

# Direct printing of Light Emitting Devices onto Textiles

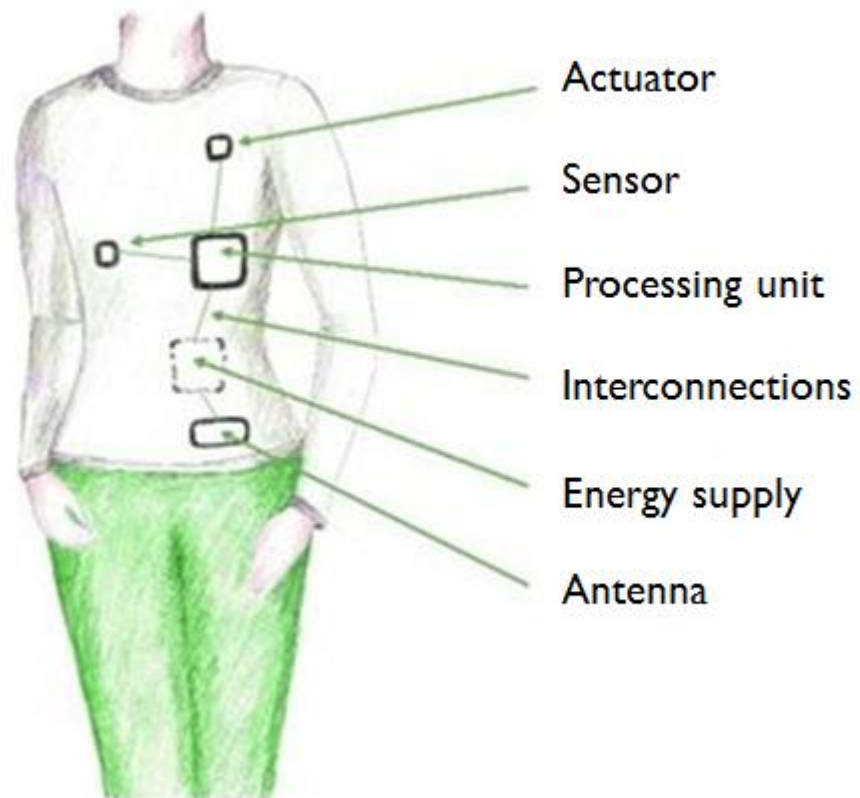
Prof. Dr. Ir. Wim Deferme

IMO-IMOMEC



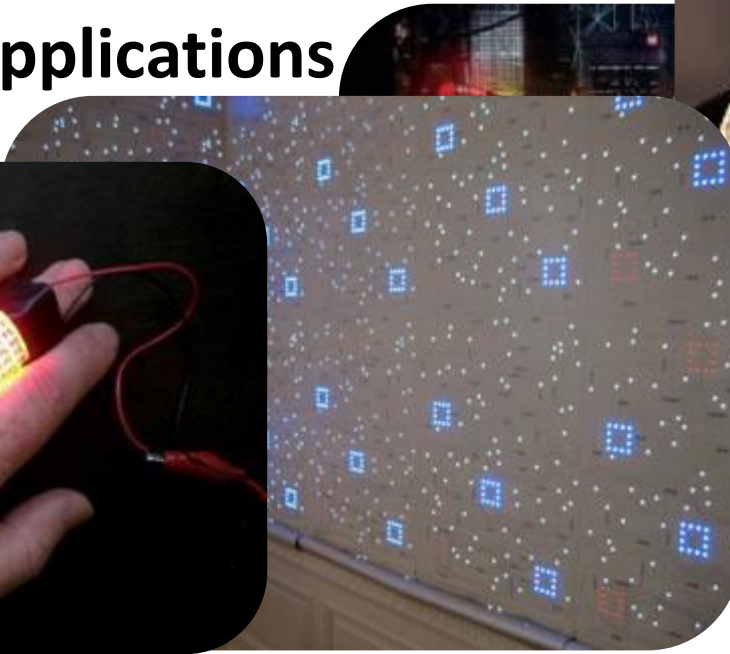
# Smart textiles

Textiles with enhanced functionality  
= **Smart textile system**



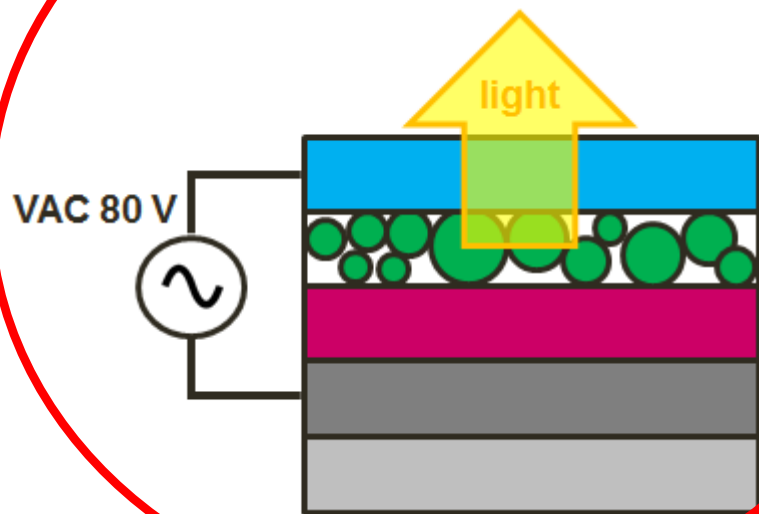
# Smart textiles

- Integration of light-emitting properties in textiles
  - Protective or safety clothing
  - Fashionable clothing
  - Indoor and outdoor applications
  - Healthcare applications



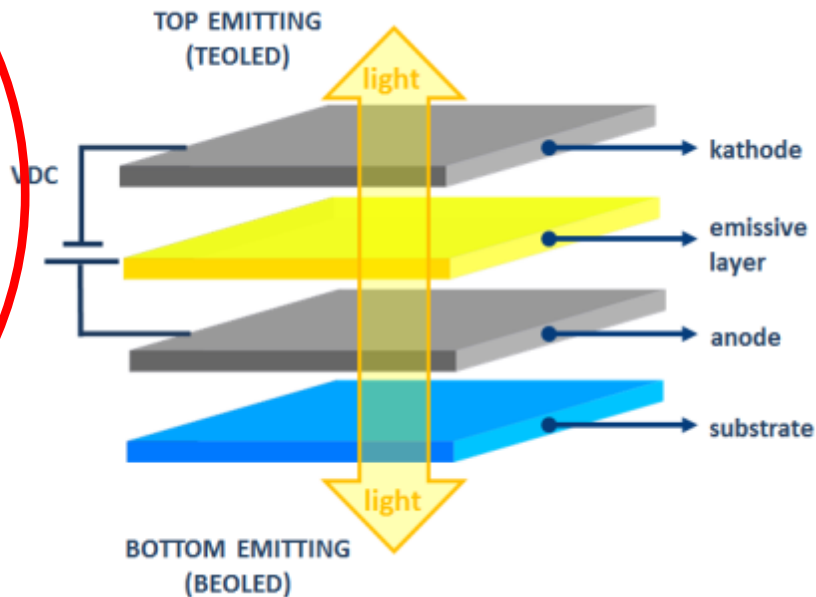
# Approaches for light emission

## ACPEL devices



Indoor and outdoor applications

## OLEDs



Wearable applications

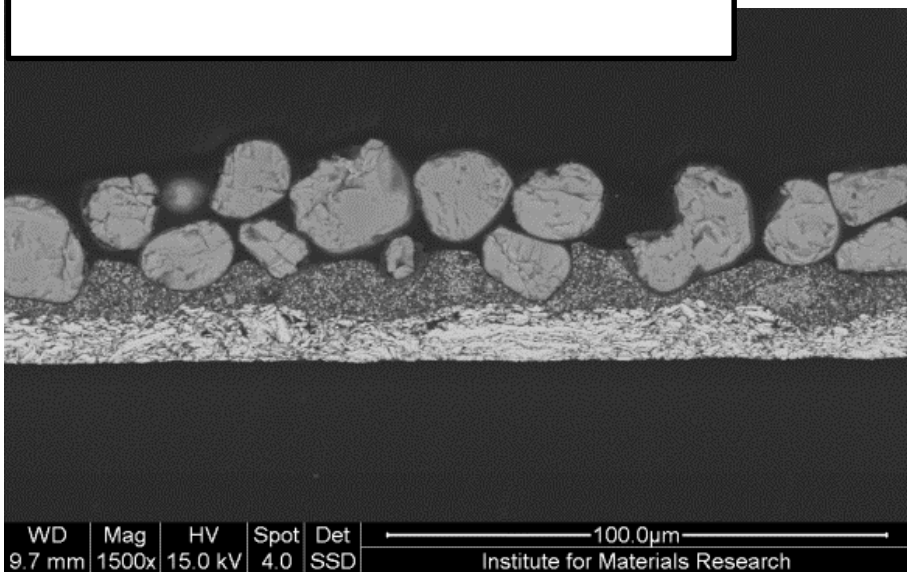
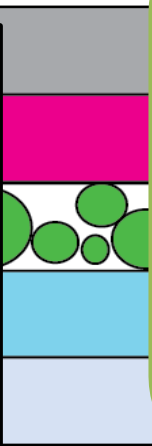
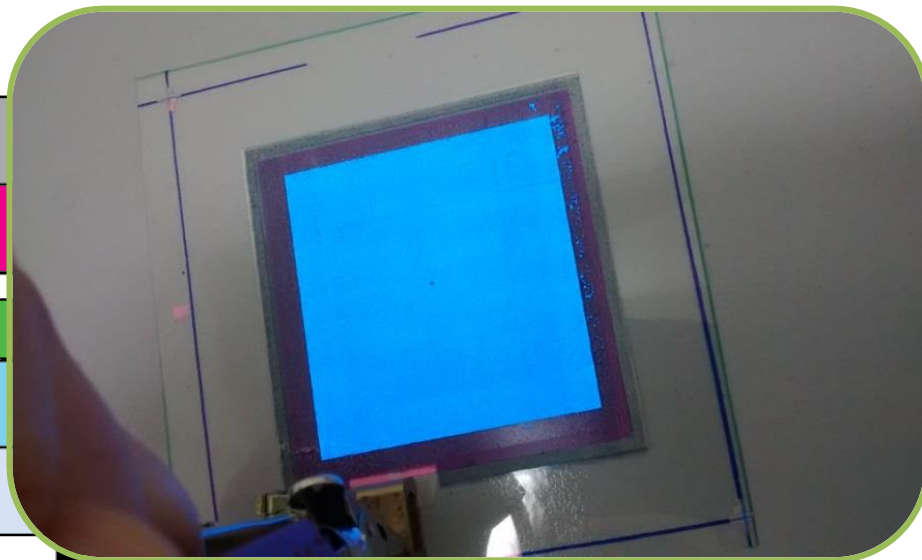


