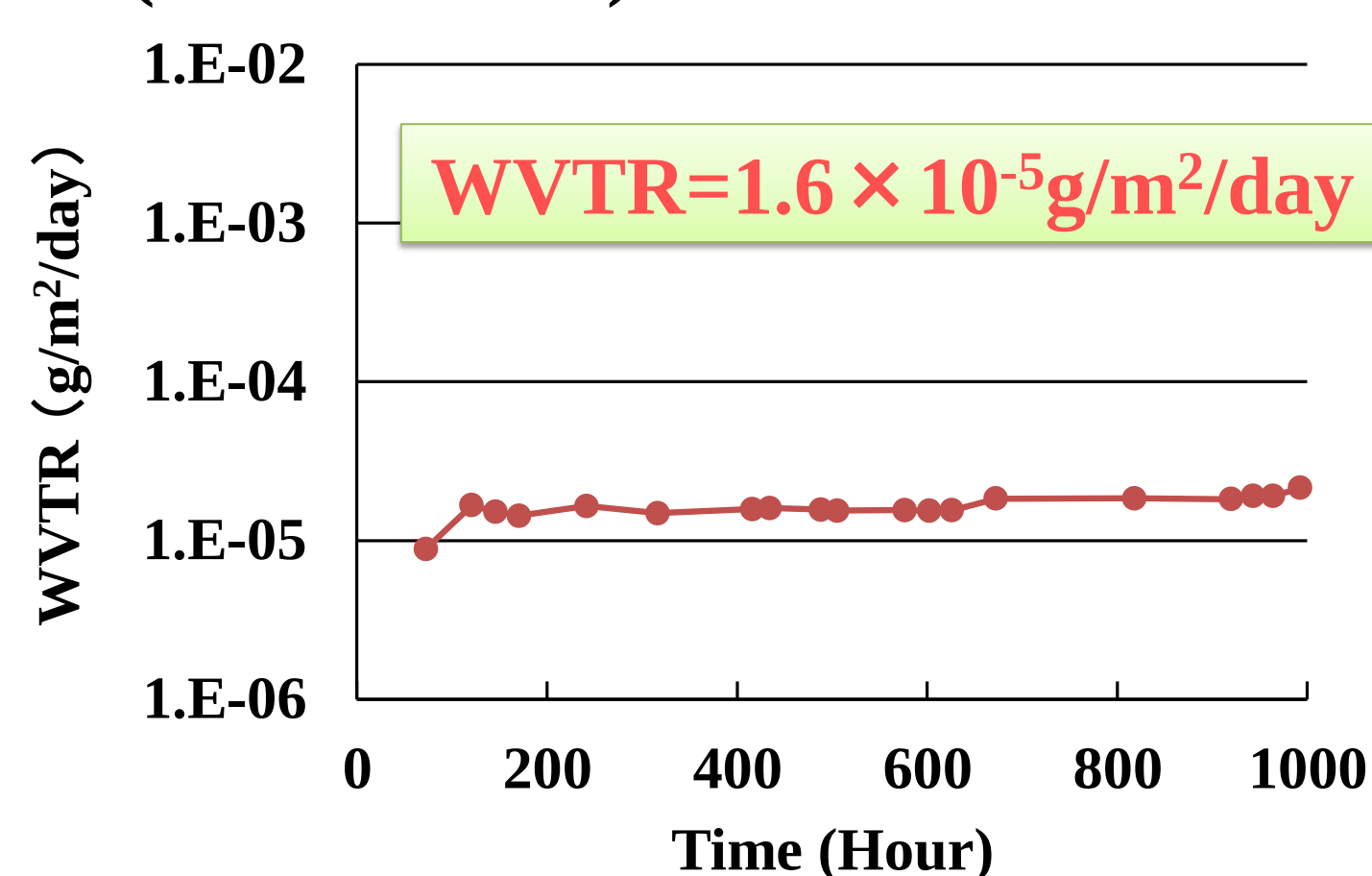


[*] Laminate encapsulation (Kaneka)

