Yamagata University Flexible Electronics Japan-Germany International Collaborative Practical Utilization Consortium (YU-FIC)

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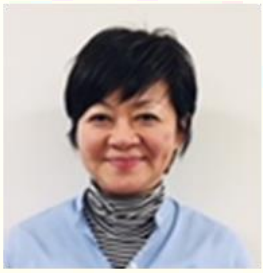

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Related program

- JST: OPERA Program Grant Number JPMOP1614 [FY2016〜FY2020].
- MEXT: Construction Program of Open Innovation Organization [FY2018〜FY2022].

Web pages

- Home page: https://inoel.yz.yamagata-u.ac.jp/yu-fic-en/

Related section

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

Yamagata University Flexible Electronics Japan-Germany International Collaborative Practical Utilization Consortium (YU-FIC)

Yamagata University Flexible Electronics Japan-Germany International Collaborative Practical Utilization Consortium (YU-FIC) collaborates with companies and institutes in Germany, aiming at novel flexible electronics products.

Subjects

- **Development of large area OLED lighting on flexible substrates**
- **Product development for signage using OLED**
- **Free Form Electronics - Freedom in design by thermo-formed printed electronics**

Collaboration with German activity

YU-FIC collaborates with German companies and institutes which are organized by Organic Electronics Saxony (OES), having twice visits a every year, respectively.

Activity

LOPEC/Germany (Mar. 2019)

Flex Japan 2019 (May 2019)

Germany (Sep. 2019)

Japan (Jan. 2020)

JFlex (Jan. 2020)

The 9th Germany-Japan Joint Workshop
"Flexible, Printed Electronics and Sensors"
February 26th 2021
German time 08:30-11:30, Japanese time 16:30-19:30 (online)

Roll-to-roll (R2R) and Printing Technologies

We provide roll-to-roll (R2R) and printing technologies, aiming at an innovation of productions in flexible organic electronics.

Roll-to-roll (R2R)

Unique roll-to-roll (R2R) equipment are utilized for fabrications of electrodes, barrier layers, organic layers, etc.

- **Substrate width : 30cm**
- **Substrate: ultra-thin glass, stainless steel foil, flexible film**

R2R sputtering &CVD (KOBELCO)

R2R screen printing and slit-coating (SERIA)

R2R wet cleaning (FEBACS)

Printing / Coating

Various printing and coating equipment can be utilized for printing tests and device fabrications.

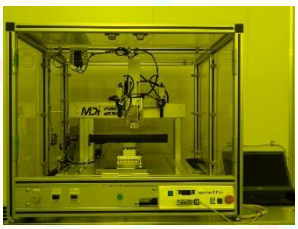
Spin-coating

Screen printing

Flexography and gravure offset printing

Process technologies

Various equipment for process technologies can be used.



Cutting Machine for Ultra-thin Glass

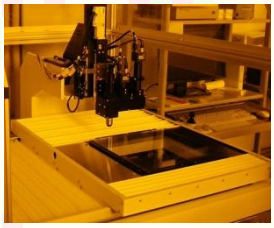
3D Forming Machine

Evaluation

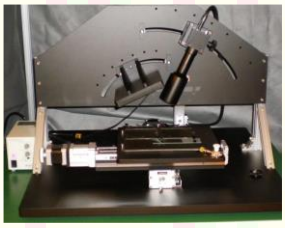
Various evaluation equipment are used for R&D of printing and roll-to-roll (R2R) technologies.

Viscoelasticity measurement

Hybrid confocal microscopy



Precise position detector



Evaluation equipment of Ca corrosion

Evaluation equipment of WVTR

Flexible OLEDs on Ultra-Thin Glass

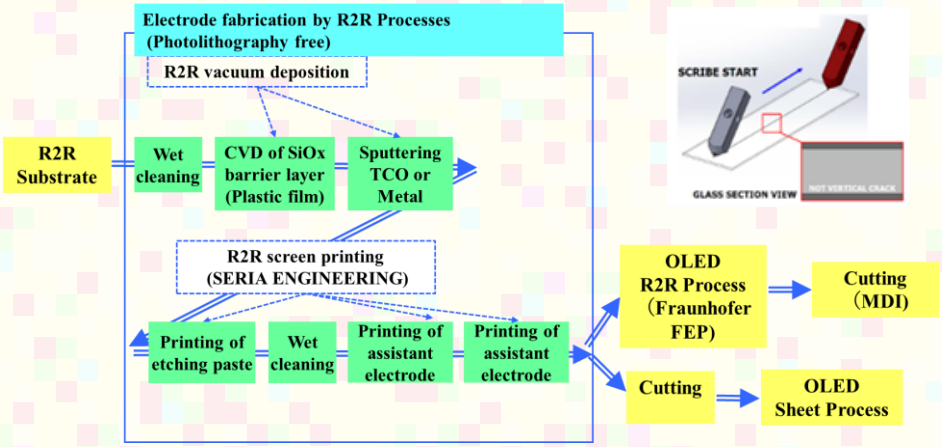
We develop flexible OLED devices on ultra-thin glass G-Leaf® (Nippon Electric Glass).

