



# PRINTING TECHNOLOGIES

2021, June 2<sup>nd</sup>

**Didier GALLAIRE**

**Defence & Security**  
Strategic  
Independence

**Nuclear Energy**  
Energy  
Independence

**Fundamental  
Research**  
Materials &  
Life Science

FROM RESEARCH TO INDUSTRY  
**cea tech**  
**Technological  
Research**  
Economic  
Competitiveness, Digital,  
Energy and Medical  
Transitions

## Key Figures 2019



**20180**  
Employees

**€ 5 Bn**  
Budget

**~7000**  
Active Patent  
Families

**5045**  
Publications in peer-  
reviewed journals



## Key Figures 2020

# 4 500

Employees

# 700M€

Annual Budget  
25% Subvention - 75% External Revenues

# > 600

Industrial Patntrns

## EVERY YEAR:



# 1 000

Multi-partner  
Research Projects



# 1 000

Industrial  
Projects



# > 600

Patent  
Submissions



# 25%

of French Bilateral  
Research

## list

cea tech

Smart Digital  
Systems

## leti

cea tech

Micro &  
Nanotechnologies

## liten

cea tech

New Energies  
& New Materials

## cea tech

Regions

Disseminating  
Technologies  
throughout the Regional

## OTHER CEA INSTITUTES



**9** RESEARCH CENTERS

**7** REGIONAL PLATFORMS



## RTO AND ACADEMIC COLLABORATIONS

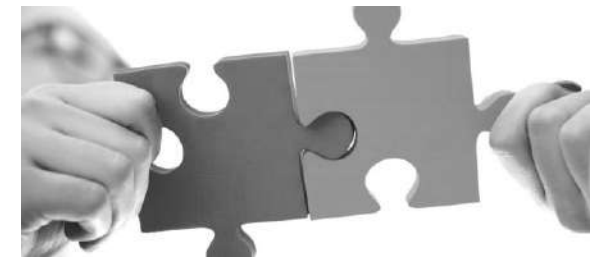


## FRENCH AND EUROPEAN ASSOCIATIONS AND INSTITUTIONS



**Multiplication of  
innovation capacities**

## MORE THAN 200 INDUSTRIAL PARTNERS





➤ Spread over our research campuses in Bourget-du-Lac and Grenoble



- SOLAR PHOTOVOLTAIC
- SMART GRID SYSTEMS
- BUILDING & ENERGY
- NETWORK AND THERMAL STORAGE

- BATTERIES
- H2 PRODUCTION & STORAGE
- FUEL CELLS
- ELECTRIC MOBILITY
- POUDR'INNOV 2.0
- BIO RESOURCES
- NANO SECURITY
- NANO-CHARACTERIZATION
- LARGE SURFACE PRINTING

Spread over our research campuses in Bourget-du-Lac and Grenoble



**13**  
PLATFORMS

- SOLAR PHOTOVOLTAIC
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## World Class Research Facilities for Flexible Electronics Towards Interactives objects and smart surfaces

**OBJECTIVE: Develop and industrialize processes using electronic inks, to functionalize large flexible surfaces (320 x 380 mm) with electronic functions.**

**ADVANCED PROCESSES:**  
**Printing techniques**  
**Vacuum deposition**  
**Back-end**



50 engineers and technicians



8M€ investment



**1000 m<sup>2</sup> clean rooms**, class 10 000 (ISO 7),  
 Standard sheet format G1 : **320mm x 380mm**



Up to ~80 patents +High level journals & conferences (ISSCC, IEDM,..)



Large partnership including start-ups, material and tool suppliers, RTO and End Users



State-of-the-art equipments

## Sheet-to-sheet pilot line

**Format:** 320 x 380 cm<sup>2</sup>

**Substrates:** plastic (PEN, PC, PI, TPU), paper, glass

**Inks:** conductive metal inks (Ag, C),  
conductive polymer inks (PEDOT...),  
dielectric formulations,  
organic semiconductor ink,  
EAP inks (PVDF-based)