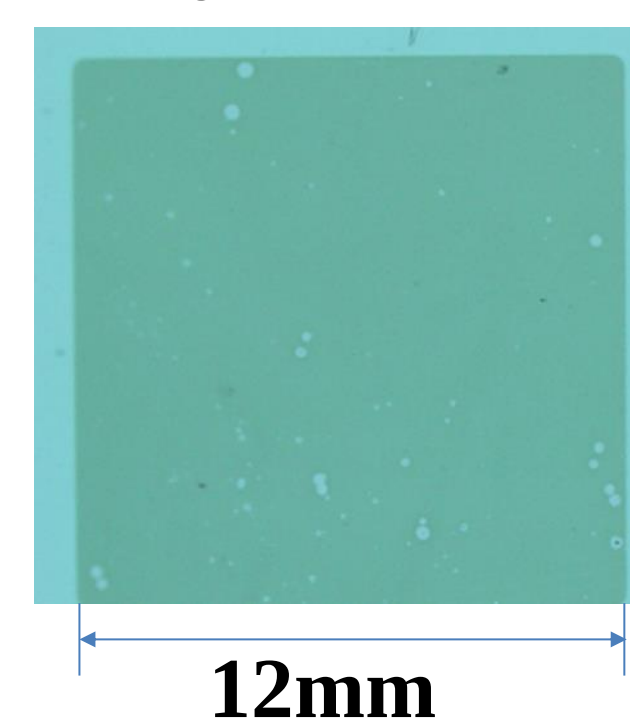


Substrate size : 50mm X 50mm
Emission area : 32mm X 32mm

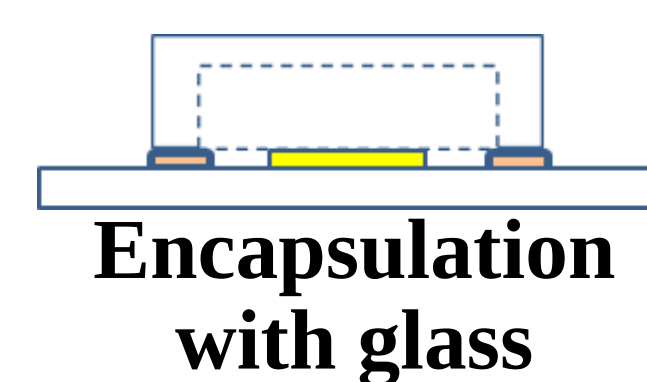
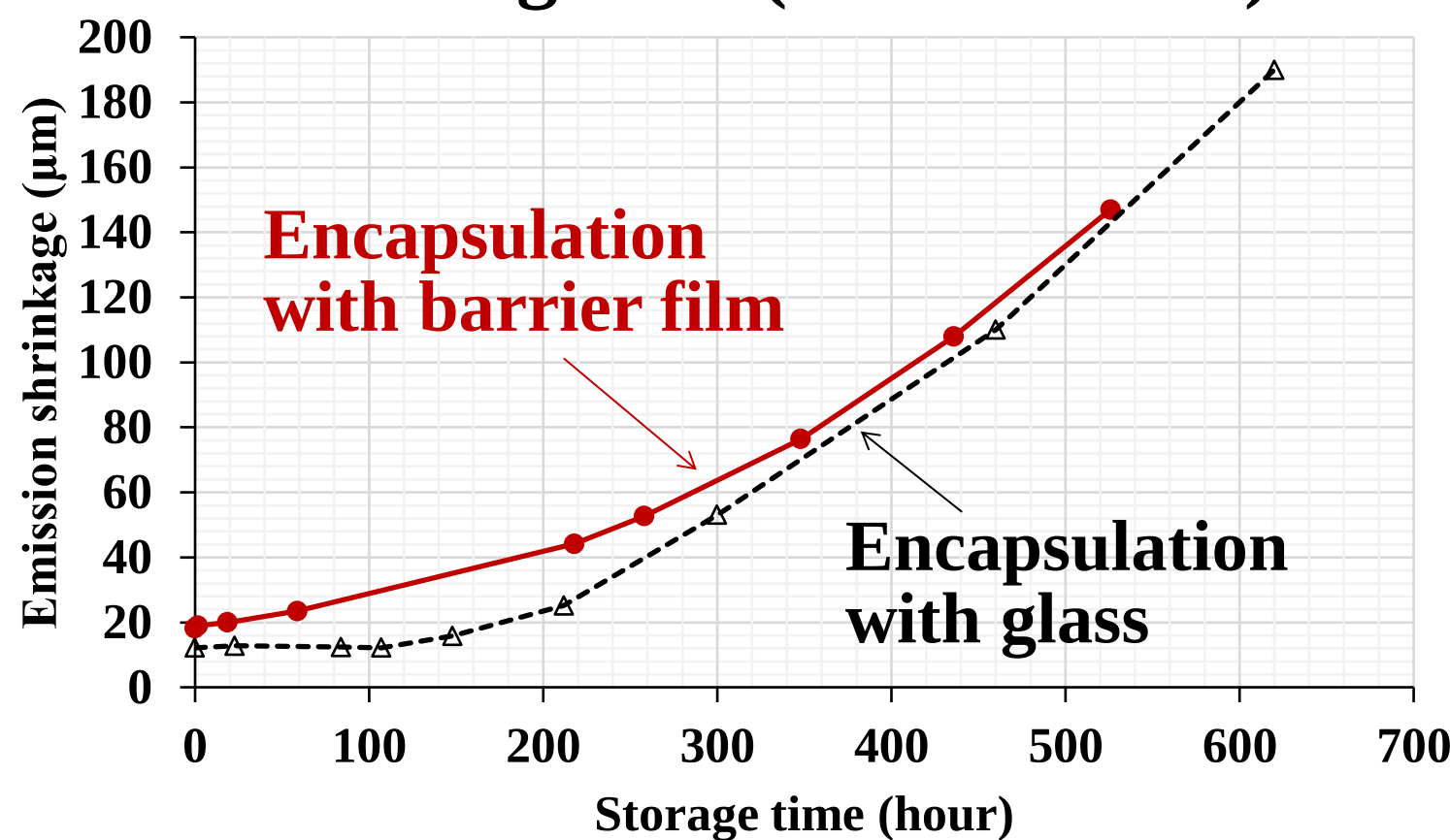
■ WVTR[*] by Ca corrosion method (40°C90%RH)



Ca corrosion image 40°C90%RH 1000h



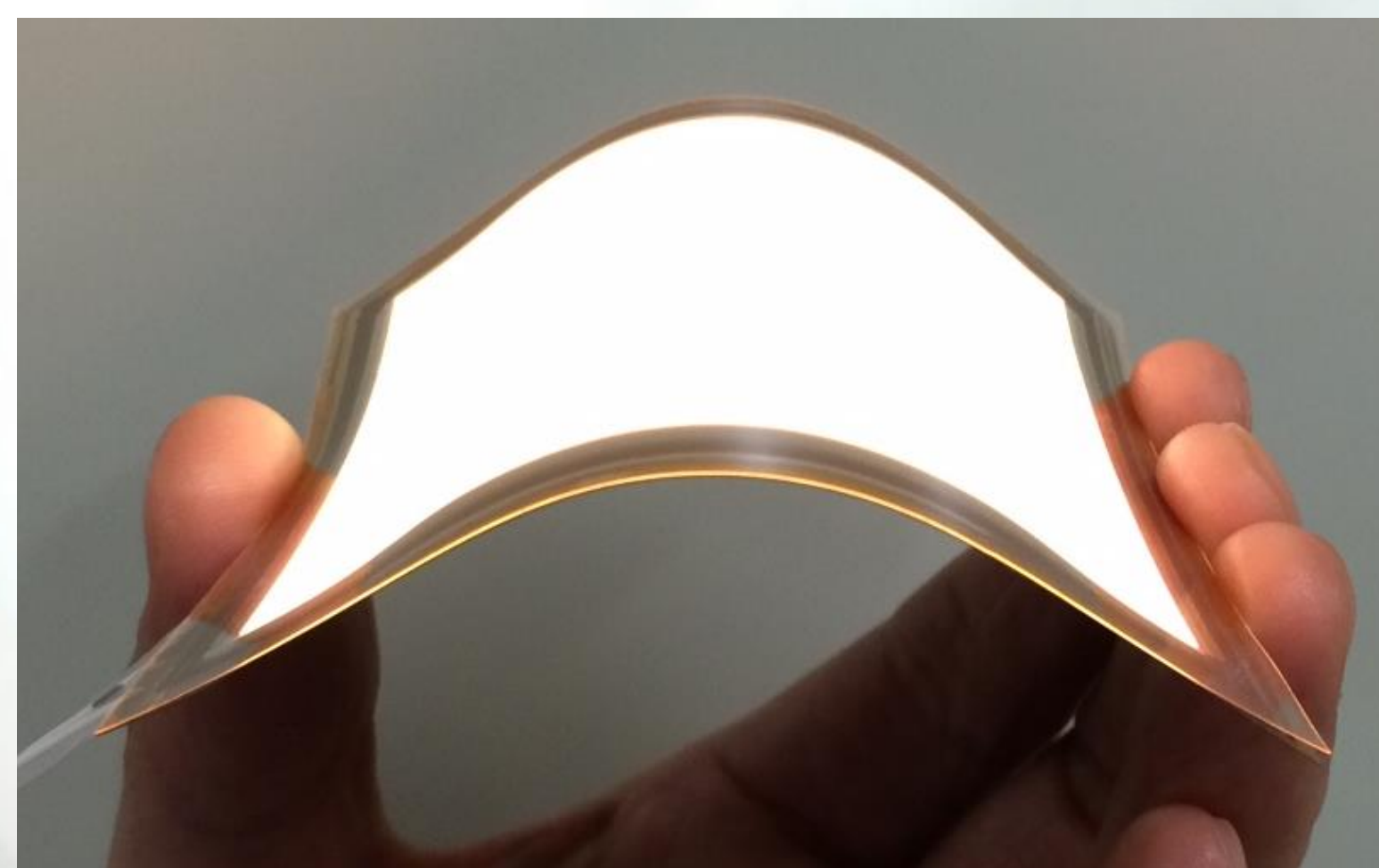
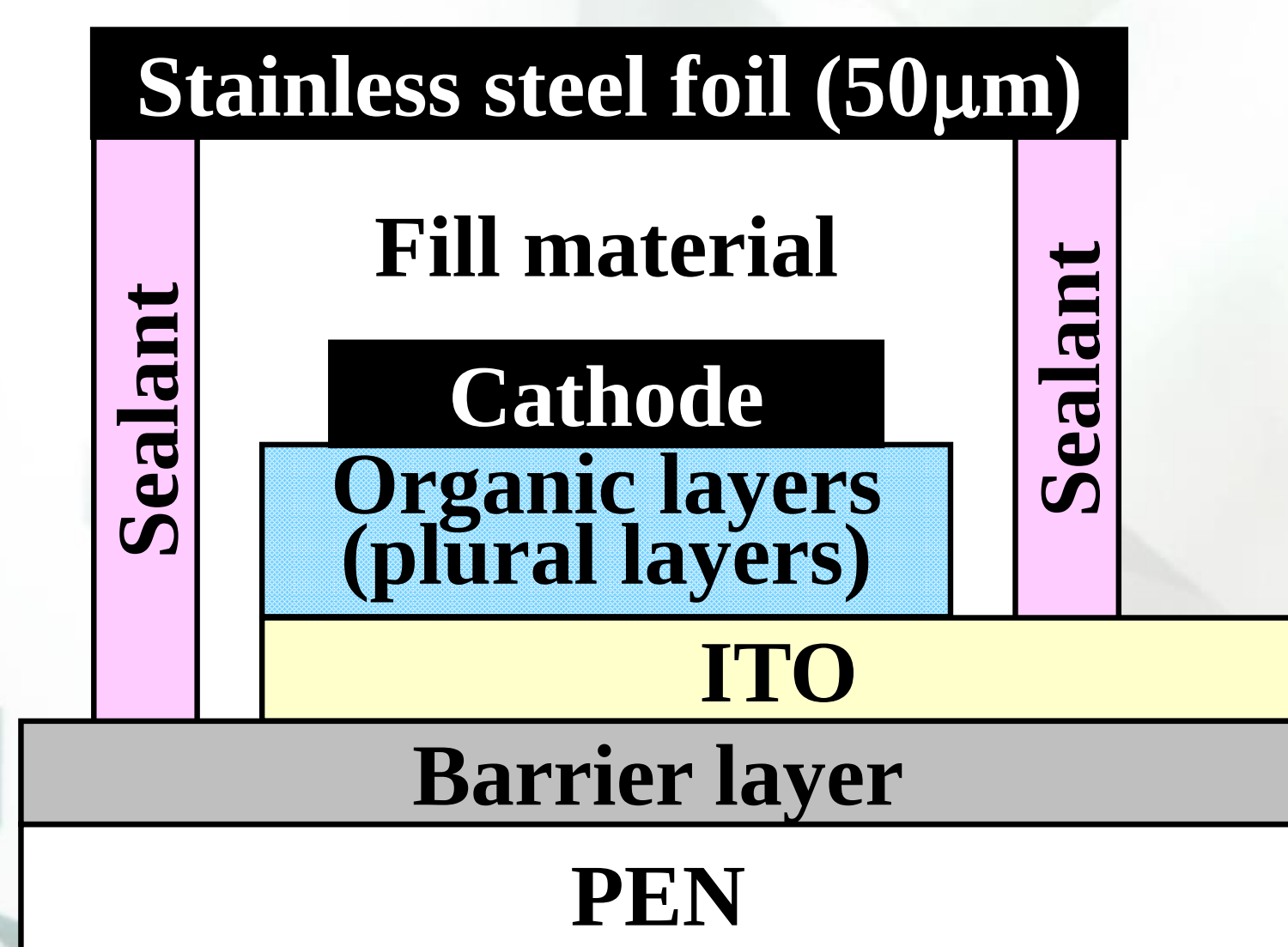
■ OLED storage test (60°C90%RH)



