Academia-Industry Cooperation
“Needs First”

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

Professor Hitoshi Nakada
Associate Professor Tadahiro Furukawa
Associate Professor Dr. Toshinao Yuki
Professor Dr. Mitsuhiro Koden

Activity p.2～3
Consortium p.4～5
Background technologies p.6～9
Developed technologies p.10～18
Topics/Publication p.19
Member p.20

“Award from Minister of State for Science and Technology Policy”
Cabinet Office, Government of Japan (2017)
**Mission and Activity**

In flexible organic electronics technologies, we offer academia-industry collaboration with “Needs First”, in which needs and requests from collaborating companies are the first priority. We support R&D for practical technologies of the collaborating companies, aiming at contribution to actual businesses. Our activity with “Needs First” was awarded from Minister of State for Science and Technology Policy, Government of Japan in 2017.

(Main technologies)

- OLED devices and processes
- Materials and components for flexible organic electronics
- Flexible substrates (ultra-thin glass, stainless steel foil, barrier film)
- Barrier technologies / Barrier evaluation and analysis
- Flexible encapsulating technologies
- Printing and roll-to-roll (R2R) technologies for flexible organic electronics

**Features**

- "Needs First” (Business First)
  Company’s needs is the first priority
- Merits in IPs
- Self-supporting accounting system
  Unique model based on collaboration with industry
- Individual collaboration / Consortium

**Activities**

- Support to company’s R&D
- Evaluation by actual devices
- Proposal of solution
- Prototype samples

**Skills**

- Flexible substrate
- OLED devices and processes
- Barrier technologies
- Barrier evaluation and analysis
- Printing and R2R

**Cooperation**

- **Academia-Industry Cooperation Consortium (p.3〜p.5)**
  1) Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016〜Mar. 2019]
- **National Project (p.3)**
- **Individual Collaboration**
- **Evaluation support (p.8)**

WVTR (Water Vapor Transmission Rate) evaluation with MORESCO
Academia-Industry Collaboration “Needs First!”

Our concept is “Needs First”, in which needs and requests from participating companies are the first priority in our academia-industry cooperation.

**Academia-Industry Collaboration Consortium**

|--------|--------|--------|--------|--------|--------|--------|--------|--------|

**Participation to National Projects**

|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|

MEXT: Regional Innovation Strategy Support Program

JST: A-STEP

MITI: “R&D subsidiary program for promotion of academia-industry cooperation”

NEDO: Development of high efficient OLED materials

JST: Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA)

MEXT: Regional Innovation Eco-system Program

MEXT: Construction Program of Open Innovation Organization

NEDO Project

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

14 Companies (Jan. 2019)


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

Yamagata University Organic Thin Film Device Consortium

Support from MITI

Yamagata University Flexible Electronics Consortium for Academia-Industry Cooperation (YU-FLEC)

Dr. Yuki

6 Companies (Jan. 2019)

FEBACS / SCREEN Finetech Solutions, Nippon Electric Glass, SERIA ENGINEERING, Shin-Etsu Chemical, TOYO INK, TEIJIN

Mr. Furukawa

“Award from Minister of State for Science and Technology Policy”, Cabinet Office, Government of Japan (2017)
Yamagata University has constructed close connection with Saxony/Dresden in Germany in the field of organic electronics, coworking with Yamagata prefecture and Yonezawa city. 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.

**Project term**
- October 2017 ~ March 2021

**Subjects**
- LAOLA: Large Area Organic Lighting Applications on ultra-thin substrates
- IonT: Internet on Things - Intelligent OLED-OPV based Signage for interactive Advertisement
- F2E: Free Form Electronics - Freedom in design by thermo-formed printed electronics

**Leaders**
- Project leader: Associate Prof. T. Furukawa
- Fellow: Prof. T. Takahashi
- Secretary: Prof. M. Koden

**Collaboration with German activity**
YU-FIC collaborates with 24 German companies and institutes which are organized by Organic Electronics Saxony (OES), having twice visits a every year, respectively.