# Alternating Current Powder Electroluminescent (ACPEL)

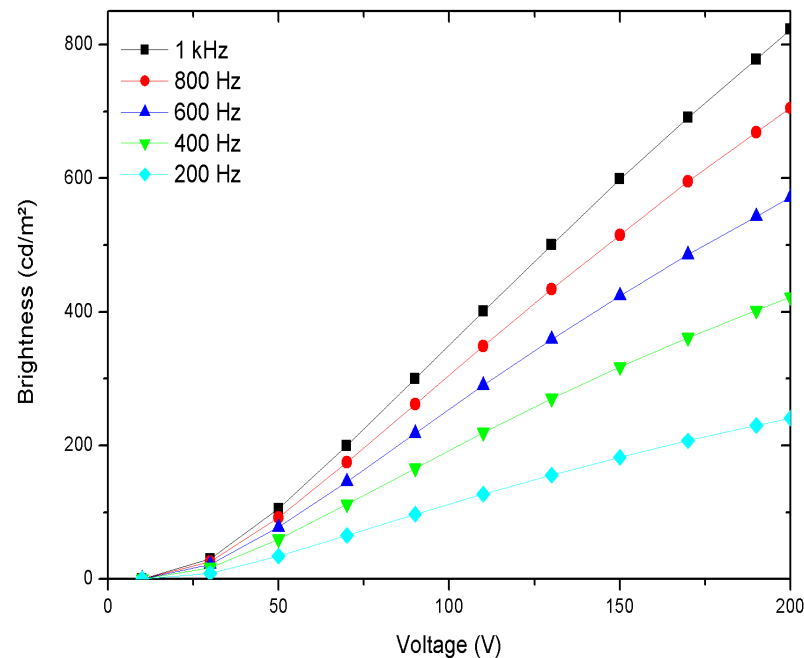
## Best EL lamp

191 cd/m<sup>2</sup> @ 100V/400Hz

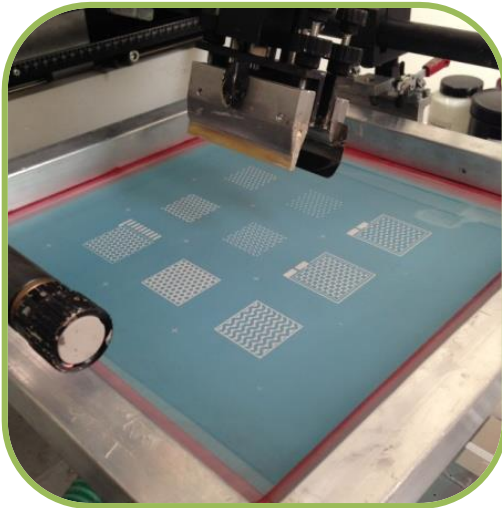
- => Reverse structure
- => High permittivity binder
- => Sinking
- => PEDOT (165-31 screen)
- => Phosphor loading 70 wt%



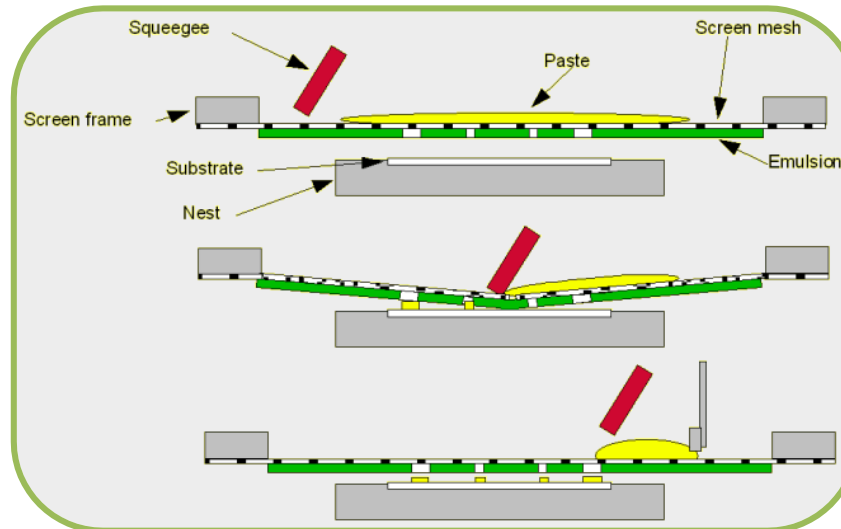
WD 9.7 mm Mag 1500x HV 15.0 kV Spot 4.0 Det SSD  
100.0µm  
Institute for Materials Research



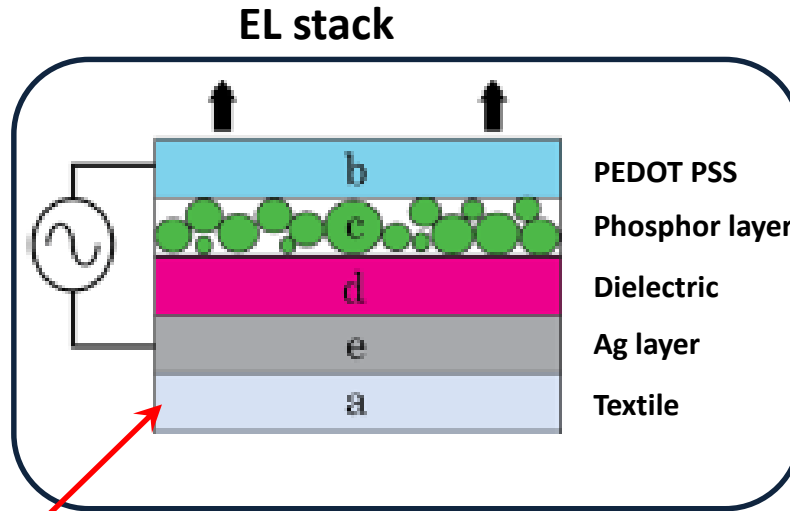
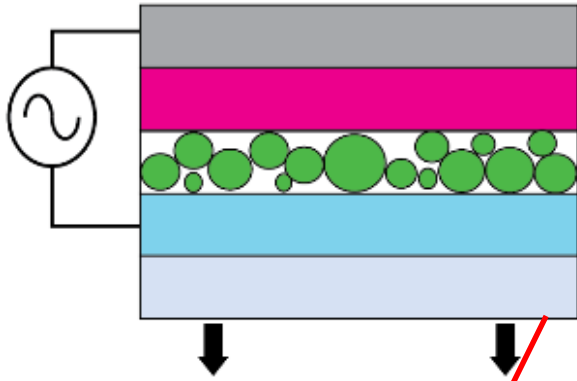
# ACPEL - Screenprinting



Screen printing is a technique whereby a mesh is used to transfer ink onto a substrate, except in areas made impermeable to the ink by a blocking stencil. A blade or squeegee is moved across the screen to fill the open mesh apertures with ink, and a reverse stroke then causes the screen to touch the substrate momentarily along a line of contact. This causes the ink to wet the substrate and be pulled out of the mesh apertures as the screen springs back after the blade has passed.



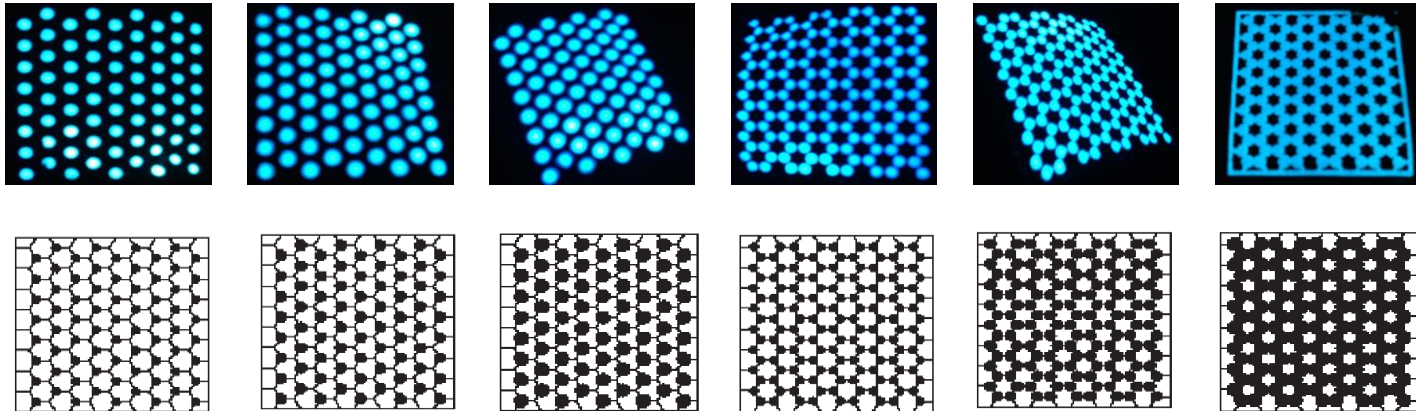
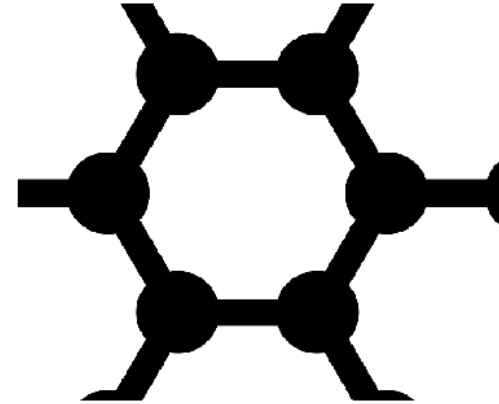
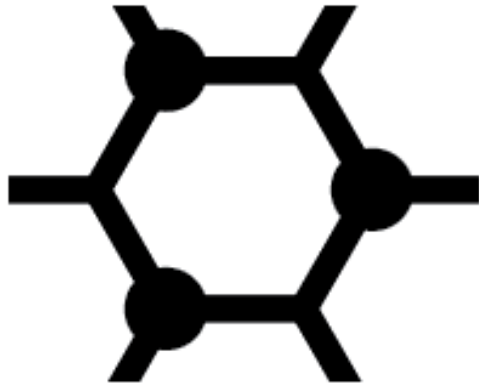
# ACPEL - Textile as a substrate