※No desiccant

[*] WVTR: Water Vapor Transmission Rate

Flexible OLED lighting device (92mm□) with barrier film (fabricated by NEC Lighting)



Substrate size : 92mm X 92mm
Emission area : 75mm X 75mm

*OLED panel : fabricated by NEC Lighting Ltd.

UniversalPHOLED® Phosphorescent OLED Technology and Materials from Universal Display Corporation

*Barrier film: Teijin, KOBELCO, FEBACS

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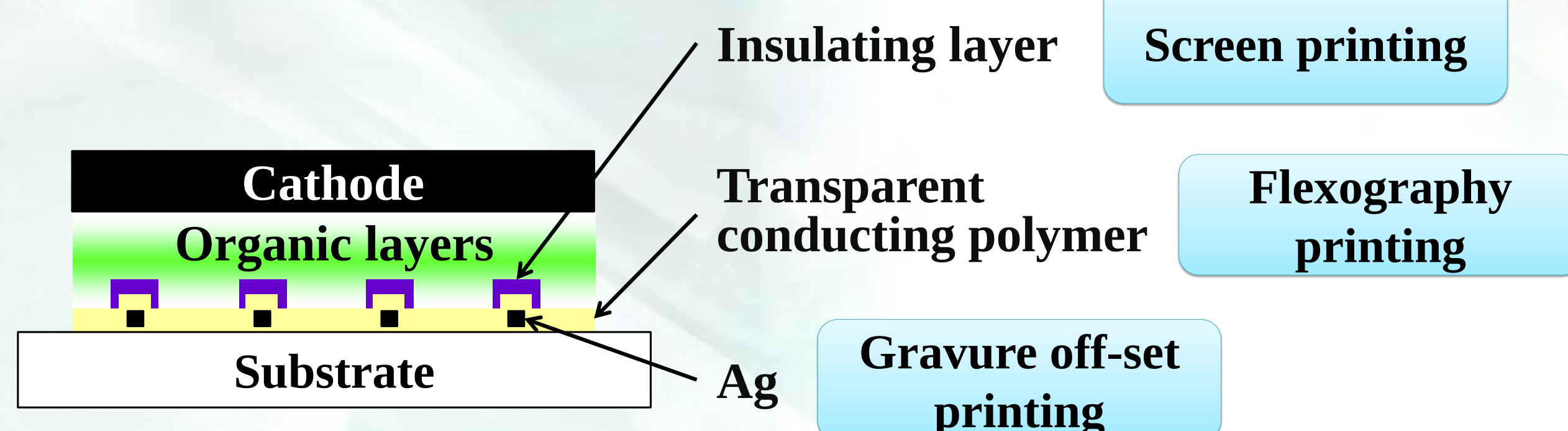
Yamagata University Organic Thin Film Device Consortium

OLED lighting devices with non-ITO transparent electrode

Issues of ITO (Indium Tin Oxide):

- Cost・・・① vacuum evaporation + photolithography, ② rare metal (In)
- Brittle in bending

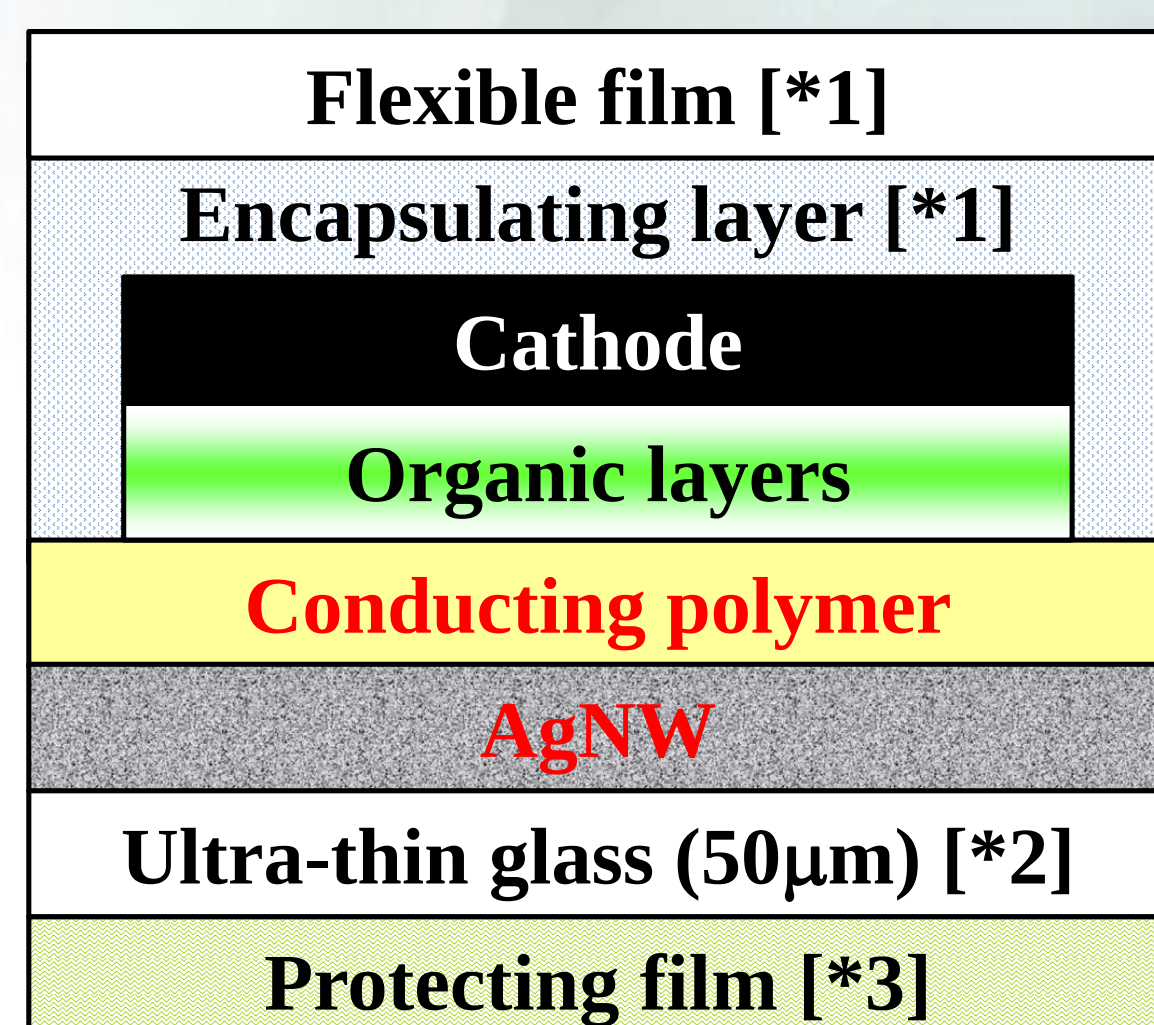
OLED lighting device using non-ITO electrodes fabricated by printing
 (DNP, DIC, Komori Machinery, SERIA, Taiyo Kikai, FEBACS, Nippon Electric Glass, Yamagata University)