## Vacuum deposition

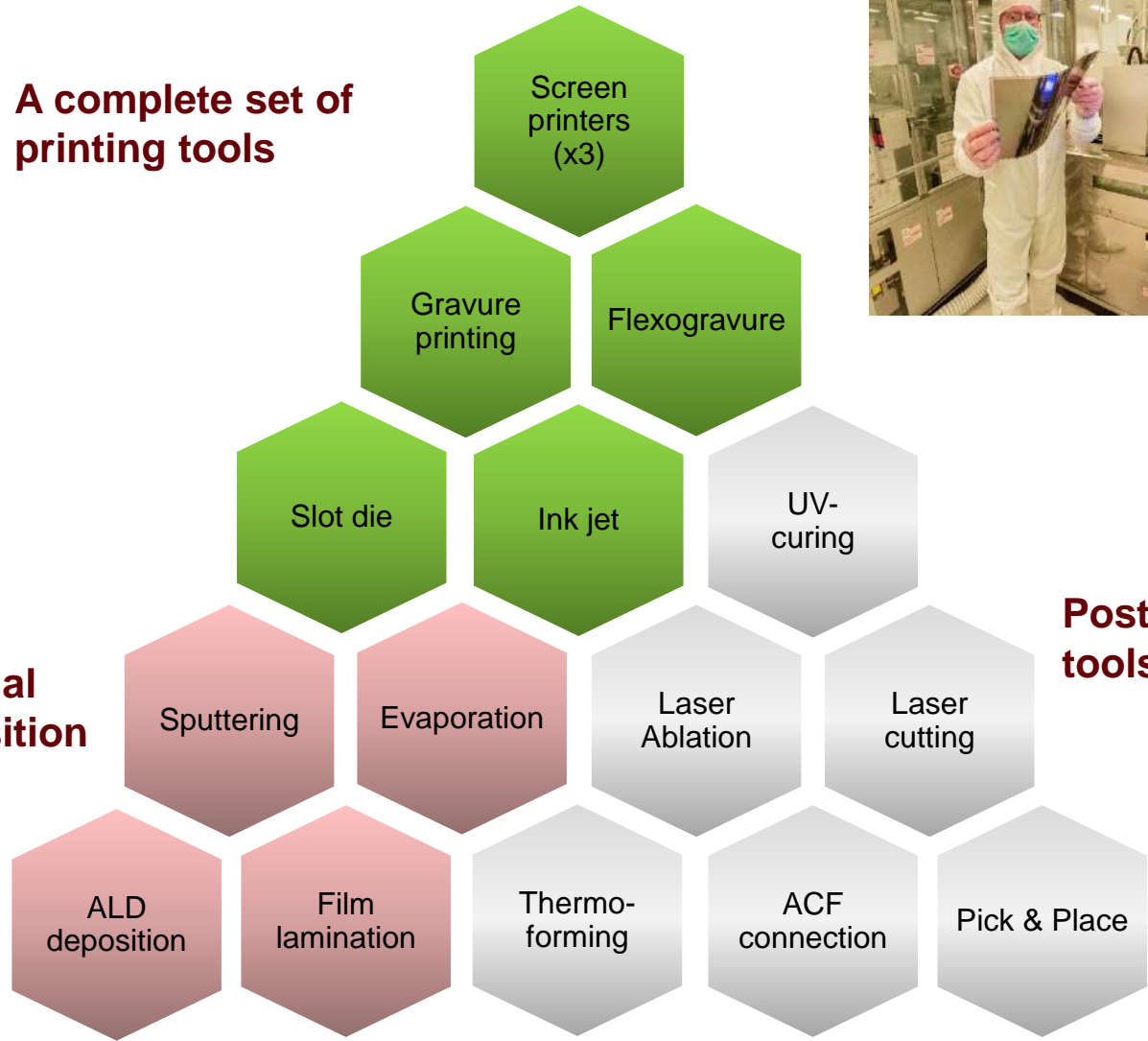
**Process:** CVD, PVD, ALD

**Materials:** Metal, Oxyde Organometallics precursors





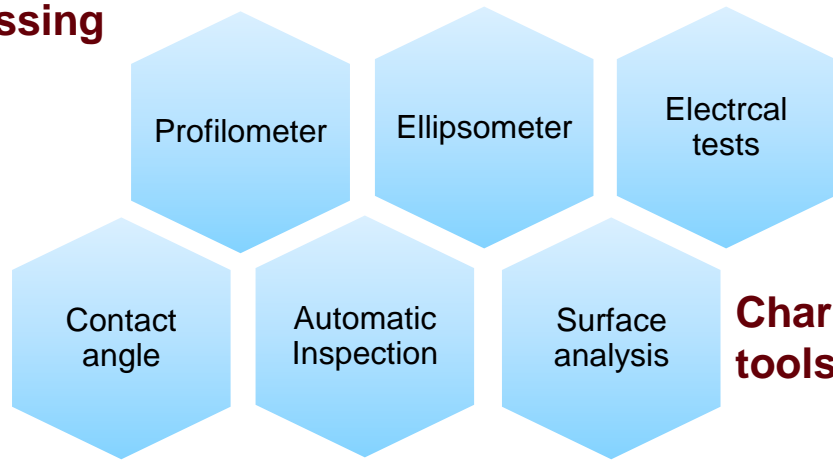
## A complete set of printing tools



Visit our virtual tour:  