Full coverage on textile limits:

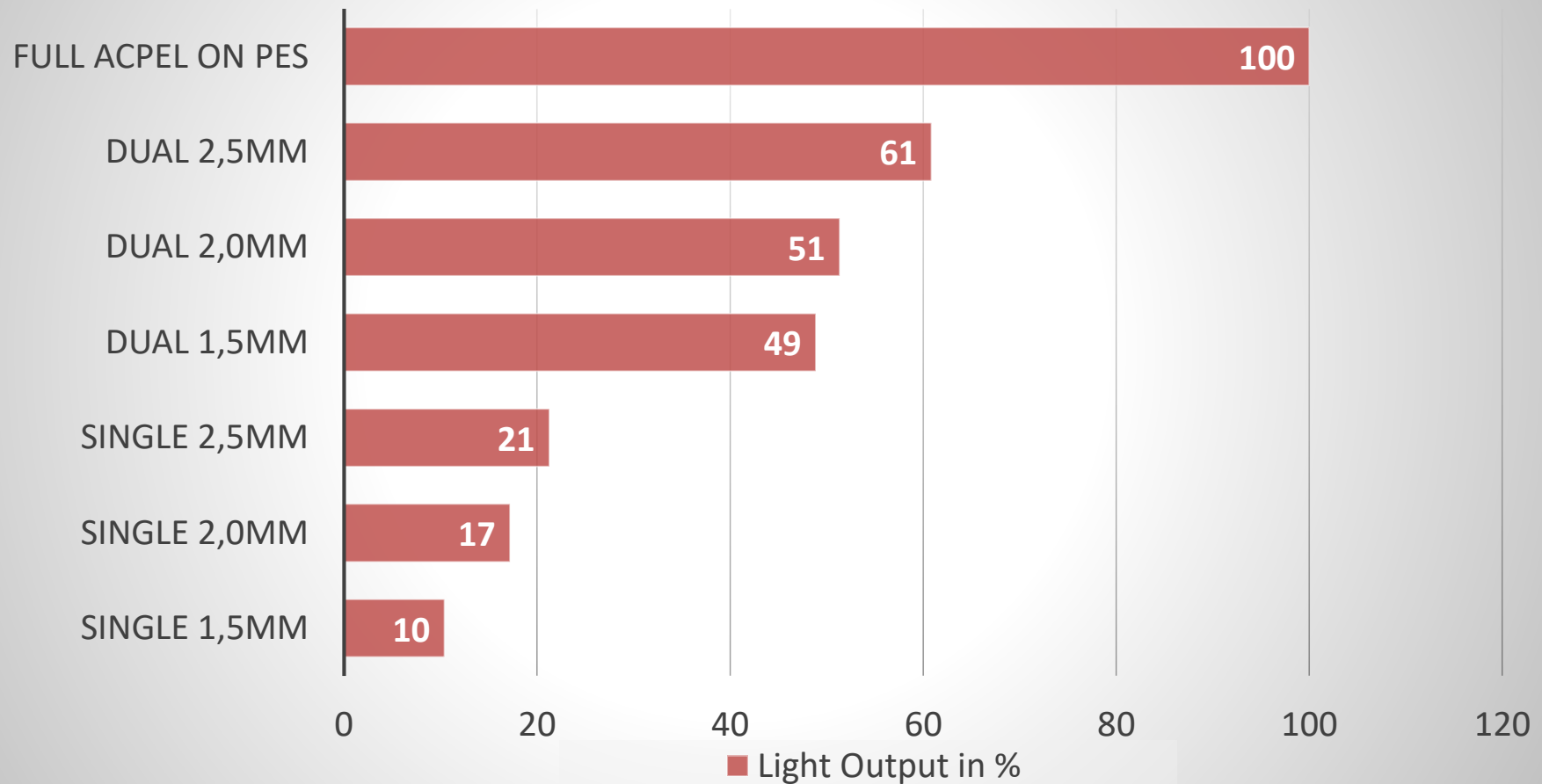
- Flexibility (drape)
- Air permeability
- Other textile aspects