Substrate size : 50mm X 50mm
 Emission area : 32mm X 32mm

➢ T. Furukawa, N. Kawamura, M. Sakakibara, M. Koden, *IDMC*, S4-4 (2015).

OLED lighting device with non-ITO electrodes consisting of silver nanowire (AgNW) and transparent conducting polymer



[*1] Supplied from Ajinomoto Fine-Techno

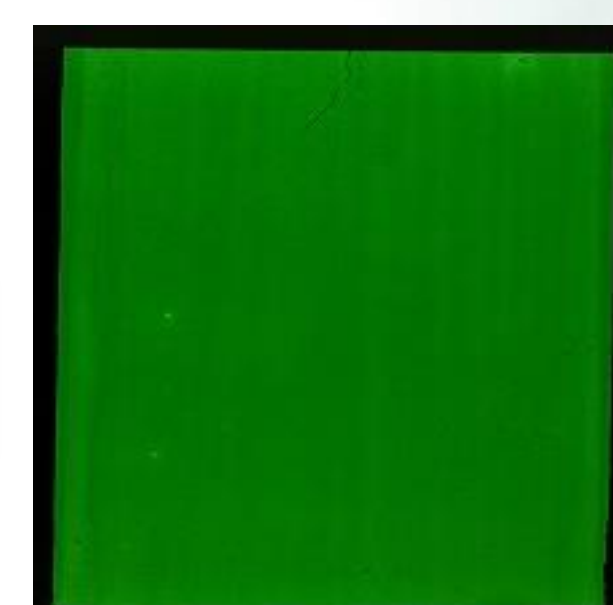
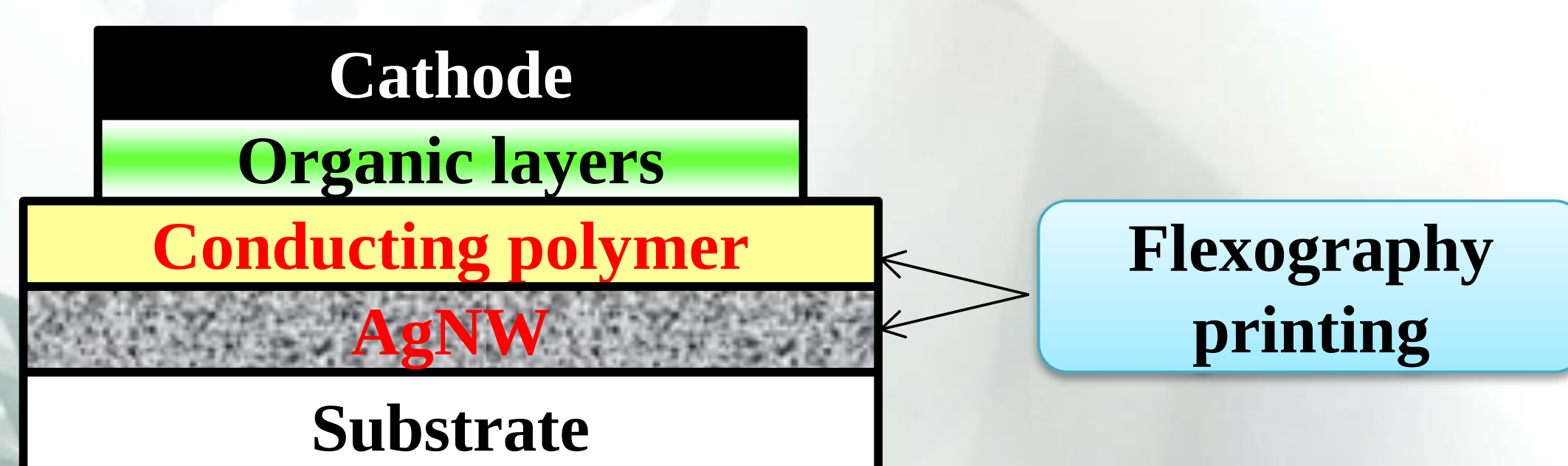
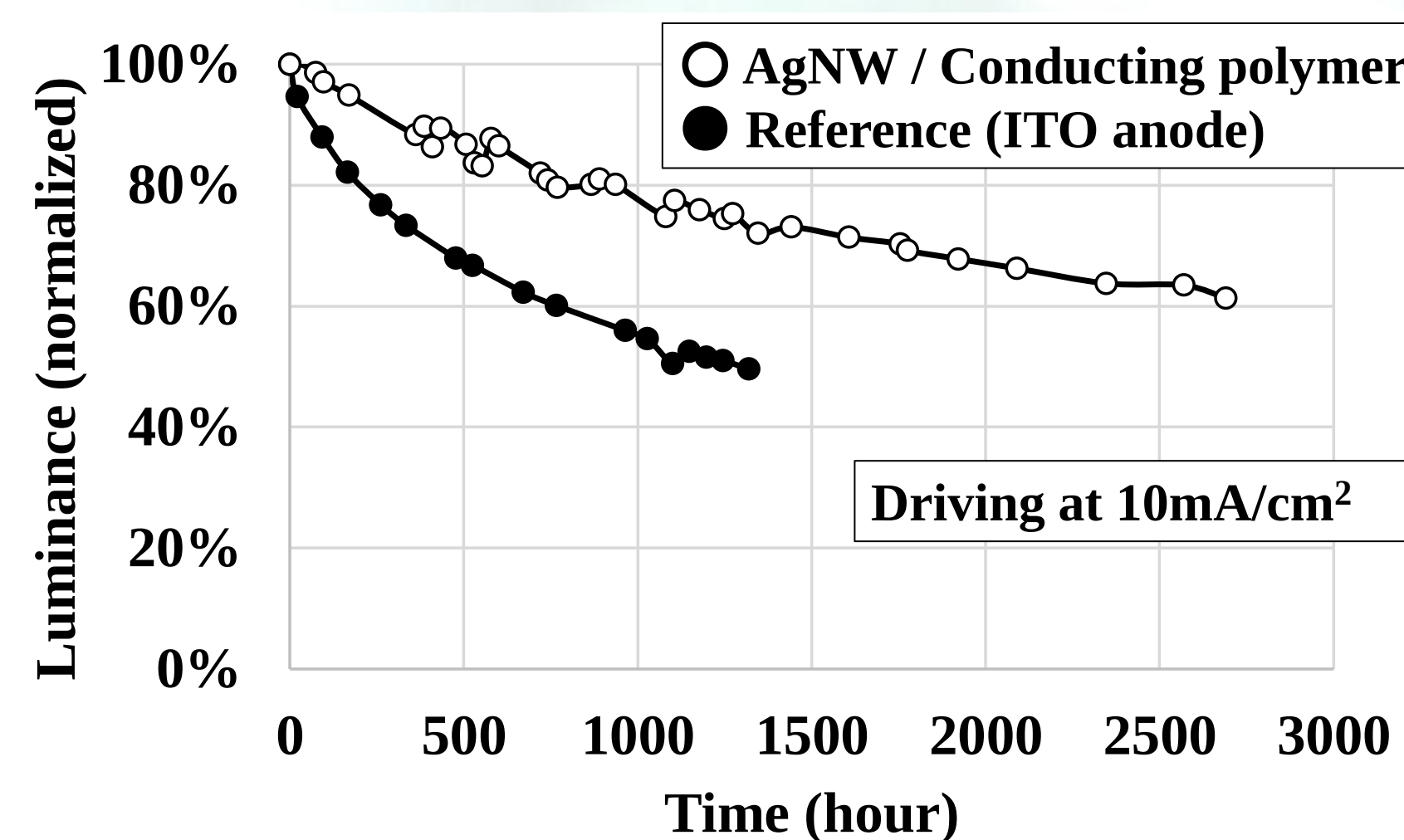
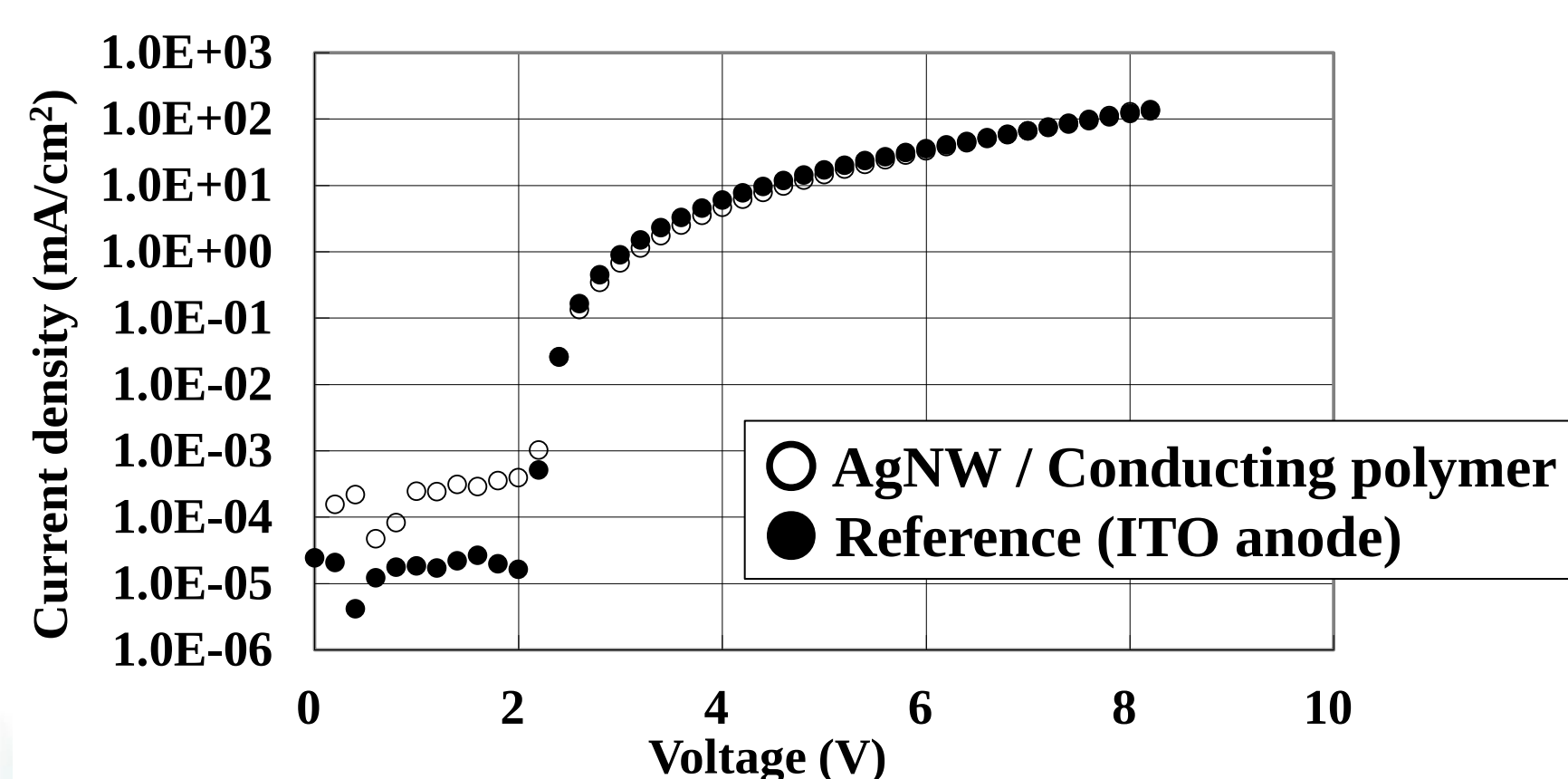
[*2] developed by Nippon Electric Glass