<http://pictic.cea.atwl.fr>



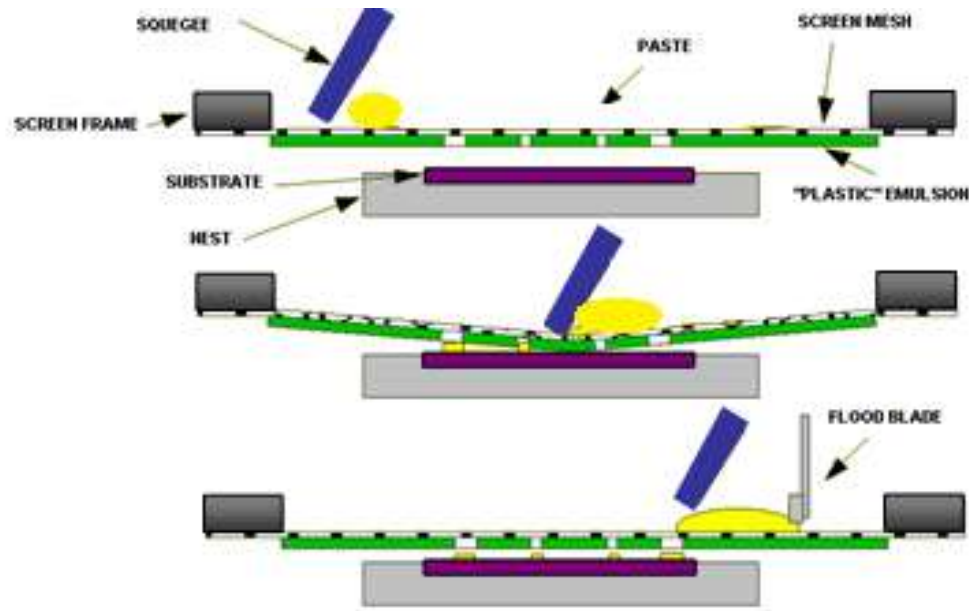
## Post-processing tools



## Characterization tools

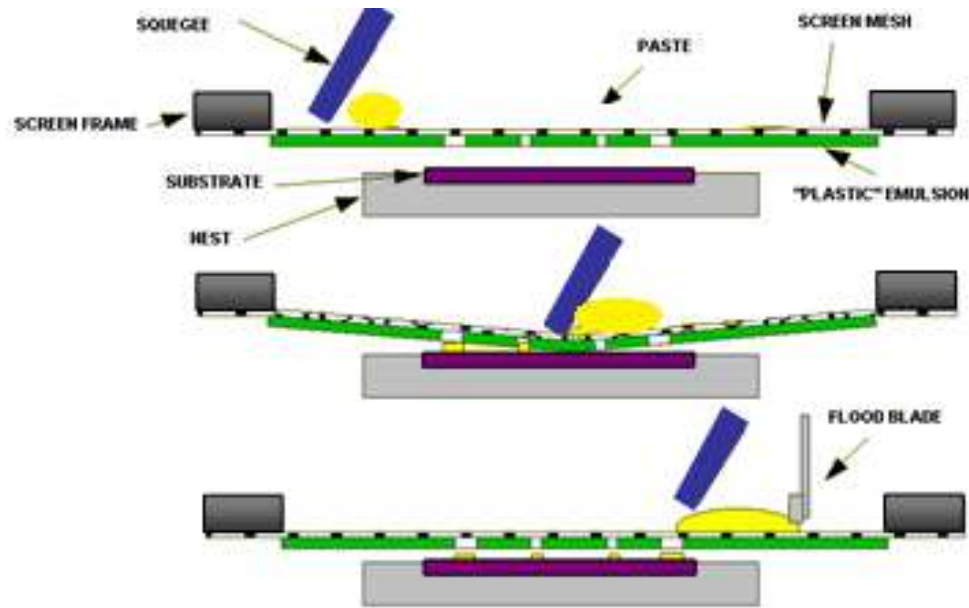
## Screen printing tool with loader and unloader conveyor (EKRA)