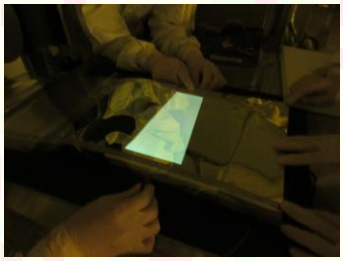
Technological features

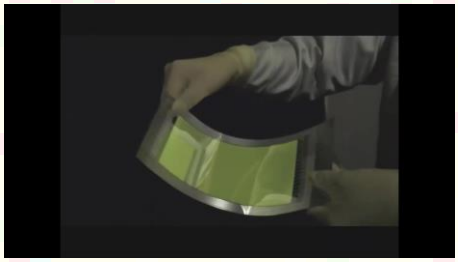
- **Advantages of ultra-thin glass G-Leaf® of Nippon Electric Glass**
  - **Flexible and roll shape due to thin thickness such as 50μm**
  - **Intrinsic advantages of glass (gas barrier, surface smoothness, temperature stability, chemical stability, size stability, etc.)**

Developed technologies

- **Flexible OLED devices on ultra-thin glass with the thickness of 50μm**
  - **Roll-to-roll (R2R) fabrication of transparent electrodes and assistant electrode on ultra-thin glass without photolithography**
  - **Handling and cutting technologies for ultra-thin glass**
  - **Application of ultra-thin glass to OLED substrate and encapsulating substrate.**







Collaboration

Fraunhofer FEP, Nippon Electric Glass, SERIA ENGINEERING, FEBACS, Mitsuboshi Diamond Industrial, NIPPON STEEL Chemical & Material Co., Ltd. FUJIKURA KASEI, TaicaCorporation, tesa

Publication

- **T. Nakagaki, T. Kawabata, H. Takimoto, T. Furukawa, IDW'19, FLXp1-9L (2019). "Scribing Tool and Cutting Method for Ultra-thin Glass"**
- **T. Furukawa, N. Kawamura, T. Noda, Y. Hasegawa, D. Kobayashi, M. Koden, *IDW'17*, FLX6-2 (2017). "Novel Roll-to-Roll Fabrication Processes of Transparent Electrodes on Ultra-Thin Glass"**
- **T. Furukawa, M. Koden, *IEICE Trans. Electron*, E100-C, 949-954 (2017). "Novel roll-to-roll deposition and patterning of ITO on ultra-thin glass for flexible OLEDs"**
- **T. Furukawa, K. Mitsugi, S, Akiyama, H, Itoh, D, Kobayashi, T. Suzuki, H,kuroiwa, M, Sakakibara, K,Tanaka, M, Kawamura, and M, Koden, IDW'14, FLX3-4 (2014). "Patterned ITO Film by Roll-to-Roll Process on Ultra-thin Glass"**

Stainless Steel Foils and Barrier Film

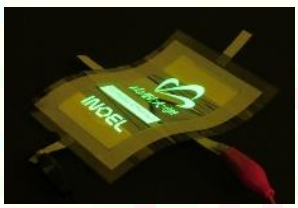
We develop flexible OLED devices using stainless steel foil and barrier film.