[*3] developed by Mitsubishi Plastics



Substrate size: 50mm X 50mm
 Emission area : 32mm X 32mm

- H. Nakada, N. Kawamura, M. Koden, 20th Japanese OLED Forum, S6-3 (2015).
- T. Yuki, N. Kawamura, H. Nakada, M. Koden 21th Japanese OLED Forum, S4-9 (2015).



Substrate size: 50mm X 50mm
 Emission area : 32mm X 32mm

➢ T. Furukawa, N. Kawamura, J. Inoue, H. Nakada, M. Koden, *SID 2015*, P-57 (2015).

(Contact) Prof. M. Koden koden@yz.yamagata-u.ac.jp
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Yamagata University Flexible Organic Electronics Practical Key Technology Consortium
(YU-FOC)

Greeting

A new consortium “Yamagata University Flexible Organic Practical Key Technology Consortium (YU-FOC)” is planned to start in April 2016, aiming at academia/industry collaboration on flexible organic electronics. This consortium is a three year program, based on the activity of the current “Yamagata University Organic Thin Film Consortium (FY2013-2015) [*]”. This consortium is planned to develop practical key technologies which contributes to business of participating companies and to expansion of flexible organic electronics industry.

[*] <http://inoel.yz.yamagata-u.ac.jp/F-consortium/index2.htm>

About of Consortium

◆Developing technologies (Tentative)