**Activity**
- Germany (Nov. 2017)
- Japan (Feb. 2018)
- LOPEC/Germany (Mar. 2018)
- Germany (Sep. 2018)
- Fintech 2018 (Dec. 2018)
- IDW’18 (Dec. 2018)

**Related program**
- JST: Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) [FY2016~FY2020]
- MEXT: Construction Program of Open Innovation Organization [FY2018~FY2022]
- MEXT: Regional Innovation Eco-system Program [FY2018~FY2022]
Yamagata University Flexible Electronics Consortium for Academia-Industry Cooperation (YU-FLEC)

Yamagata University Flexible Electronics Consortium for Academia-Industry Cooperation (YU-FLEC) is constructed by one-by-one collaboration with individual companies, proposing practical development based on the concept of “Needs First”. We would appreciate it if you are interested in YU-FLEC.

Project term
January 2018 ~ March 2023

Participants
7 Companies (Jan. 2019)

Subjects
➢ Flexible electronics
➢ Organic electronics such as OLED
➢ Others which collaborating companies request

Leaders
➢ Project leader: Associate Prof. T. Yuki
➢ Fellow: Prof. H. Nakada
➢ Secretary: Prof. M. Koden

Activity

➢ Flexible OLEDs on stainless steel foil (p.11)
  (Nippon Steel & Sumitomo Metal Corporation)
  ✓ To apply stainless steel foil with excellent gas barrier,
    temperature stability, chemical stability, size stability, etc. to
    flexible OLEDs
  ✓ To fabricate electrodes on stainless steel foil by using roll-to-roll
    (R2R) technologies

➢ Barrier films with high temperature tolerance for flexible
  OLEDs (p.13)
  (KURABO INDUSTRIES LTD.)
  ✓ To apply barrier films with high temperature tolerance to
    flexible OLEDs

➢ Flexible encapsulating technologies for OLEDs (p.18)
  (Ajinomoto Co., Inc. / Ajinomoto Fine-Techno Co., Inc.)
  ✓ To develop laminating encapsulation for flexible OLEDs

➢ Solution materials for novel light emitting devices.
  ✓ To evaluate solution materials for novel light emitting devices
  ✓ To develop novel light emitting devices with solution materials

➢ Equipment technologies for OLEDs
  ✓ To develop novel technologies for OLED fabrication equipment

Related program
● MEXT: Construction Program of Open Innovation Organization [FY2018〜FY2022]
OLED Device Fabrication

Various types of OLED devices are fabricated based on the requests from collaborating companies. The fabricated OLED devices are utilized for the evaluation of technology potential and prototype samples.

**Material**
- Small molecular OLED materials
- Polymer OLED materials
- Fluorescent, phosphorescent and TADF materials
- Quantum dot (QD) materials

**Device structure**
- Bottom emitting OLED
- Top-emitting OLED
- Transparent OLED (Both side emitting)

**Barrier layer**
- Inorganic barrier layer: CVD, Sputtering, ALD
- Inorganic/organic alternative stacking barrier layer

**Process for organic layers**
- Vacuum evaporation
- Solution processes: Spin-coat, Ink-jet, etc.

**Encapsulation**
Various encapsulating technologies are applied
- Common encapsulation with desiccant
- Laminating encapsulation

**Large size OLED**
Large size OLED devices can be fabricated. The maximum substrate size: 30cm × 30cm

**Flexible OLED**
Flexible OLED devices with various designs can be fabricated.
OLED devices with technologies of collaborating companies are evaluated from practical points of view. All evaluating results are feedbacked to the collaborating company and can be utilized to not only the next development but also the demonstration to their customers.

**Emission uniformity**
- Emission quality such as uniformity, defects, etc. of OLED devices are evaluated by visual microscopic observations.

**I-L-V characteristics**
- OLED device characteristics are evaluated.
  * I-V characteristics
  * L-I characteristics
  * Emission spectrum, etc.