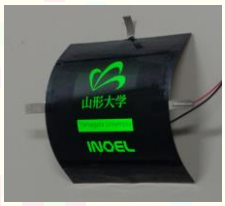
Technological features

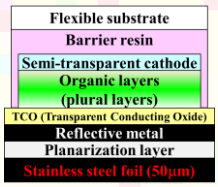
- **Advantages of stainless steel foils of NIPPON STEEL Chemical & Material Co., Ltd.**
  - **・Thickness: 50μm or 30μm**
  - **・Excellent temperature and process resistances**
  - **・High gas barrier ability**
- **Barrier Film**
  - **・High barrier ability with WVTR (Water Vapor Transmission Rate) of the order of 10^{-6}g/m^2/day**
  - **・High gas barrier films with transparent electrode**

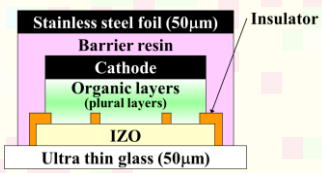
Developed technologies

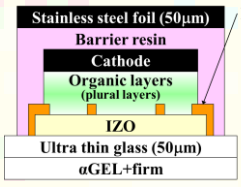
- **Stainless steel foil**
  - **・Electrode (reflective anode) is fabricated on stainless steel foil by roll-to-roll (R2R) photolithography-free processes**
  - **・Development of flexible OLED devices on stainless steel foil**
  - **・Improved mechanical durability of OLED devices by using stainless steel foil as an encapsulation substrate**
- **Barrier Film**
  - **・Roll-to-roll (R2R) photolithography-free fabrication of barrier layer(PE-CVD) and transparent electrode(spattering and printing) on Plastic film**

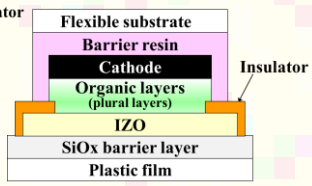












Collaboration

Teijin, NIPPON STEEL Chemical & Material, Nippon Electric Glass, Mitsuboshi Diamond Industrial, FUJIKURA KASEI, tasa

Publication

- **Y. Hagiwara, T. Furukawa, T. Yuki, S. Yamaguchi, N. Yamada, J. Nakatsuka, M. Koden, H. Nakada, *IDW'17*, FLXp1-9L(2017). "Roll-to-Roll Patterning of Reflective Electrode on Planarized Stainless Steel Foil"**
- **M. Koden, T. Furukawa, T. Yuki, H. Kobayashi, H. Nakada, *IDW/AD'16*, FLX3-1 (2016). "Substrates and Non-ITO Electrodes for Flexible OLEDs"**
- **Y. Hagiwara, H. Itoh, T. Furukawa, H. Kobayashi, S. Yamaguchi, N. Yamada, J. Nakatsuka, M. Koden, H. Nakada, *IDW/AD'16*, FLXp1-5 (2016). "Roll-to-Roll Processing of Silver/ITO Continuous Deposition on Planarized Stainless Steel Foil"**
- **K. Taira, Taiga Suzuki, W. Konno, H Chiba, H. Itoh, M. Koden, T. Takahashi, T. Furukawa, IDW'18, FLX2-4L (2019). "Development of High Gas Barrier Film Using Novel Precursor by Roll to Roll PECVD"**
- **T. Suzuki, W. Konno, K. Taira, H Chiba, H. Itoh, M. Koden, T. Takahashi, T. Furukawa, IDW'18, FLXp1-10L (2019). "High Gas Barrier Films with Heterogeneous Multilayer"**
- **K. Taira, T. Furukawa, N. Kawamura, M. Koden, T. Takahashi, IDW'17, FLXp1-8L (2018). "High gas barrier film for OLED"**
- **T. Furukawa, N. Kawamura, M. Koden, H. Itoh, H. Kuroiwa, K. Nagai, LOPEC (2017). "Gas barrier film for OLED devices"**

Roll-to-Roll (R2R) Fabrication of Barrier Film and Evaluation of Barrier Properties

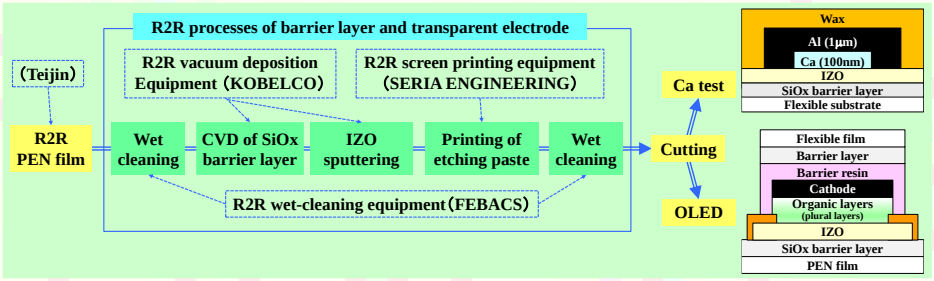
We develop fabrication technologies of gas barrier layer and transparent electrode on flexible film, using roll-to-roll (R2R) PE-CVD (Plasma Enhanced Chemical Vapor Deposition)