Practical key technologies for flexible organic electronics

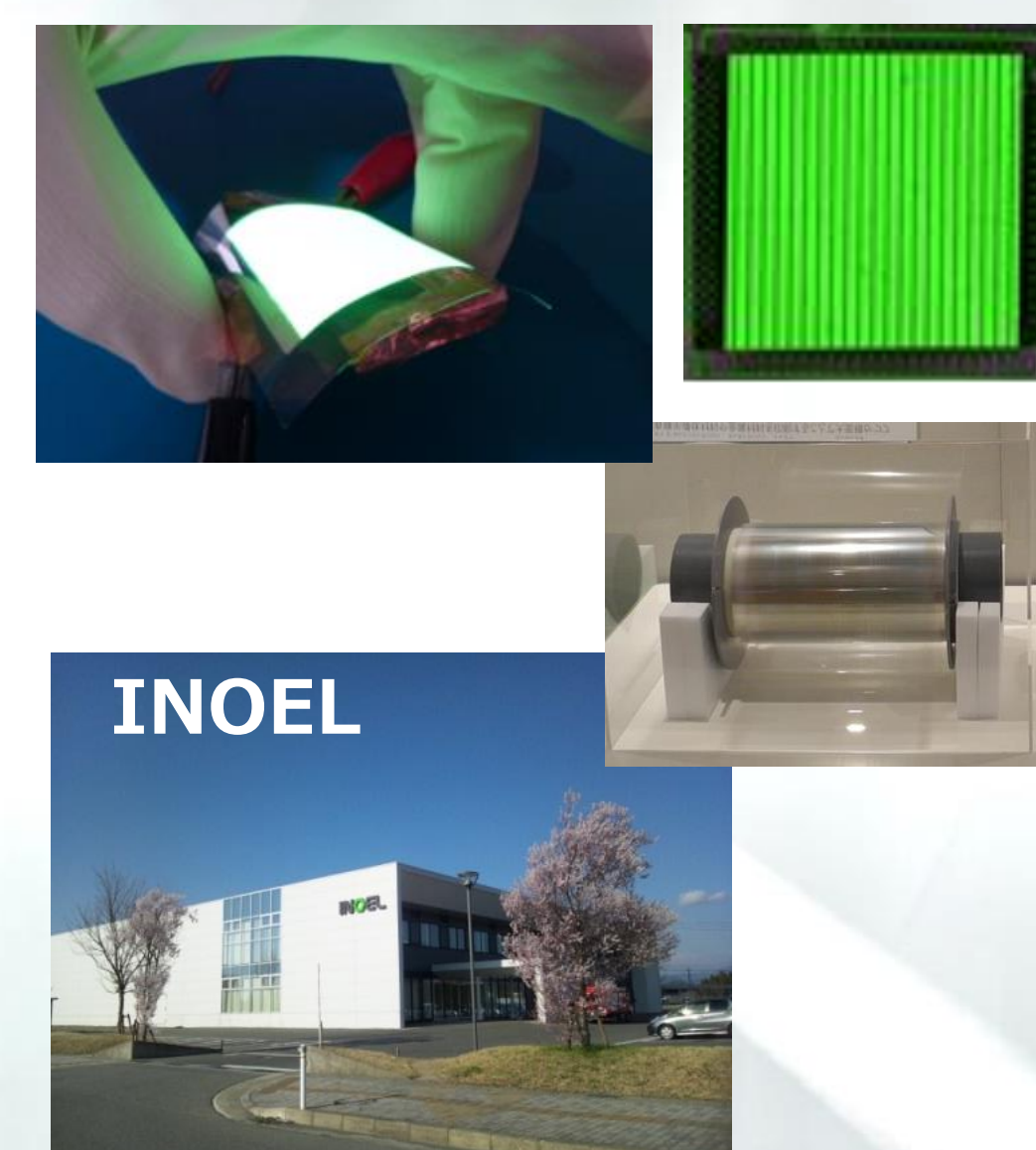
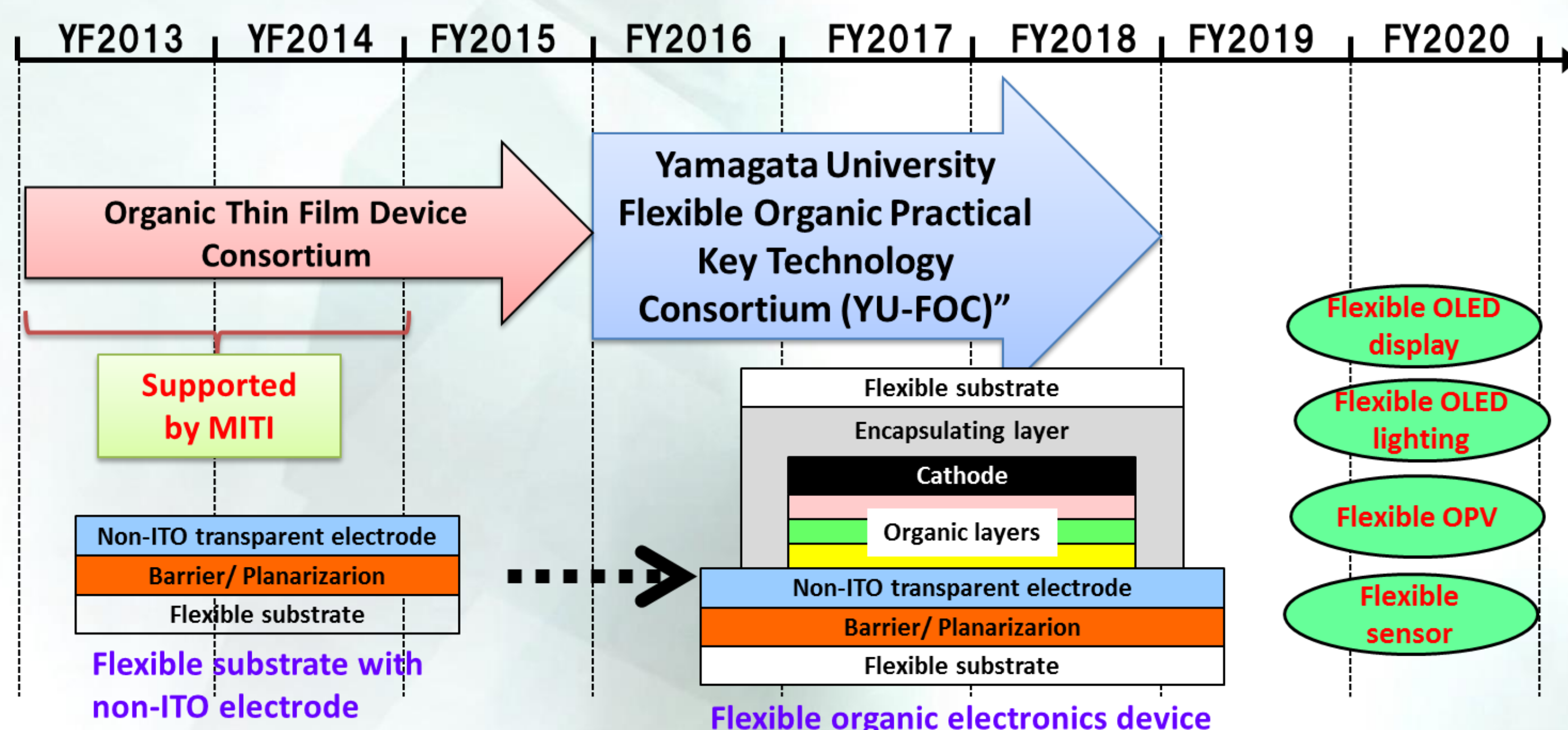
- Flexible substrates
- Materials for flexible devices
- Flexible device technologies
- Process technologies for flexible devices
- Equipment
- Inspection, evaluation, repair, etc.

◆Development term:

April 2016~March 2019 (Three years)