**Driving lifetime**
The reduction of emission intensity of OLED devices under constant current driving is evaluated.

**Storage lifetime**
The change of emission is observed after storage test with high temperature and high humidity.

**Bending tests**
The influences of various bending stress on device characteristics, lifetime, etc. are evaluated using bending equipment.

**Others**
Other evaluations can be used, based on the request from collaborating companies.
(Example)
- Defect analysis
- SEM, AFM
- 3D profile, etc.
Evaluation of Barrier Properties

Evaluation of barrier properties is very important in flexible organic electronics development. We provide two evaluation methods which are “Calcium corrosion method” and “MA method (Modified differential pressure method with an Attached support)”.

✓ Ca corrosion method utilizes the change in Ca reflectivity which changes by the reaction of Ca and H₂O. This method is useful for the evaluation of defects in barrier layer.
✓ WVTR (Water Vapor Transmission Rate) is calculated from the evaluation results in Ca corrosion method.

Ca corrosion method

MA method

WVTR (Water Vapor Transmission Rate) evaluation (Collaborating with MORESCO)

➢ We provide WVTR (Water Vapor Transmission Rate) evaluation, using the WVTR measurement equipment “Super Detect” of MORESCO.
➢ The “Super Detect” utilizes the MA method (Modified differential pressure method with an Attached support) developed by the collaboration of MORESCO and AIST (National Institute of Advanced Industrial Science and Technology).
➢ The MA method reduces measurement time of high gas barrier film such as higher than 10⁻⁴ g/(m² day), which are required in flexible OLED, OPV, etc. For example, the “Super Detect” requires only about 20 hours for the WVTR measurement of barrier films with the order of 10⁻² g/(m² day), for which the previous methods require about 100 hours. It should be noticed that the measurement time of the “Super Detect” is only 1/5 of previous methods.
➢ In addition, the “Super Detect” is able to evaluate wide ranges of WVTR such as 10⁻¹⁻⁻⁷ g/(m² day).
➢ The “Super Detect” with the MA method is able to warrant the WVTR value by the attached compensating unit developed by AIST.
➢ Moreover, the “Super Detect” is able to evaluate the transmission rate of not only water vapor but also various gasses.
Printing and Roll-to-roll (R2R) Technologies

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

**Printing / Coating**

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

- Screen printing
- Flexography and gravure offset printing
- Ink-jet
- Spin-coating

**Roll-to-roll (R2R)**

Four types of 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 (KOBELOCO)
- R2R screen printing (SERIA)
- R2R gravure offset and flexography printing (Komori Machinery / Taiyo Kikai)
- R2R wet cleaning (FEBACS)

**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
- Contact angle measurement

**Related programs**

- MITI: “R&D subsidiary program for promotion of academia-industry cooperation” [FY2013～FY2014]
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.)
- Application of ultra-thin glass to flexible OLED devices.
  - Handling technologies overcoming the brittleness of ultra-thin glass

**Developed technologies**

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

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**Related program**

- Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016～Mar. 2019]
- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022]

**Publication**

Flexible OLEDs on Stainless Steel Foil

We develop flexible OLED devices with stainless steel foil (thickness: 50μm) of NIPPON STEEL & SUMITOMO METAL CORPORATION GROUP.

**Technological features**

- Advantages of stainless steel foils of NIPPON STEEL & SUMITOMO METAL CORPORATION GROUP
  - Thickness: 50μm
  - Excellent surface smoothness (Ra ~ 0.6nm)
  - Excellent temperature and process resistances
  - High gas barrier ability

**Developed technologies**

- Flexible OLED on stainless steel foil
  Electrode (reflective anode) is fabricated on stainless steel foil by roll-to-roll (R2R) photolithography-free processes

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**Related program**

- MEXT: Construction Program of Open Innovation Organization [FY2018 ~ FY2022]

**Publication**

Barrier Films for Flexible OLEDs

We develop fabrication technologies of gas barrier layer on PEN film (TEIJIN), using roll-to-roll (R2R) PE-CVD.