# ACPEL - Sample Preparation

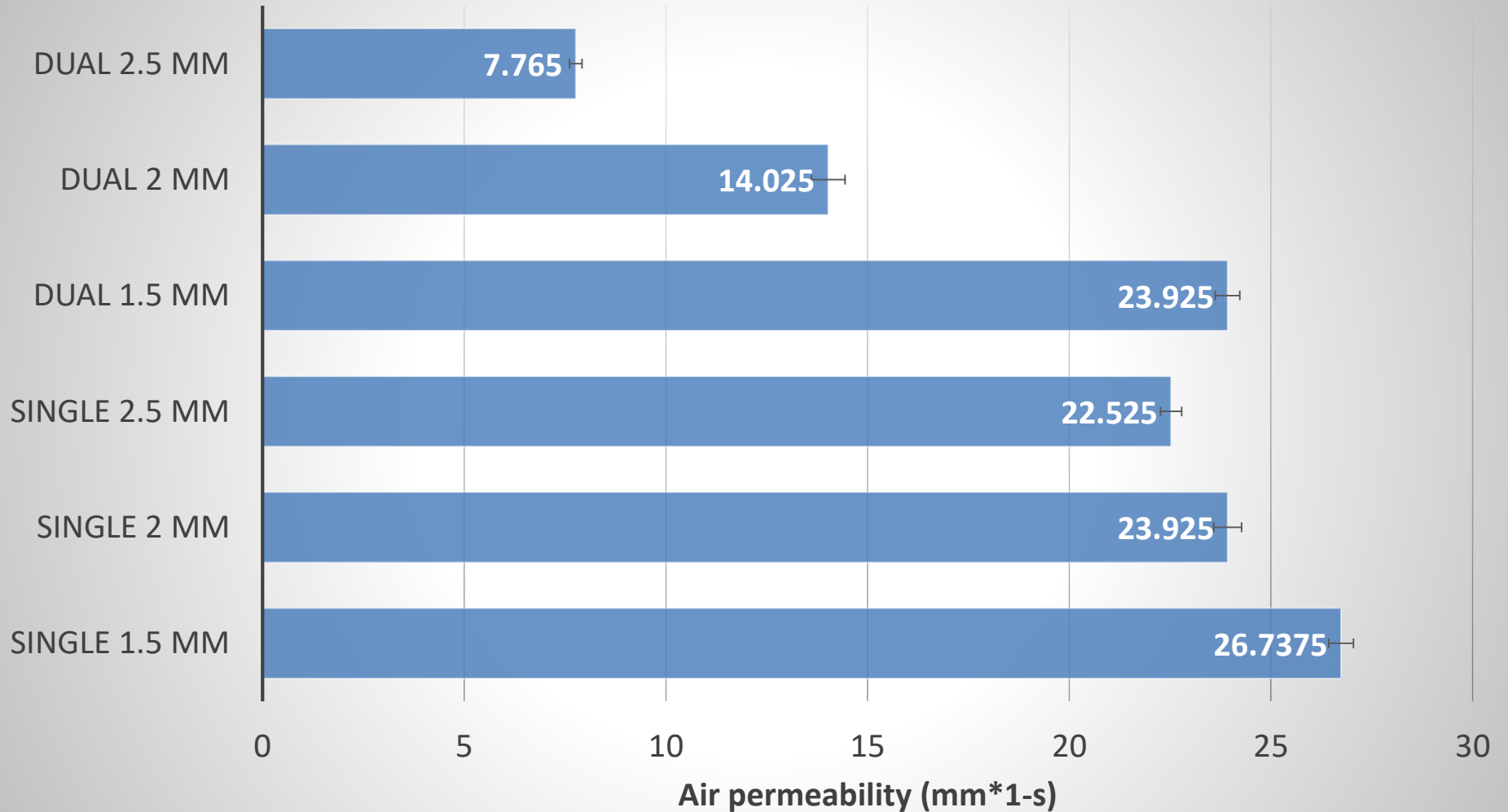




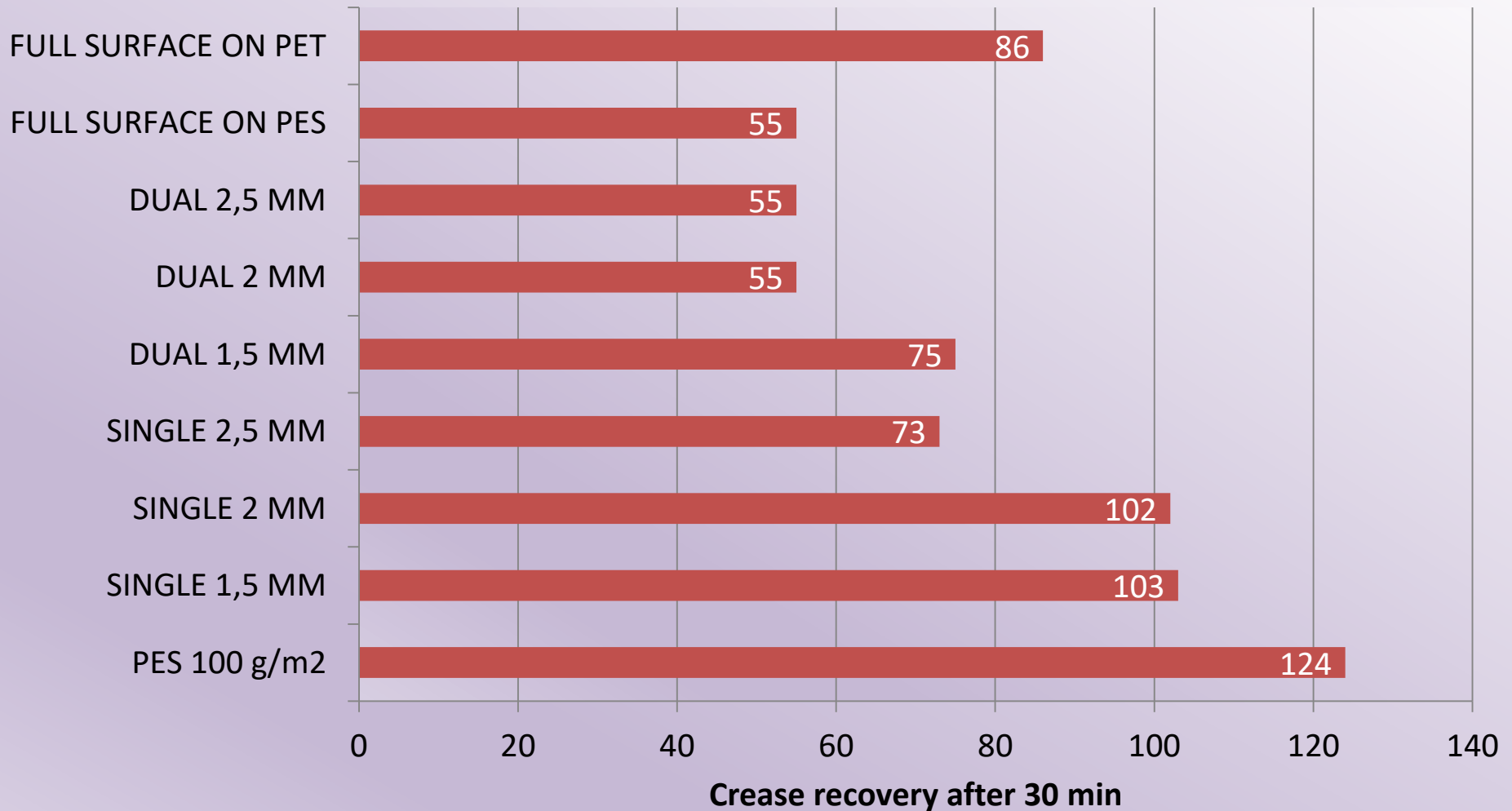
# ACPEL - Light Output



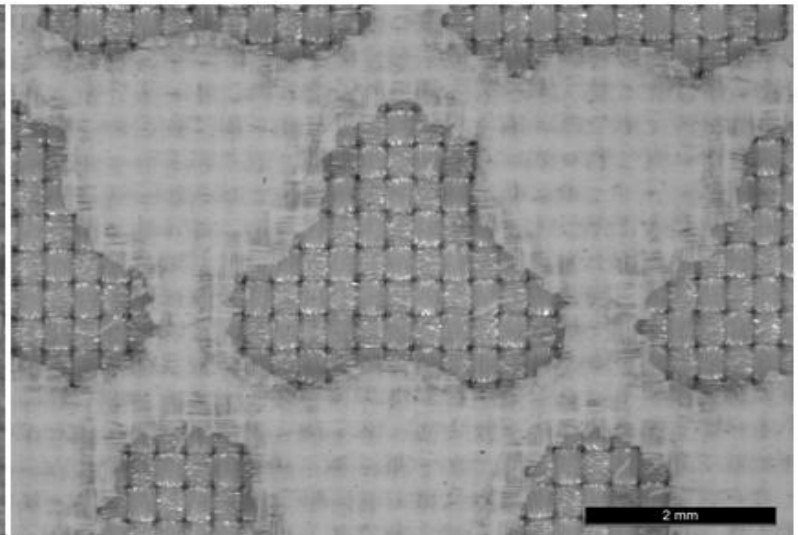
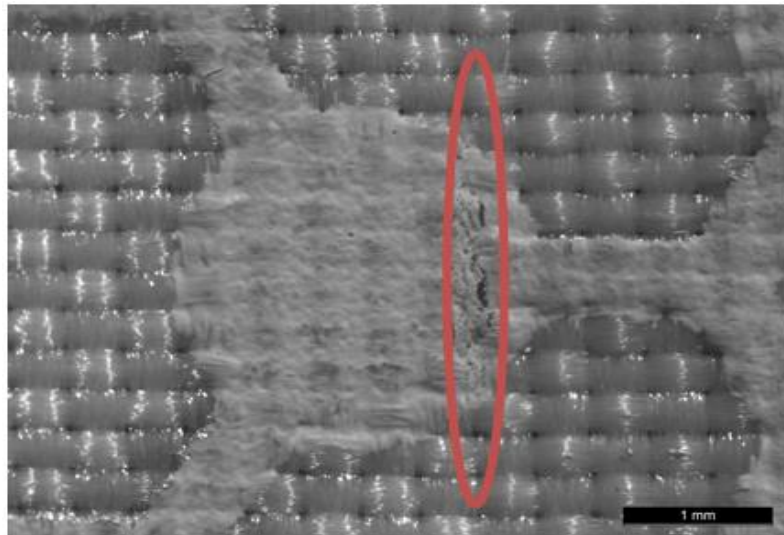
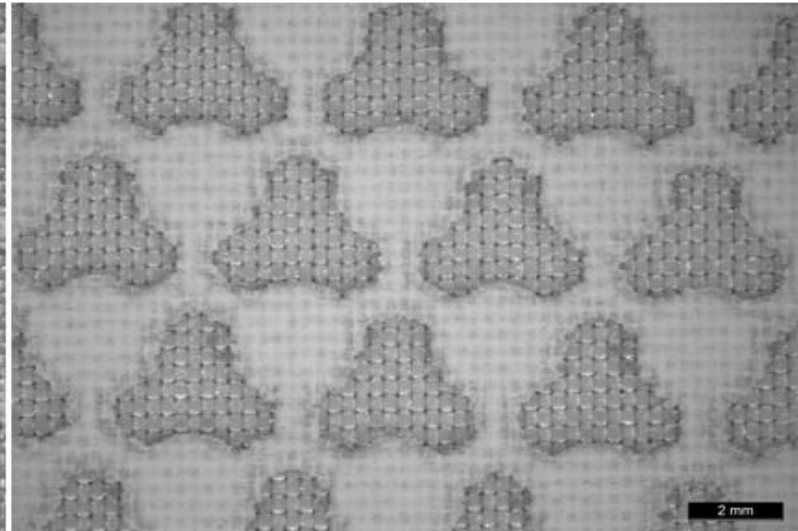
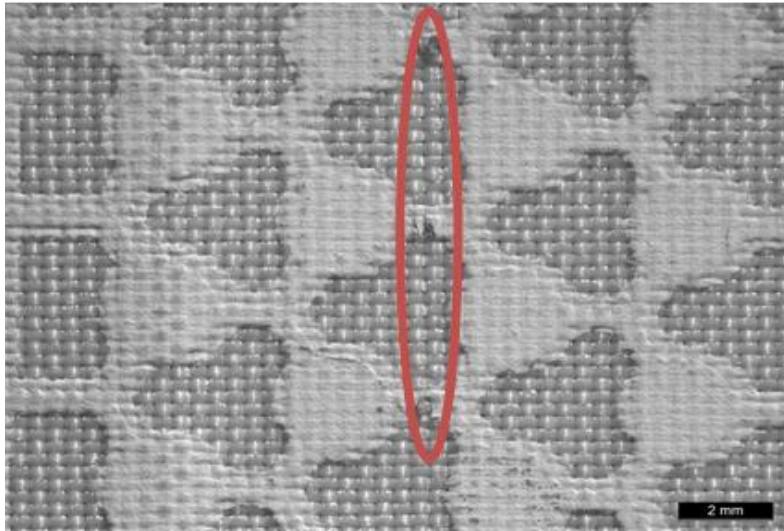
# ACPEL - Air permeability