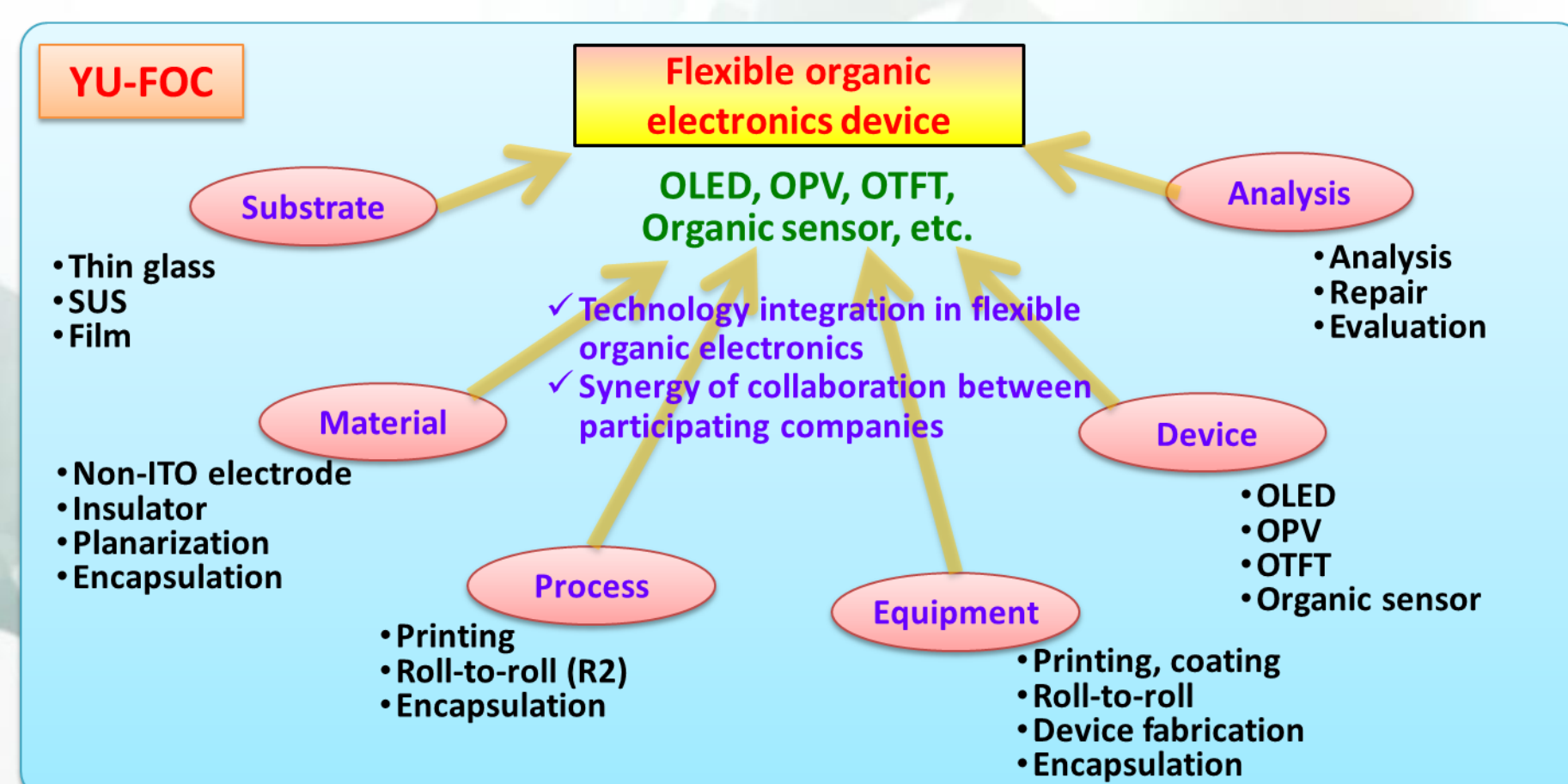
◆Web page:

<http://inoel.yz.yamagata-u.ac.jp/F-consortium/YU-FOC2.html>

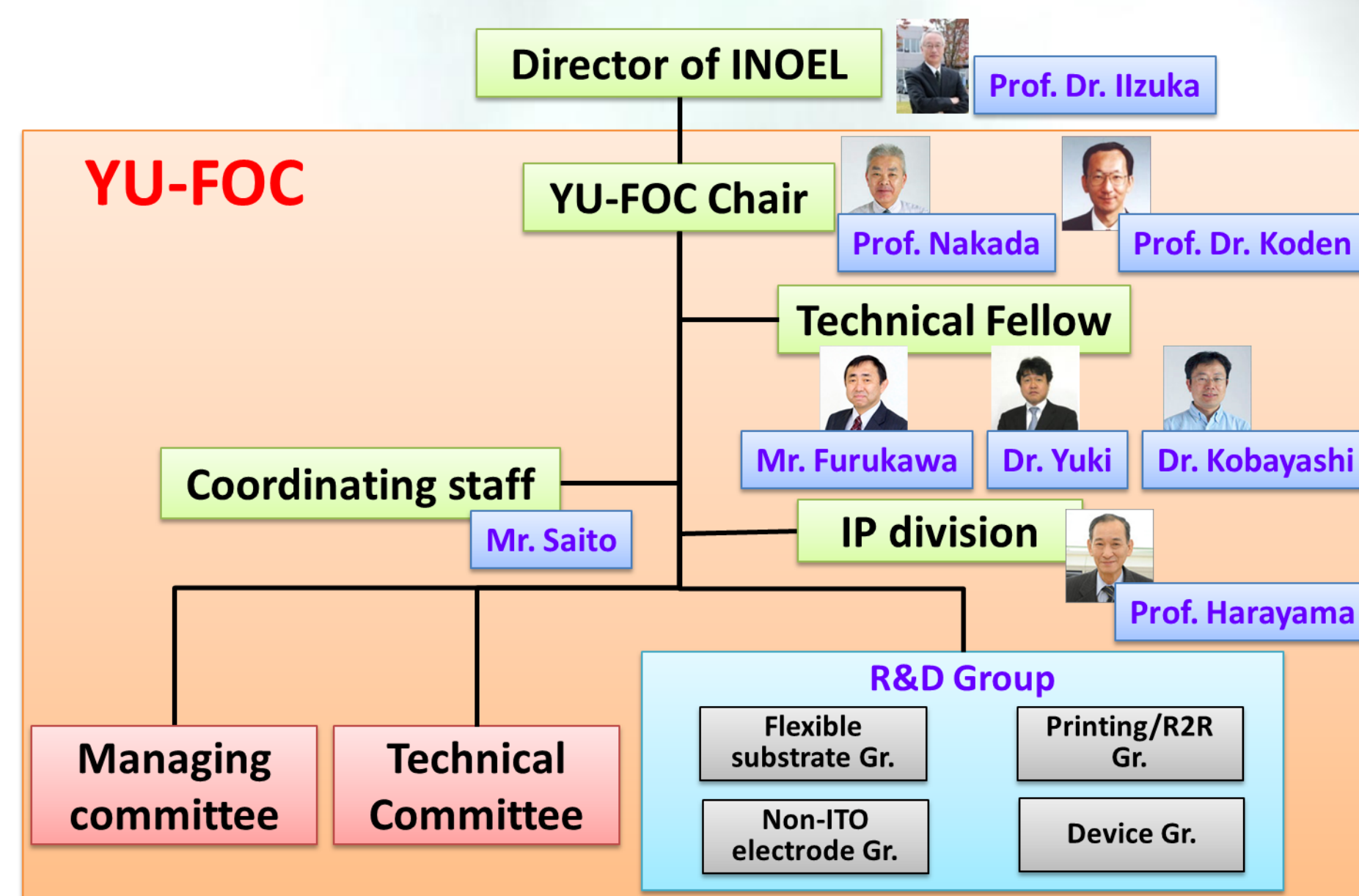


Features of consortium

1. Technology Integration for flexible organic electronics, based on collaboration among companies with various technologies (substrates, materials, printing, equipment, devices, etc.).
2. Business First!
 - * Contribution to participating companies is first priority.
 - * R&D in the consortium is based on the request from participating companies.