Technological features

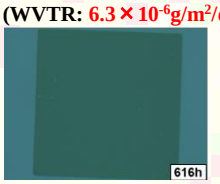
- Roll-to-roll (R2R) PE-CVD deposition of gas barrier layer on flexible films
- High barrier ability with WVTR (Water Vapor Transmission Rate) of the order of 10^{-6}g/m^2/day
- High gas barrier films with transparent electrode
- Evaluation for gas barrier film

Developed technologies

- Roll-to-roll (R2R) photolithography-free fabrication of barrier layer and transparent electrode on flexible films



- High gas barrier property (WVTR: 6.3×10^{-6}g/m^2/day)



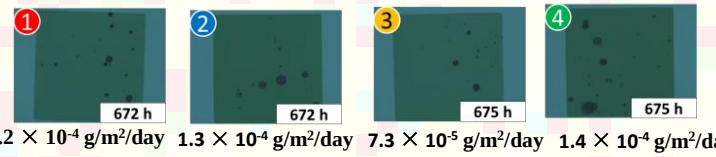
Ca corrosion device after 616 hours under 40°C/90%RH (Thickness of barrier layer: 720nm)

International standard

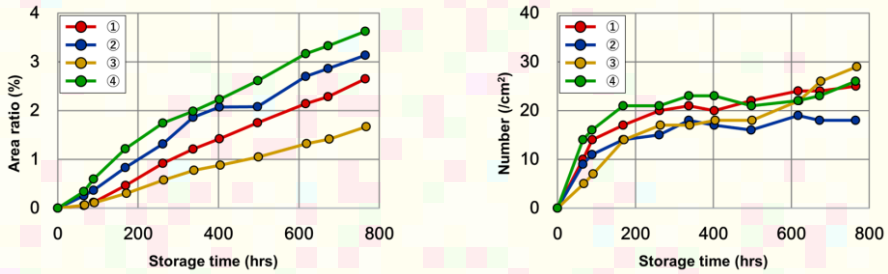
- We contributed to the establishment of standards for high gas barrier film

SEMI D78 - Test Method of Water Vapor Barrier Property for Plastic Films with High Barrier for Electronic Devices

- Gas barrier properties due to changes in area ratio and number of defects over time



1.2 × 10^{-4} g/m^2/day 1.3 × 10^{-4} g/m^2/day 7.3 × 10^{-5} g/m^2/day 1.4 × 10^{-4} g/m^2/day



IDW'18, FLXp1-10L (2019).

SEMI D80 - Test Method for Measurement of Water Vapor Transmission Rate for High Gas Barrier Plastic Film in a Short Time

- Measurement of WVTR using Quadrupole mass spectrometer

Collaboration TEIJIN LIMITED, Tosoh Corporation, MORESCO

Related program

- JST: OPERA Program Grant Number JPMOP1614 [FY2016～FY2020].
- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022].

3D-molding technologies

We develop 3D-molding technologies with electrodes for developing fabrication processes of 3D-circuit board and their applications.

Technological features

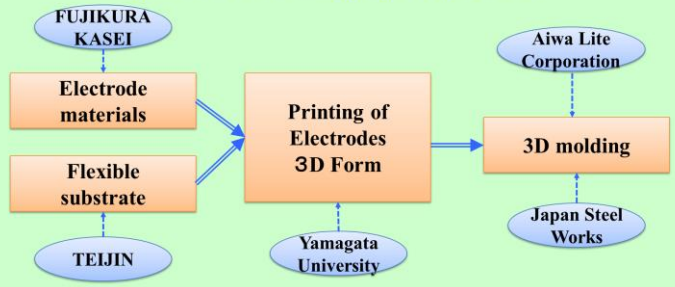
- 3D-molding technologies with electrodes
- Process simplification in fabrication of circuit board by printing technologies

Application areas

- Automotive interiors (lighting, controller, etc. of instrument panels and consoles)
- Thin IoT devices