Technological features

- Roll-to-roll (R2R) PE-CVD deposition of gas barrier layer on PEN film
- High barrier ability with WVTR of the order of $10^{-6}$ g/m²/day
- High gas barrier films with transparent electrode

Developed technologies

- Roll-to-roll (R2R) fabrication of barrier layer and transparent electrode on PEN film

High gas barrier property

(WVTR: $6.3 \times 10^{-6}$ g/m²/day)

Flexible OLED devices

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

Collaboration

TEIJIN LIMITED, Tosoh Corporation, FEBACS CO., LTD.

Related program

- Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016~Mar. 2019]
- JST: Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) [FY2016~FY2020]
- MEXT: Construction Program of Open Innovation Organization [FY2018~FY2022]

Publication

OLED fabrication often requires high temperature processes (higher than 200°C). From this point of view, we develop high temperature tolerant barrier films for flexible OLEDs, using EXPEEK film developed by KURABO.

**Technological features**

- Advantages of high temperature tolerant film EXPEEK (KURABO INDUSTRIES LTD.)
  - Biaxially stretched PEEK (polyetheretherketone) film
  - Similar temperature tolerance to polyimide (PI) (Tg: 320°C)
  - Excellent solvent tolerance
  - Excellent transparency
  - Low thermal shrinkage

- Application of EXPEEK with gas barrier layer to flexible OLED devices
  - No requirement of reduction in process temperature (Ordinal fabrication processes for OLEDs can be used.)

**Developed technologies**

- Flexible OLED devices on high temperature tolerant film EXPEEK with gas barrier layer
  - Barrier evaluation of high temperature tolerant film EXPEEK with gas barrier layer
  - Flexible OLED device prototypes on high temperature tolerant film EXPEEK with gas barrier layer

**Example of flexible OLED device**

<table>
<thead>
<tr>
<th>Adhesive resin</th>
<th>EXPEEK film (25μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al (150nm)</td>
<td>Organic layers (plural layers)</td>
</tr>
<tr>
<td>IZO(120nm)</td>
<td>Barrier layer</td>
</tr>
<tr>
<td>EXPEEK film (25μm)</td>
<td></td>
</tr>
</tbody>
</table>

**Prototypes of flexible OLED devices**

- KURABO INDUSTRIES LTD.

**Related program**

- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022]

**Publication**


EXPEEK® is a registered trademark of KURABO INDUSTRIES LTD.
Fabrication Technologies of Inorganic Barrier Layers for OLEDs

OLED devices require high gas barrier technologies. We develop fabrication technologies of inorganic gas barrier layers by using LIA (Low Inductance Antenna)-CVD developed by SCREEN Finetech Solutions.

**Technological features**
- Inorganic gas barrier layer produced by LIA-CVD developed by SCREEN Finetech Solutions
  - **<Advantages of LIA-CVD>**
    - High deposition rate: SiNx faster than 3.0nm/sec
    - Excellent thickness uniformity within ±3%
      (Deposition area 1,200mm × 1,000mm)
    - Deposition-up architecture

**Developed technologies**
- Inorganic gas barrier layers fabricated by LIA-CVD
  - Fabrication of barrier layer (thickness: 400nm) on PEN film
  - WVTR (Water Vapor Transmission Rate): order of 10^{-5}g/m²/day
    (Ca corrosion method, 40°C/90%RH)

Ca corrosion test (40°C/90% RH)

**Barrier film**

<table>
<thead>
<tr>
<th>Flexible substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca corrosion device</td>
</tr>
<tr>
<td>[*] fabricated by LIA-CVD in SCREEN Finetech Solutions</td>
</tr>
</tbody>
</table>

**OLED devices with inorganic gas barrier layer fabricated by LIA-CVD**

<table>
<thead>
<tr>
<th>Flexible substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IZO (150nm)</td>
</tr>
<tr>
<td>HATCN (5nm)</td>
</tr>
<tr>
<td>HTL (120nm)</td>
</tr>
<tr>
<td>Alq₃:Coumarin(C545T,1.5%) (30nm)</td>
</tr>
<tr>
<td>ETM:Liq(25%) (45nm)</td>
</tr>
<tr>
<td>Al (100nm)</td>
</tr>
</tbody>
</table>

[*] fabricated by LIA-CVD in SCREEN Finetech Solutions
Non-ITO Transparent Electrode with Implanted Al-mesh Structure

ITO (Indium Tin Oxide), which is the most common transparent electrode in LCDs and OLEDs, has issues in cost, productivity, etc. We develop OLED devices using a non-ITO transparent electrode with novel implanted Al-mesh structure fabricated by Toyo Aluminium.