Organization (Tentative)



Contact

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Innovation Center for Organic Electronics (INOEL)
Yamagata University
TEL +81-238-29-0575 FAX +81-238-29-0569
Prof. H. Nakada: nakada@yz.yamagata-u.ac.jp
Prof. M. Koden: koden@yz.yamagata-u.ac.jp

Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC)

Equipment of YU-FOC

Four original roll-to-roll (R2) equipment (Roll width: 30cm)



R2R sputtering
&CDV (KOBELCO)



R2R screen printing
(SERIA)



R2R Gravure offset and
Flexography printing
(Komori Machinery/ Taiyo Kikai)



R2R wet cleaning
(FEBACS)



Flexography / Gravure
printing



Screen printing

Sheet-to-sheet printing equipment

Device fabrication equipment



Organic deposition



Sputtering

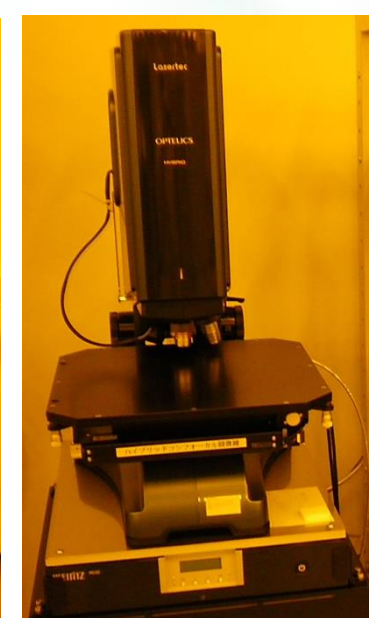


Vacuum laminator

Analysis and evaluation equipment



Viscoelasticity
measurement



Hybrid confocal
microscopy



Precise position
detector



WVTR evaluation
(Ca method)

Main members of YU-FOC



Prof. Hitoshi Nakada

Field: Organic electronics device
E-mail: nakada@yz.yamagata-u.ac.jp

1981 Graduated at Tohoku University
1981~2013 Pioneer Corporation
1988~ R&D of OLED display and OLED lighting
2013~ INOEL, Yamagata University (current position)



Prof. Mitsuhiro Kodon (PhD)

Field: LCD, Display, OLED, Chemistry
Email: koden@yz.yamagata-u.ac.jp

1983 Graduated at Osaka University (PhD)
1983~2012 Sharp Corporation (Liquid crystal materials, LCD, OLED display, etc.)
1998~2011 Guest prof. of Nara Institute of Science and Technology
2012~ INOEL, Yamagata University (current position)



Associate Prof. Tadahiro Furukawa

Field: Fine patterning technology,
Printing, Roll-to-roll technology
E-mail: ta-furukawa@yz.yamagata-u.ac.jp

1984 Graduated at Saitama University (Master degree)
1984~2011 Kyoto Printing Co., Ltd.
R&D and production of Color filter (CF)
R&D of flexible CF and LCD
2011~ INOEL, Yamagata University (current position)



Associate Prof. Toshinao Yuki (PhD)

Field: OLED (display, lighting, device),
Polymer material engineering
E-mail: t-yuki@yz.yamagata-u.ac.jp

1993~1996 Teijin Limited
1996~1999 Graduated at Yamagata University (PhD).
1999~2015 Tohoku Pioneer Corporation (PMOLED, AMOLED, Tiling OLED, OLED lighting, etc.)
2015~ INOEL, Yamagata University (current position)



Associate Prof. Hideyuki Kobayashi (PhD)

Field: OLED, Thin film device, Physics
E-mail: h-kobayashi@yz.yamagata-u.ac.jp

2000 Graduated at Tokyo Institute of Technology (PhD)
2000~2003 Institute of Physical and Chemical Research (RIKEN)
2003~2009 Fujifilm, Corporation, IMES, Rohm Co., Ltd. (R&D of OLED)
2009~2013 Lumiotec Inc. (OLED lighting manufacturing line, R&D of OLED)
2013~ INOEL, Yamagata University (current position)

Collaboration with our members

Collaboration with individual member is possible, being apart from YU-FOC. Please to not hesitate to contact with us.

(Contact)

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Prof. H. Nakada nakada@yz.yamagata-u.ac.jp
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Yamagata University Organic Thin Film Device Consortium

Publications

International conference

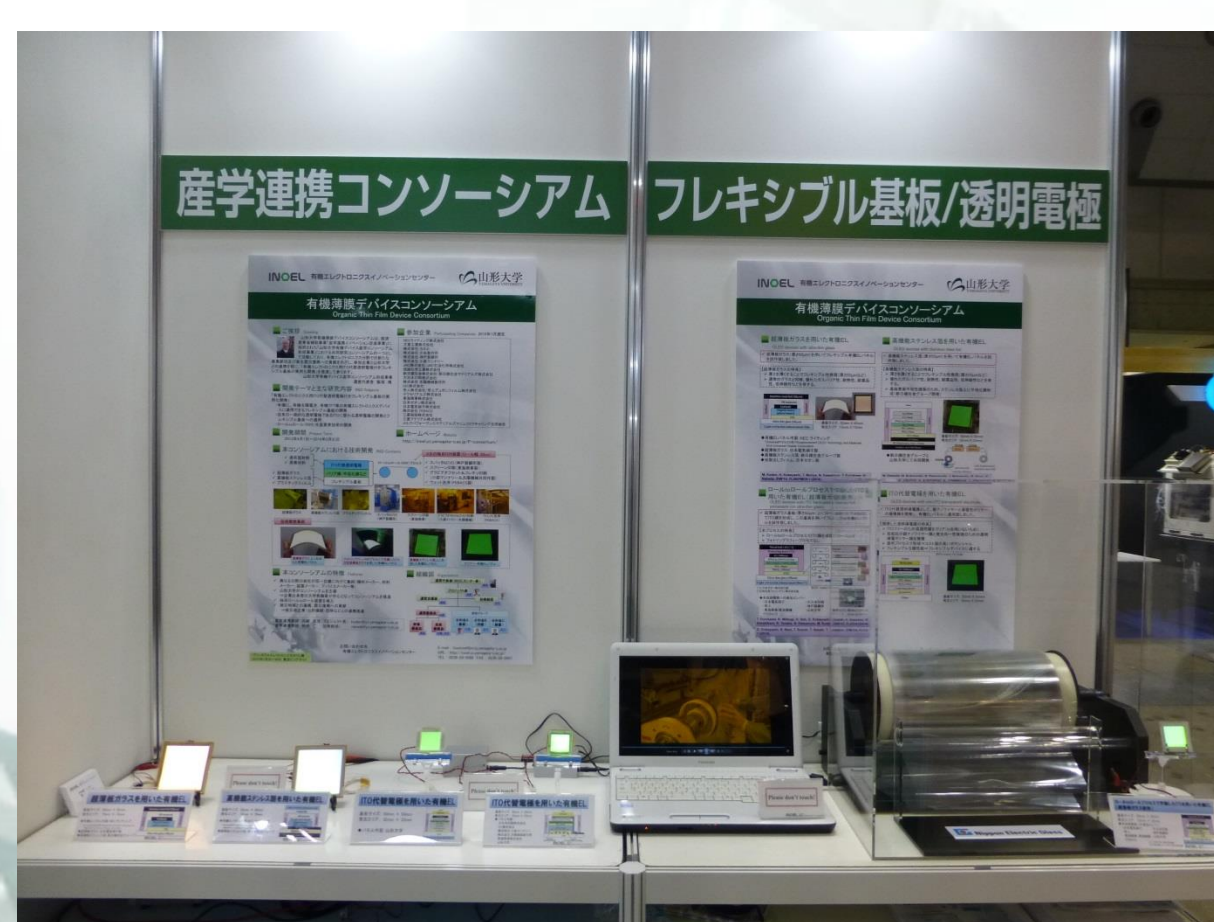
- M. Koden, SID'14 seminar (2014). (USA)
"OLED Devices, Processes, Encapsulation, and Flexible Substrates "
- M Koden , H. Nakada, Nanofair 2014 (2014). (Dresden) *[Invited]*
"Flexible substrate with alternative electrode of ITO for organic electronics"
- M. Koden, H. Kobayashi, T. Moriya, N. Kawamura, T. Furukawa, H. Nakada, IDW'14, FMC6/FLX6-1 (2014). *[Invited]*
"Flexible Substrates and Alternative Electrodes of ITO for OLED Lighting"
- D. Kobayashi, N. Naoi, T. Suzuki, T. Sasaki, T. Furukawa, IDW'14, FLX3-1 (2014). *[Invited]*
"Novel Roll-to-Roll Screen Printing Machine for Flexible Devices"
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