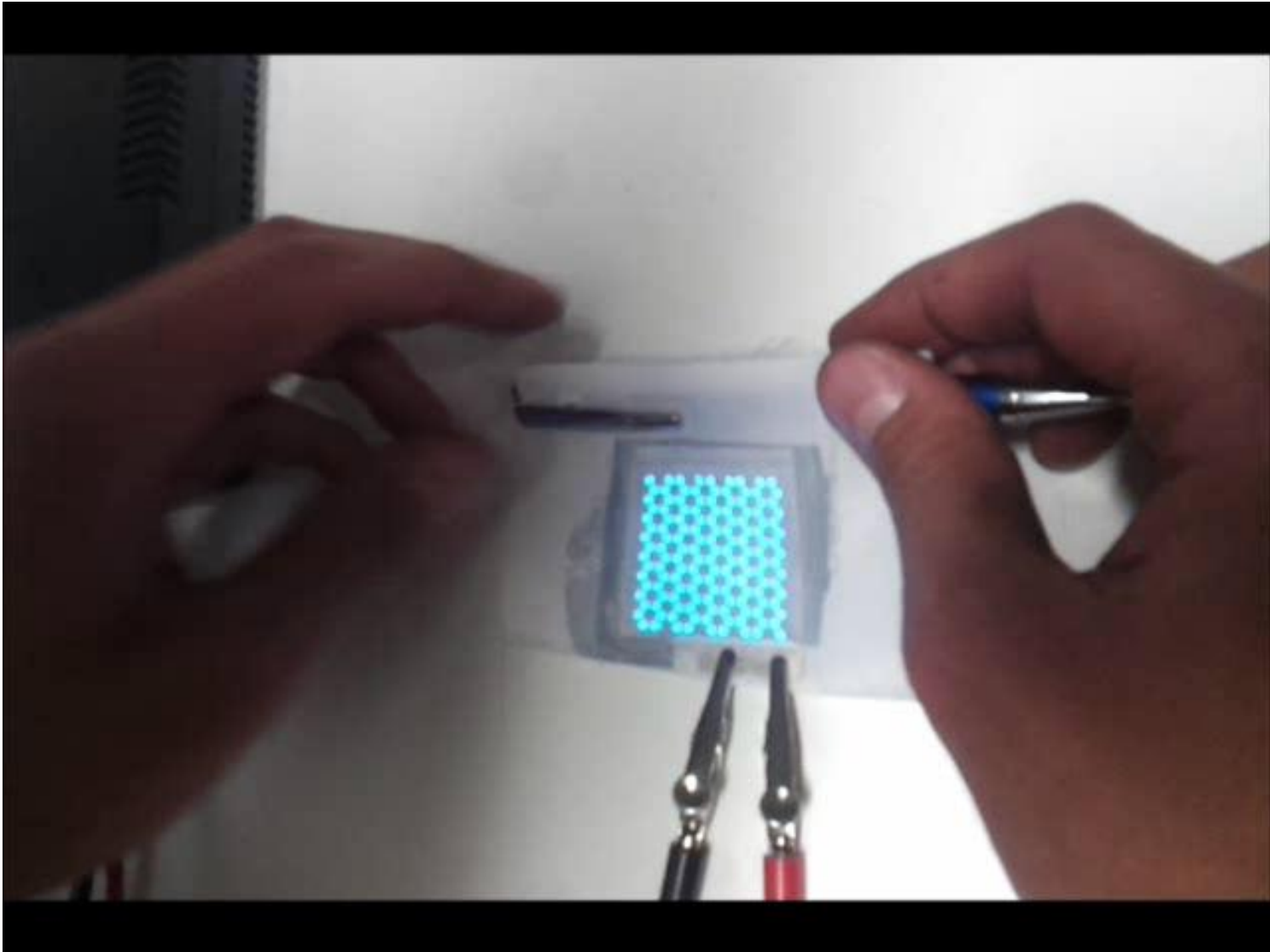
# ACPEL - Crease recovery



# ACPEL - Crease Recovery



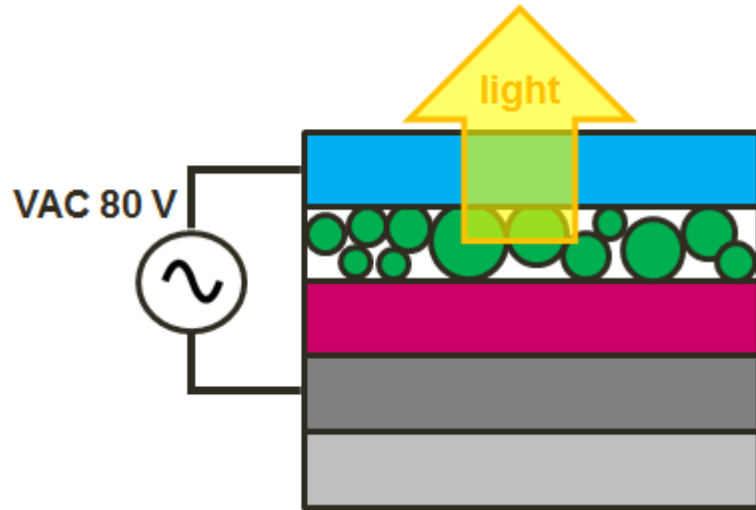
# ACPEL – Final demonstrator





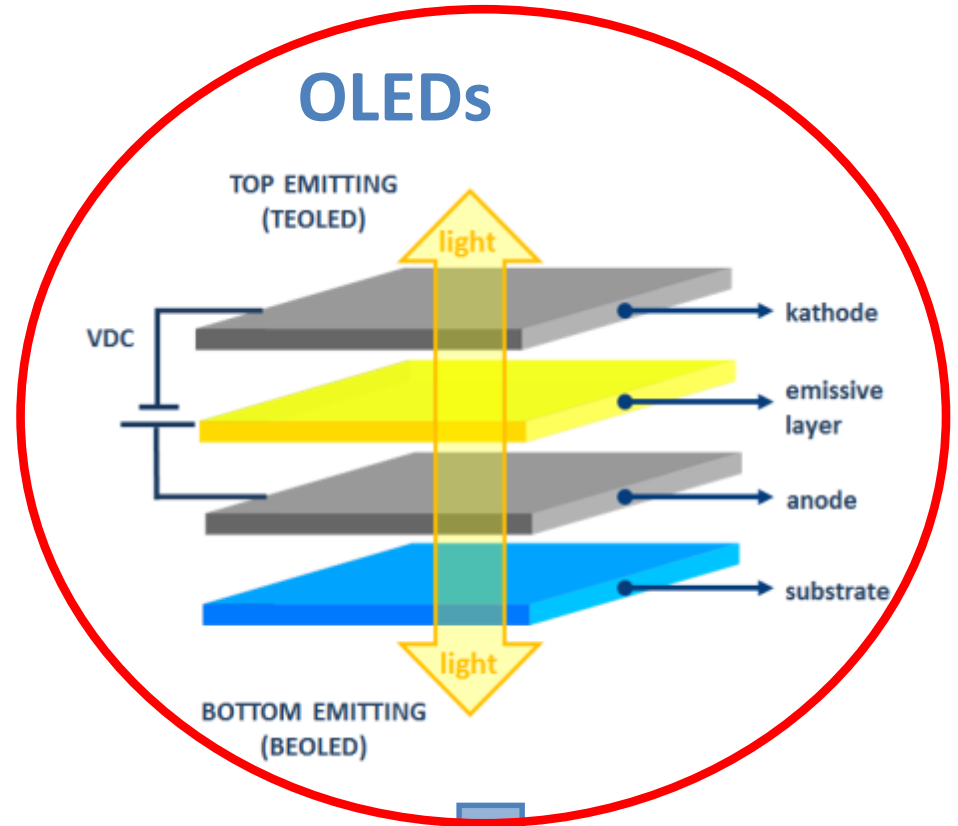
# Approaches for light emission

## ACPEL devices



Indoor and outdoor applications

## OLEDs



Wearable applications

# OLED advantages and disadvantages

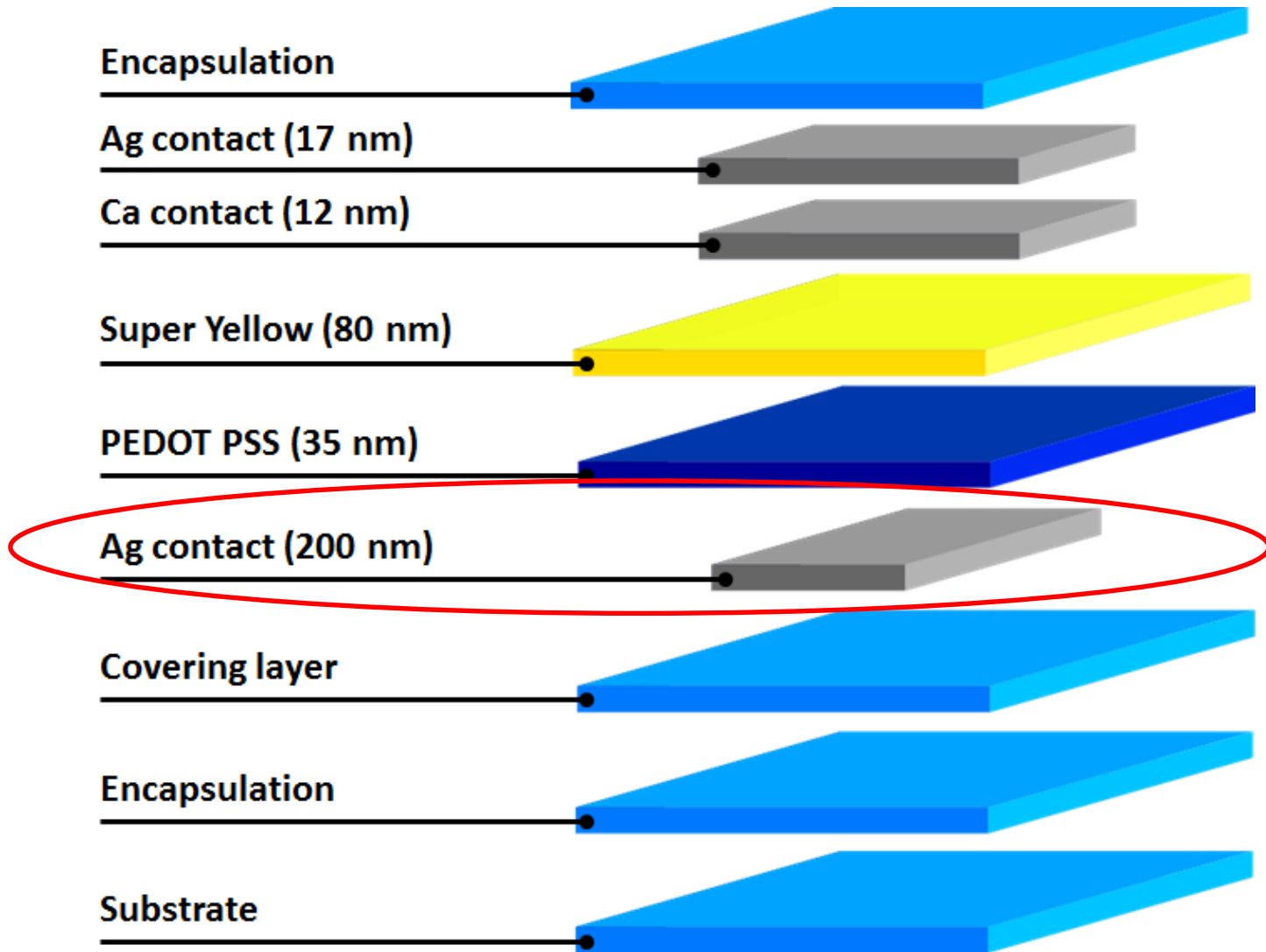


- Thin layers
- Flexible substrates
- High brightness
- Low power supply (3-5 V)
- Low energy consumption
- Good efficacy
- Wide range of vision