- Non-contact printing technique
- Sheet to sheet
- Free-standing / sheets on glass carrier
- Alignment : +/- 100  $\mu\text{m}$
- Material : OSC, Dielectrics, Conductive ink, resist deposition, chemical patterning...



## Automatic screen-printing line (NEWLONG)

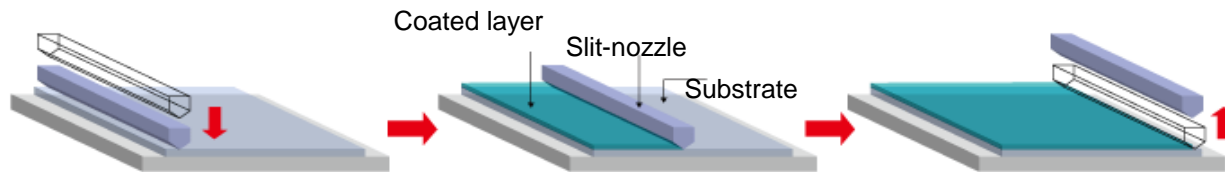
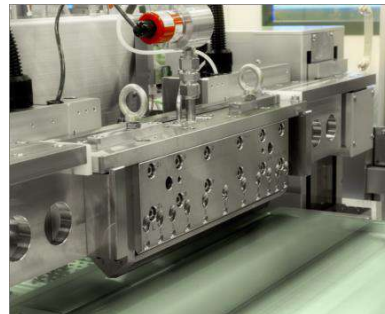
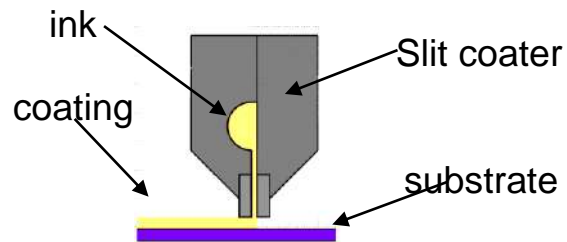
- Non-contact printing technique
- Cassette to cassette / Free standing
- Can be used in semi-automatic mode (manual loading)
- Max Throughput: 1 sheets / 45 s
- Infrared oven in-line
- Alignment : +/- 50  $\mu\text{m}$
- Material: PVDF, dielectrics, conductive ink, photoresist





## Slot-die (TAZMO)

- Non-contact printing technique
- Blanket coating for large area
- Layer thickness  $100 \text{ nm} < e < 2 \text{ mm}$
- Thickness uniformity = 7 % for 300 nm
- Material : OSC in organic or aqueous solvent, dielectric material, inks with nanoparticles
- Transfert robot, VCD (no heating), Hotplate (up to  $200^\circ\text{C}$ ), Cooling plate.