Collaboration scheme

Process for 3D PCB / Inter-company collaboration

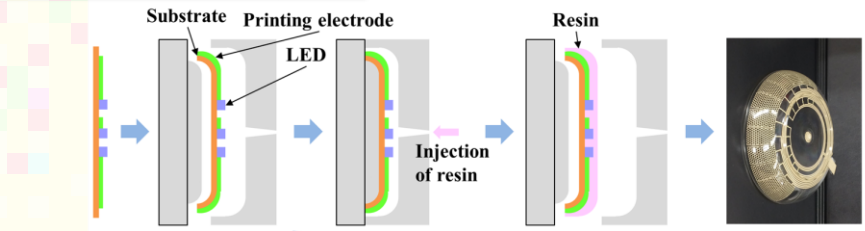


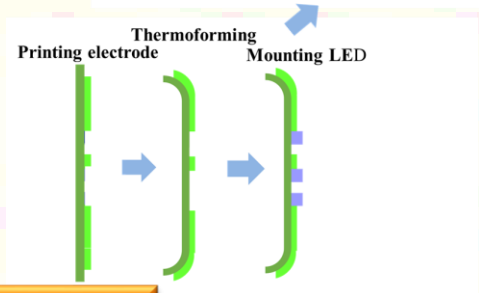
One of the final targets

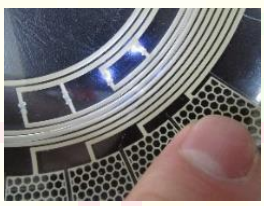
Sensors for agriculture

Developed technologies

3D-shaped prototype with touch screen and LEDs







Collaboration

Aiwa Lite Corporation, The Japan Steel Works, LTD. , TEIJIN LIMITED , FUJIKURA KASEI CO., LTD. , Nishimu Electronics Industries Co., Ltd.

Related program

- JST: OPERA Program Grant Number JPMOP1614 [FY2016～FY2020].
- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022].

Unique application with OLEDs

Technological features

■ **Unique application to packages etc.**

Developed technologies


Bookmark


Medicine case


Traditional Japanese helmet


Mouse shield


Nameplate with wood pattern


Pencil case

Collaboration **KOMORI Corporation , TAKEDA PRINTING CO. LTD., Taica Corporation**

International Conference

- **Y. Kawamura, T. Takahashi, T. Furukawa, ICFPE2021 (2021), "Improvement of printed electrodes disconnection after 3D thermoforming by optimizing print process on PC film"**
- **Y. Kawamura, T. Takahashi, K. Wakabayashi, H. Hirose, Y. Azakami, H. Itoh, T. Furukawa, IDW'20, FLX3-04L (2020). "Effect of Pressure Forming Conditions on PC Sheet integrating Electric Wiring for 3D Electronics Technology"**
- **T. Nakagaki, T. Kawabata, H. Takimoto, T. Furukawa, *IDW'19*, FLXp1-9L (2019). "Scribing Tool and Cutting Method for Ultra-thin Glass"**
- **T. Furukawa, M. Koden, ICDT2019 (2019). "Novel R2R and Printing Technologies for Electrodes of Flexible OLED Lighting"**
- **K. Taira, Taiga Suzuki, W. Konno, H Chiba, H. Itoh, M. Koden, T. Takahashi, T. Furukawa, *IDW'18*, FLX2-4L (2018). "Development of High Gas Barrier Film Using Novel Precursor by Roll to Roll PECVD"**
- **T. Furukawa, *Advanced Materials-2018 (WCAM2018)* (2018). [Invited] "Substrates for Organic Electronics - Ultra-thin Glass, Stainless Steel Foil and High Gas Barrier Plastic Film"**
- **M. Koden, T. Furukawa, T. Yuki, H. Nakada, *LS16* (2018). [Invited] "Roll-to-roll and printing technologies for electrodes of flexible OLED lighting"**
- **T. Furukawa, N. Kawamura, T. Noda, Y. Hasegawa, D. Kobayashi, M. Koden, *IDW'17*, FLX6-2 (2017). "Novel Roll-to-Roll Fabrication Processes of Transparent Electrodes on Ultra-Thin Glass"**
- **T. Furukawa, N. Kawamura, M. Koden, H. Itoh, H. Kuroiwa, K. Nagai, *LOPEC* (2017). "Gas barrier film for OLED devices"**
- **M. Koden, T. Furukawa, T. Yuki, H. Kobayashi, H. Nakada, *IDW/AD'16*, FLX3-1 (2016). [Invited] "Substrates and Non-ITO Electrodes for Flexible OLEDs"**
- **T. Furukawa, *IWFPE2016* (2016). [Invited] "Flexible Substrates and Printed Transparent Electrode for OLED Lighting"**
- **T. Furukawa, N. Kawamura, H. Nakada, M. Koden, *The International Conference on Flexible and Printed Electronics (ICFPE 2016)*, O15-6 (2016). "Novel ITO fabrication processes on ultra-thin glass"**