### Technological features
- Non-ITO transparent electrode with novel implanted Al-mesh structure fabricated by Toyo Aluminium K.K.
  - High conductivity led by Al-mesh
  - Smooth surface due to the implanted Al-mesh electrode into resin
  - Applicable to OLED, OPV, etc.
  - Applicable to flexible devices

<table>
<thead>
<tr>
<th></th>
<th>Surface resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITO (on glass)</td>
<td>~10Ω/□</td>
</tr>
<tr>
<td>ITO (on film)</td>
<td>~40Ω/□</td>
</tr>
<tr>
<td>Al-mesh developed by Toyo Aluminium</td>
<td>0.05~1Ω/□</td>
</tr>
</tbody>
</table>

### Developed technologies
- OLED devices using non-ITO transparent electrode with implanted Al-mesh electrode substrate fabricated by Toyo Aluminium K.K.

**Device structure of OLED**

- Encapsulating glass
- Desiccant
- Cathode
- Organic layers (plural layers)
- Glass substrate
- Transparent conducting polymer
- Al
- Sealant
- Resin

**Emission of OLED devices**

**Related program**
- JST: Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) [FY2018~FY2022]
Roll-to-roll (R2R) Fabrication of Flexible Substrates with Electrode

We develop roll-to-roll (R2R) fabrication technologies of flexible substrates with electrode, aiming at large size OLED lighting.

※Collaboration with German companies and institutes in Yamagata University Flexible Electronics Japan-Germany International Collaborative Practical Utilization Consortium (YU-FIC)

We develop roll-to-roll (R2R) fabrication technologies of flexible substrates with electrode, aiming at large size OLED lighting.

Technological features

- Roll-to-roll (R2R) fabrication of electrodes on flexible substrates by photolithography-free processes. (low cost, high productivity)

Key technologies

- Ultra-thin glass (Nippon Electric Glass)
- Stainless steel foil (NIPPON STEEL Chemical & Material Co., Ltd.)
- Plastic film (TEIJIN)

- Screen mask (Tokyo Process Service)
- Conducting ink (FUJIKURA KASEI)
- Cutting (Mitsuboshi Diamond Industrial)
- Screen printing equipment (SERIA ENGINEERING)

Collaboration

- Nippon Electric Glass, NIPPON STEEL Chemical & Material, TEIJIN, SERIA ENGINEERING, Tokyo Process Service, FUJIKURA KASEI, Mitsuboshi Diamond Industrial

Related program

- Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016～Mar. 2019]
- JST: Program on Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA) [FY2016～FY2020]
- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022]
- MEXT: Regional Innovation Eco-system Program [FY2018～FY2022]

Publication

We develop TFE (Thin Film Encapsulation) technologies for OLED devices, using organic resins developed by TOYO INK SC HOLDINGS.

**Technological features**

- **To apply “Non-solvent UV-IJ resin ink” developed by TOYO INK SC HOLDINGS**
- **Advantages of “Non-solvent UV-IJ resin ink” developed by TOYO INK SC HOLDINGS”**
  - To support SiN barrier layer
  - UV cure type (non-solvent)
  - Applicable to ink-jet

**Developed technologies**

- **TFE structure with high gas barrier property**
  - “Non-solvent UV-IJ resin ink” developed by TOYO INK SC HOLDINGS is sandwiched by SiN barrier layers
  - High gas barrier property:
    * No actual damage after storage test of 1,000 hours under 40℃/90% RH
    * WVTR (Water Vapor Transmission Rate): order of 10^-6 g/m²/day (40℃/90% RH)

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**Related program**

- Yamagata University Flexible Organic Electronics Practical Key Technology Consortium (YU-FOC) [Apr. 2016～Mar. 2019]

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**Publication**

Laminating Encapsulation for OLEDs

We develop flexible OLED devices, using laminating encapsulating film AFTINNOVA™ EF developed by Ajinomoto Co., Inc. / Ajinomoto Fine-Techno Co., Inc.