Head moving above substrate  
(from 50 to 300  $\mu\text{m}$ )

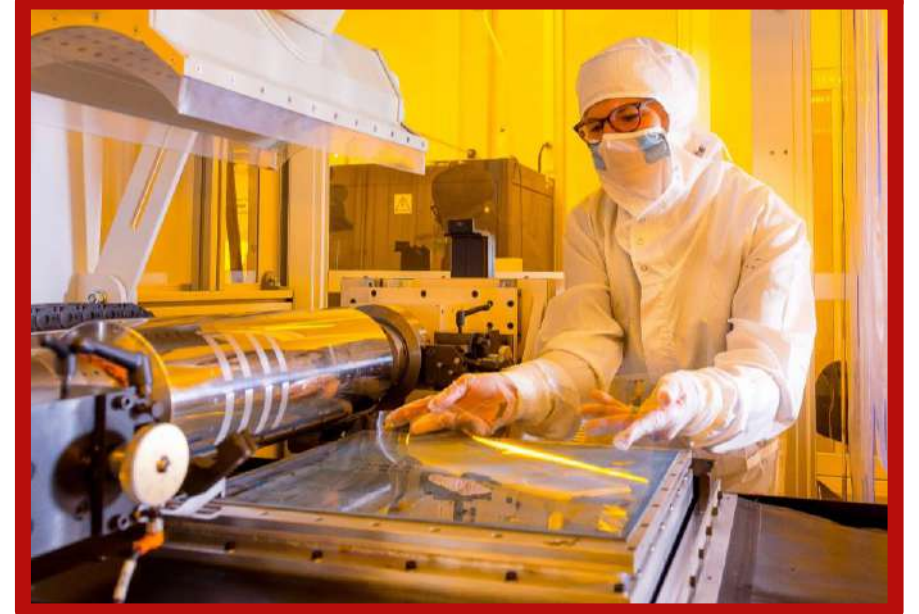
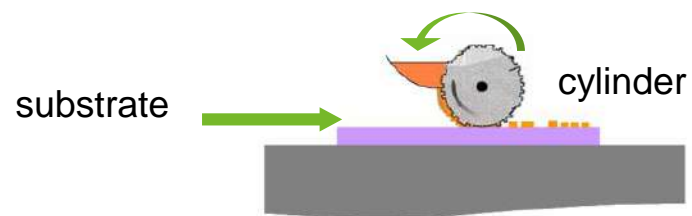
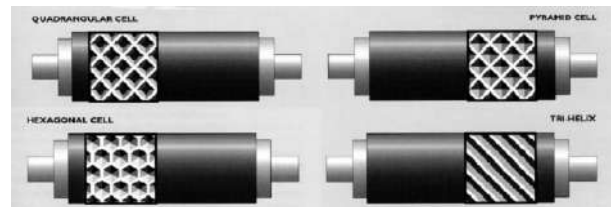
Coating

Head moving up



## Gravure Printing (OHIO)

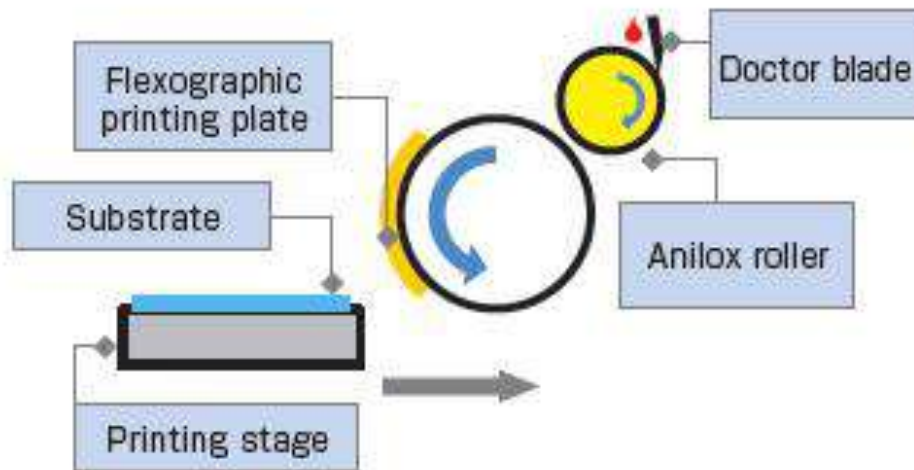
- Contact printing technique
- Engraved cylinders
- Layer thickness :  $40 \text{ nm} < e < 1 \mu\text{m}$
- Typically 10-500 cps
- Material : OSC, dielectrics, conductive ink