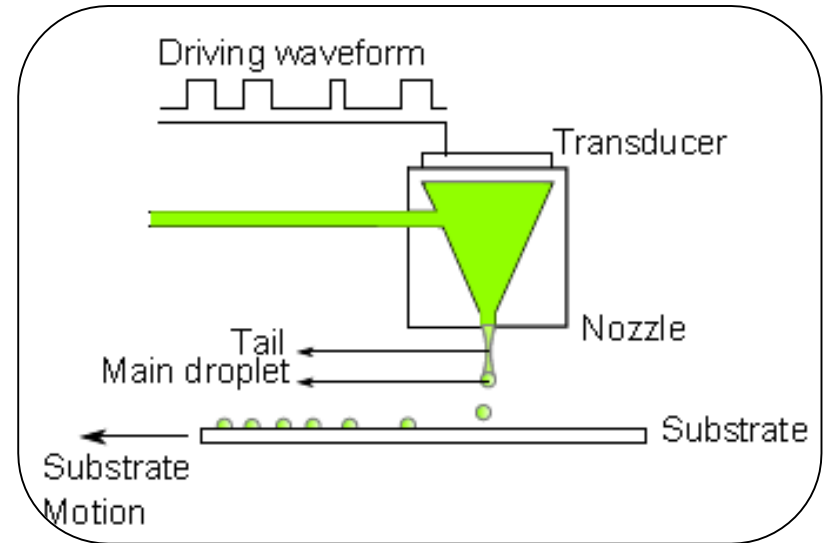
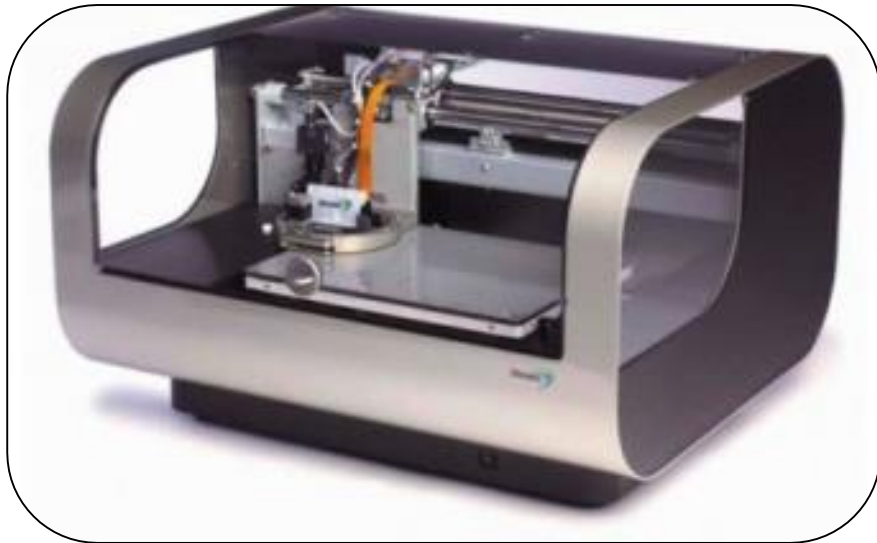
- Encapsulation necessary (to avoid exposure to water vapor and oxygen)
- Low lifetime
- Harmful solvents (toluene, chlorobenzene, ...)
- Expensive production techniques (vacuum deposition, ..)