Technological features
- AFTINNOVA™ EF substrate protecting water penetration from side of OLED device
- Simple device architecture and simple fabrication process
- Reduction of defect occurrence by stress release effect of AFTINNOVA™ EF

Developed technologies

High gas barrier property:
- No actual damage after storage test of 8,000 hours under 60℃/90%RH
- WVTR (Water Vapor Transmission Rate): order of 10^{-6} g/m^2/day (60℃/90%RH)

Flexible OLED devices

Related program
- MEXT: Construction Program of Open Innovation Organization [FY2018～FY2022]
Award

Book

Paper
“Novel roll-to-roll deposition and patterning of ITO on ultra-thin glass for flexible OLEDs”

International Conference
“Substrates for Organic Electronics - Ultra-thin Glass, Stainless Steel Foil and High Gas Barrier Plastic Film”
“Roll-to-roll and printing technologies for electrodes of flexible OLED lighting”
“Novel Roll-to-Roll Fabrication Processes of Transparent Electrodes on Ultra-Thin Glass”
“High gas barrier film for OLED”
“Gas barrier film for OLED devices”
“Substrates and Non-ITO Electrodes for Flexible OLEDs”
“Flexible Substrates and Printed Transparent Electrode for OLED Lighting”

Exhibitions
➢ “JFlex2019” (Jan. 2019).
➢ “LOPEC” (March 2018, Germany).
➢ “LED & OLED EXPO 2017” (June 2017, Korea)
➢ “Printable electronics 2017” (Feb. 2017).
➢ “G7 Exhibition” (May. 2016).
➢ “International Photonics Exhibition 2015” (Korea) (Oct. 2015).
➢ “Printable electronics 2015” (Jan. 2015).

Printable Electronics 2017 Award
“Originality Award” to INOEL
Members

Professor, Deputy Director

Hitoshi Nakada
nakada@yz.yamagata-u.ac.jp

Field: Organic electronics devices

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

(Award)
- Award from Minister of State for Science and Technology Policy”, Cabinet Office, Government of Japan (2017).
- Optoelectronics Industry and Technology Development Association, 19th Kenjirou-Sakurai Memorial Award (2003).
- 47th Okochi Memorial Award (2000).

(Development)

Associate Professor

Tadahiro Furukawa
ta-furukawa@yz.yamagata-u.ac.jp

Field: Fine patterning technology, Printing, Roll-to-roll technology

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)

(International conference)

Professor

Dr. Mitsuhiro Koden
koden@yz.yamagata-u.ac.jp

http://www.asahi.net.or.jp/~ar3t-kudn/technology.html

Field: LCD, Display, OLED, Chemistry

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)

(Award)
- Award from Minister of State for Science and Technology Policy”, Cabinet Office, Government of Japan (2017).
- Award from The Japanese Liquid Crystal Society (2005).

(Development)
- 17” Ferroelectric liquid crystal display (FLCD) prototype (1999).
- 3.6” Polymer OLED display with world’s highest resolution (2006).

(Book)

Associate Professor

Dr. Toshinao Yuki
t-yuki@yz.yamagata-u.ac.jp

Field: OLED (Display, Lighting, Device),

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)

(Award)
- The 4th Japan OLED Forum Outstanding Achievement Awards (2011).

(Development)
- World’s first large size tiling OLED display product (2010).

January 2019 (revised in Feb. 2019)
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URL: http://inoel.yz.yamagata-u.ac.jp/F-consortium/home.html