# OLED - Structure Top Emitting OLED



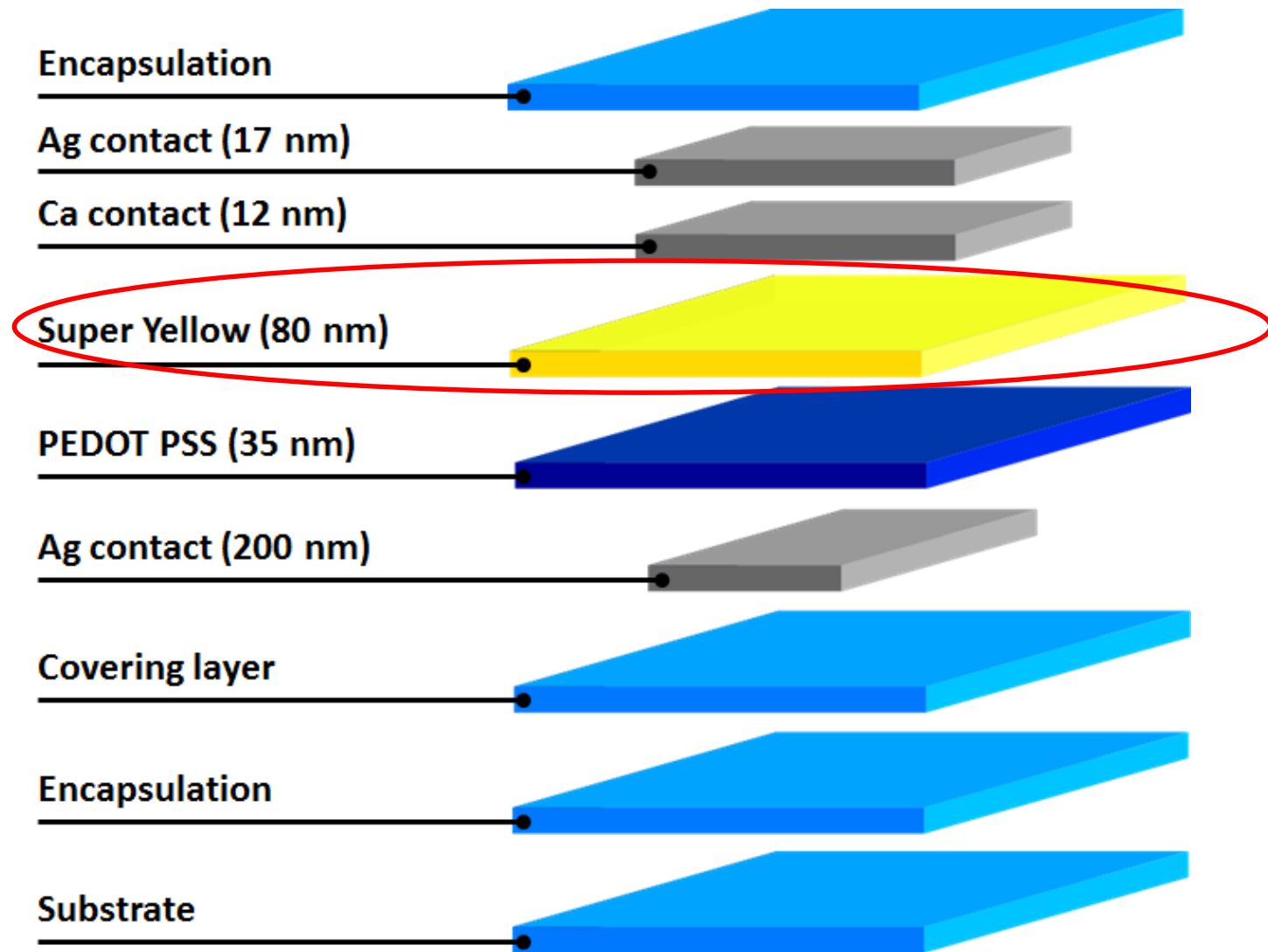
# OLED - Fabrication

## Inkjet printing



200 nm Ag contact

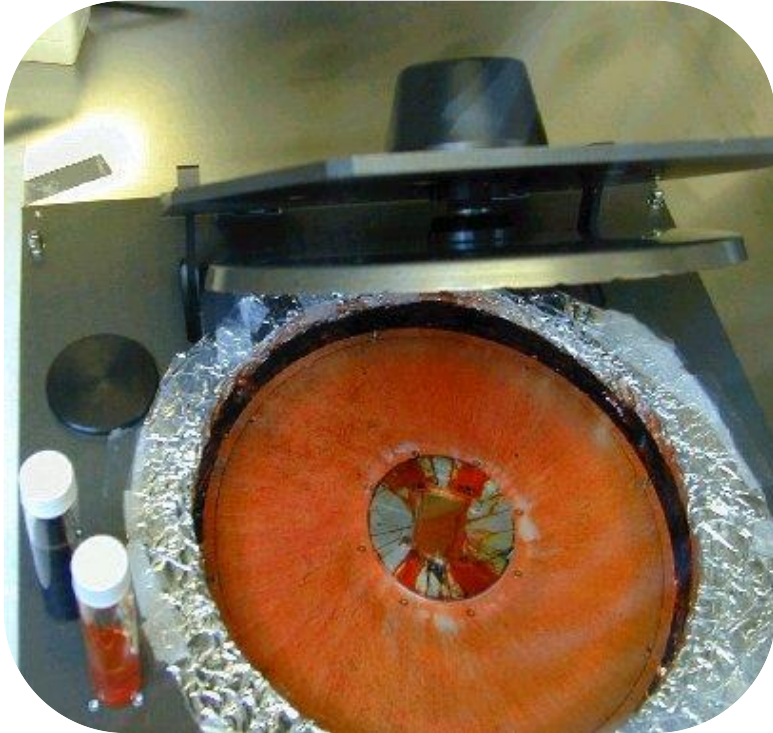
# OLED - Structure Top Emitting OLED





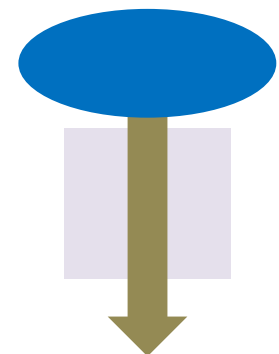
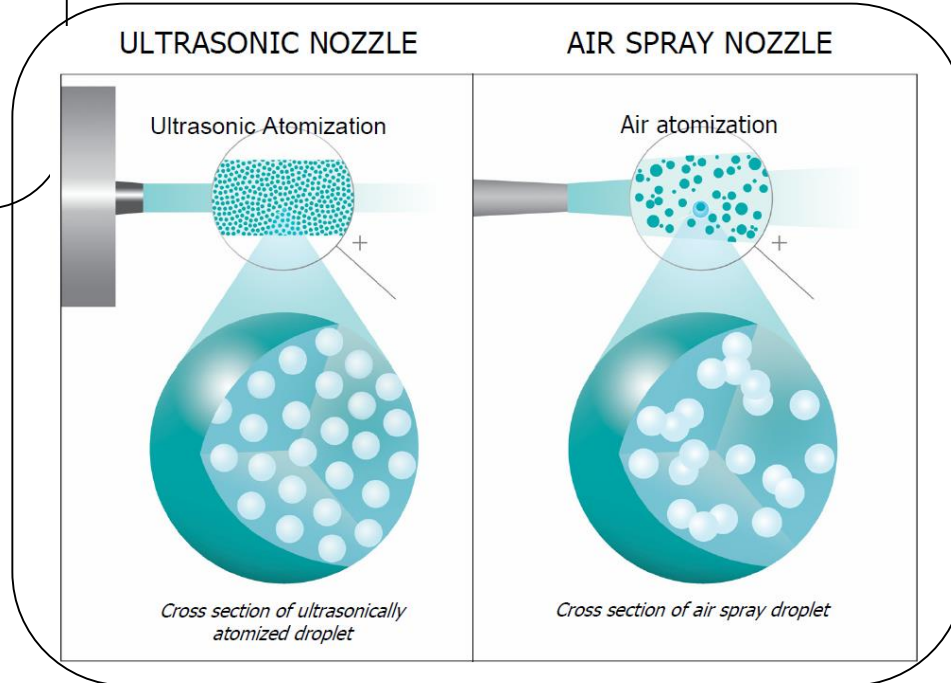
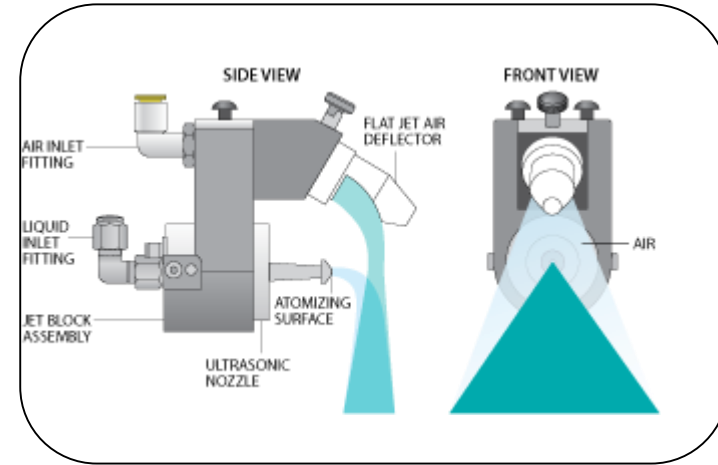
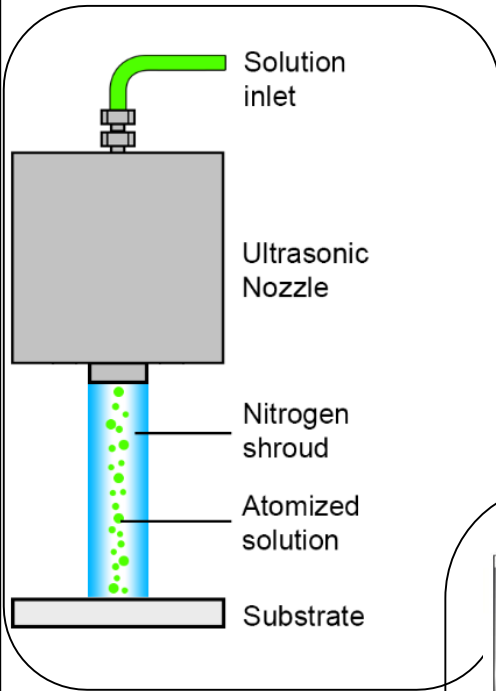
# Making a TEOLED

Spin coating and ultrasonic spray coating

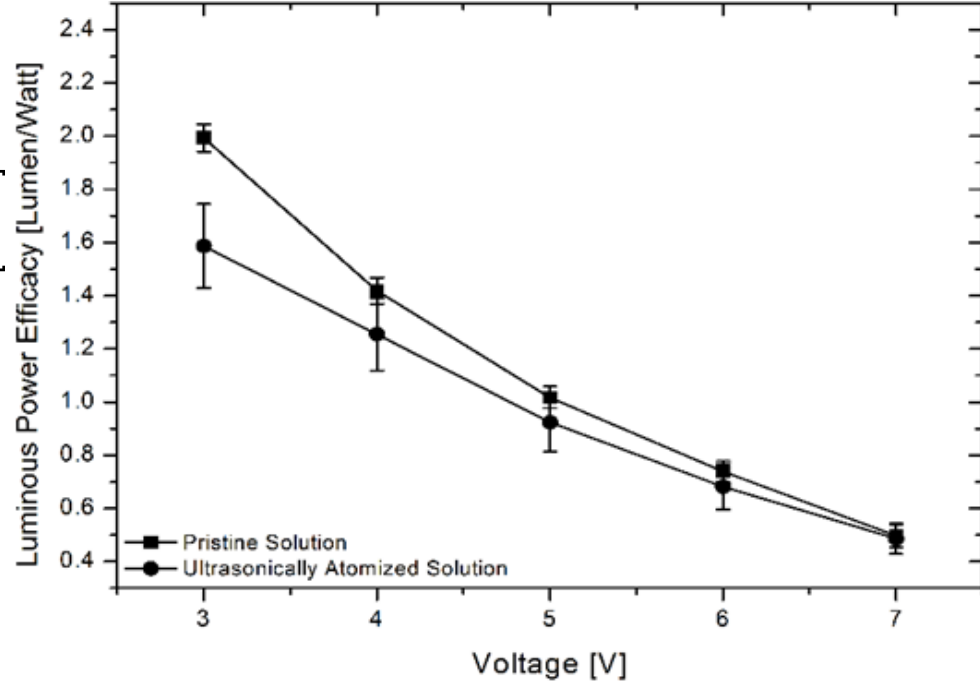
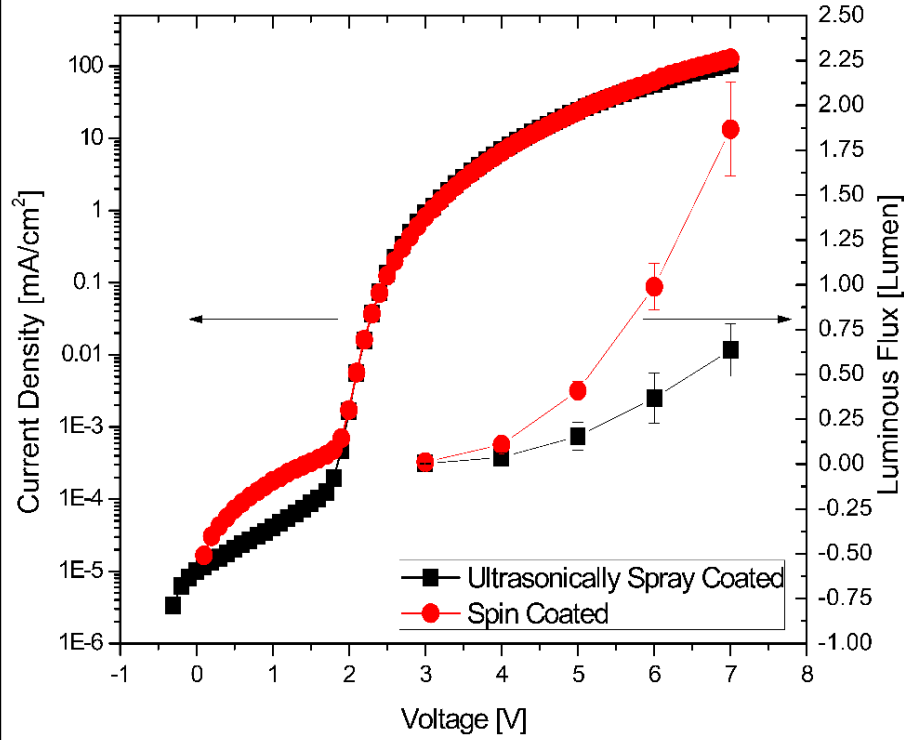


80 nm Super Yellow

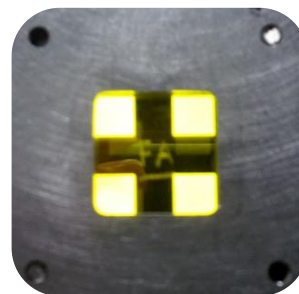
# OLED - Ultrasonic spray coating



# OLED - Ultrasonic spray coating

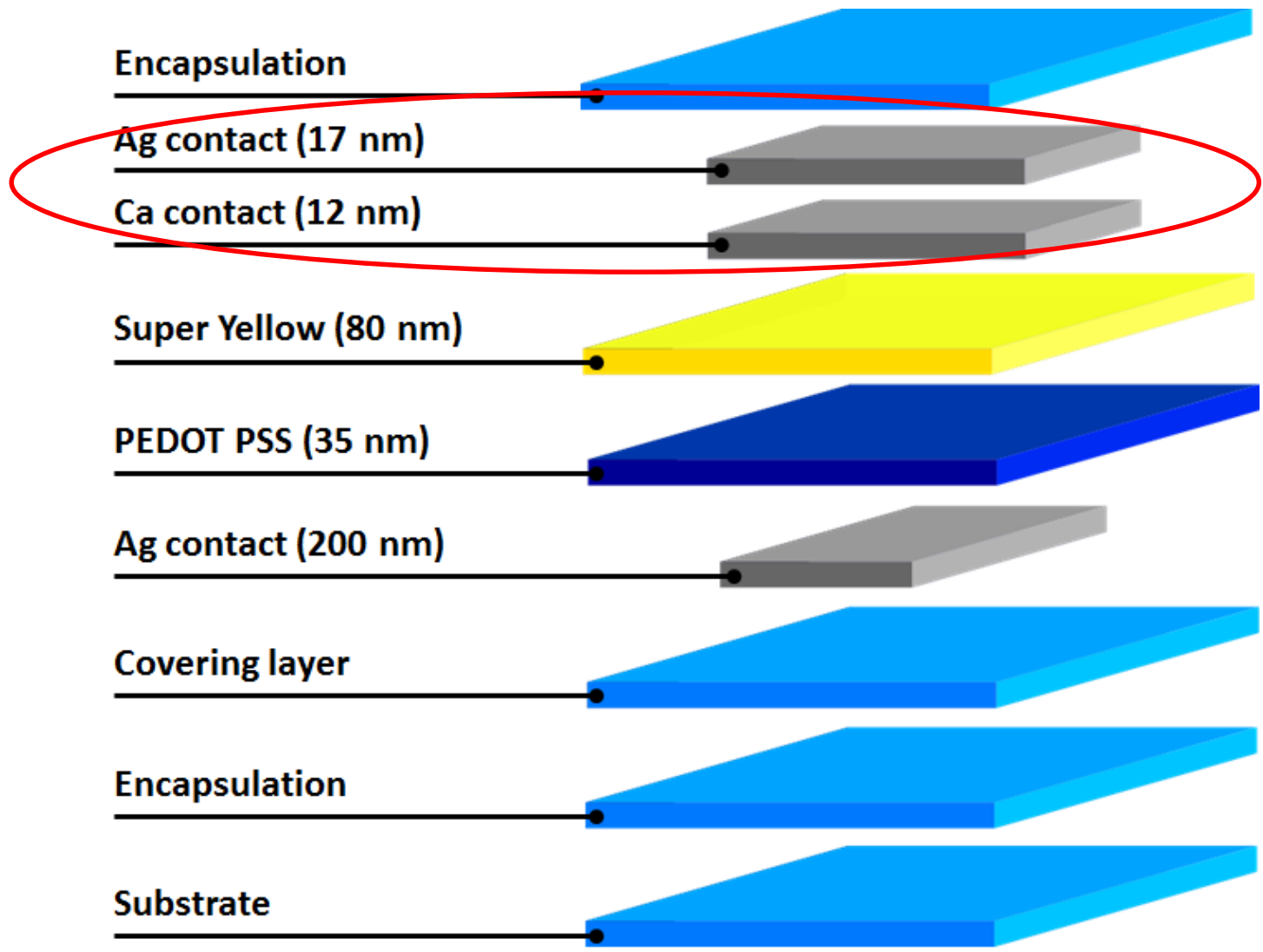


Spray coated OLED



Spin coated OLED

# OLED - Structure Top Emitting OLED



# OLED – Top contact

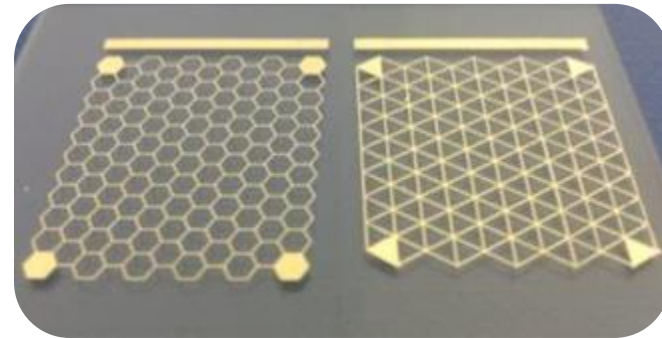
## Optimal transparent top contact

### Au layers



- ▶ Thermal evaporation
- ▶ **Layer thickness 1-15 nm**
- ▶ Sheet resistance 3,2-123,7  $\Omega/\square$
- ▶ Transparency 25-70 %

### Ag grids

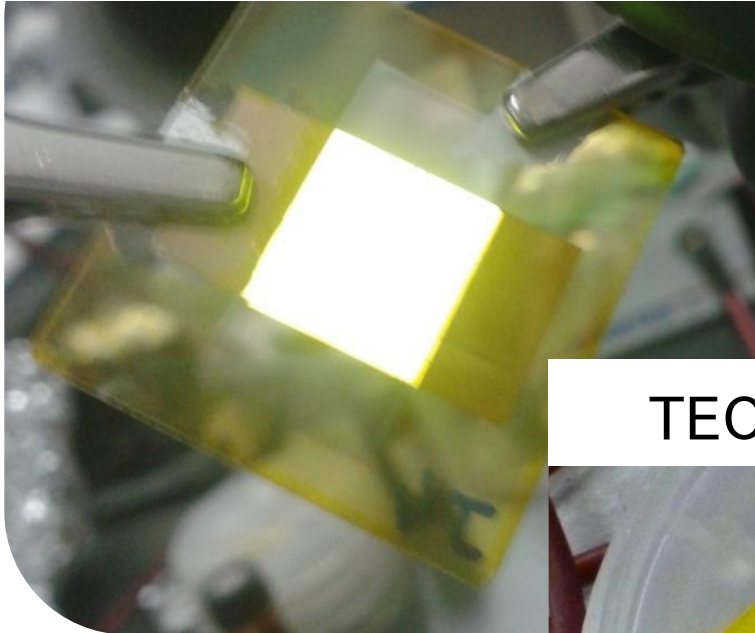


- ▶ **Ink jet printing**
- ▶ Layer thickness 150-250 nm
- ▶ **Sheet resistance 0,82-2,7  $\Omega/\square$**
- ▶ **Transparency 70-90 %**

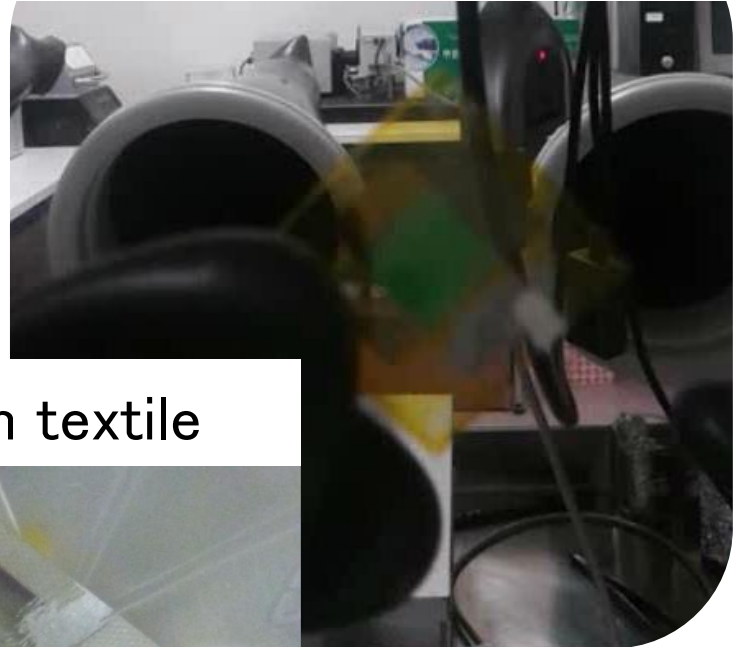


# OLED – Final demonstrator

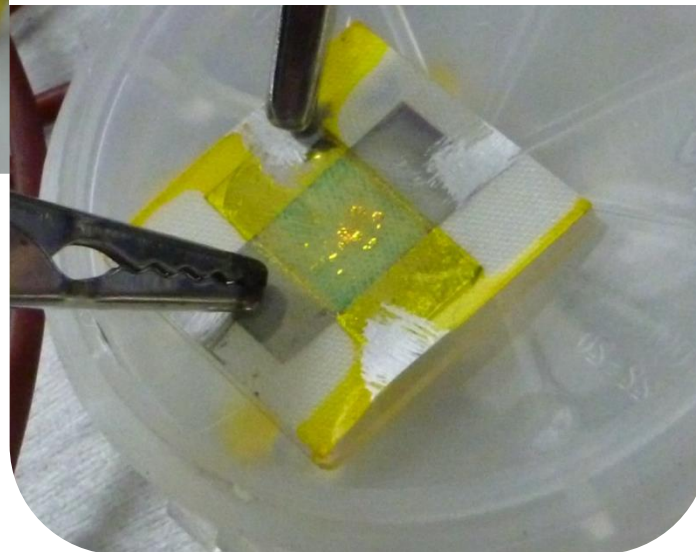
TEOLED on glass



TEOLED on PET



TEOLED on textile



# Conclusion and future work

## ACPEL devices

Screenprinting on textile =  
reproducible

Using conductive yarns and/or CNT  
coating = smart

Structured EL = maintaining the strong  
properties of textile as substrate

## OLEDs

Further development  
of flexible and  
encapsulated OLEDs  
on PET

Research best suitable  
covering and smoothing  
layer on textile

Development of flexible  
and encapsulated OLEDs  
on textile

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