## Flexo printing (NAKAN)

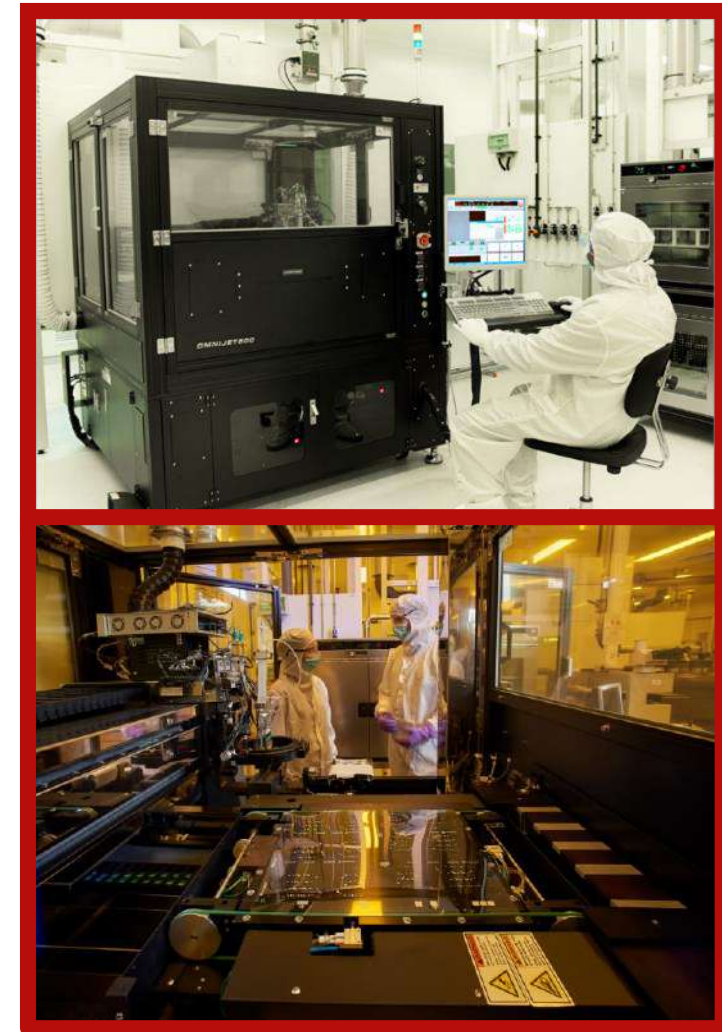
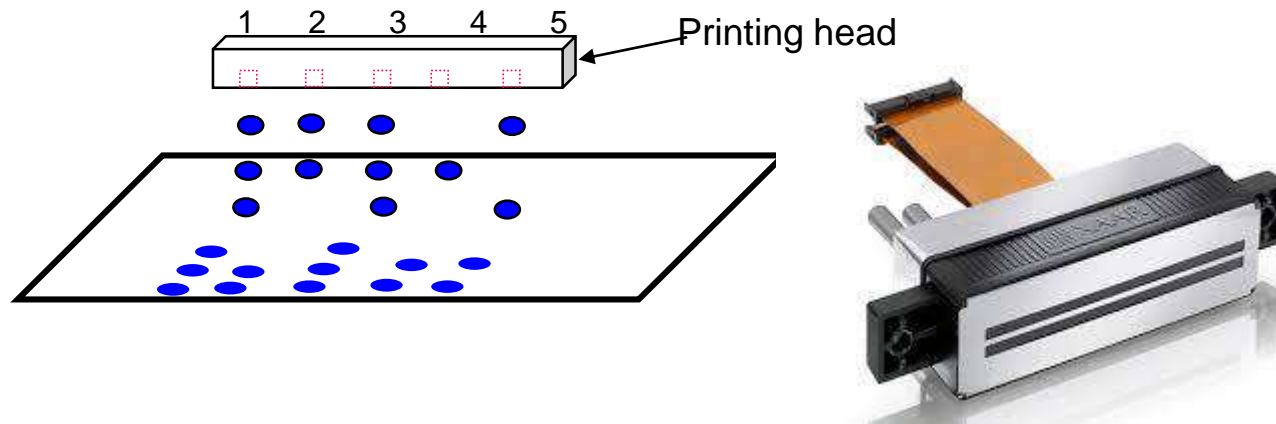
- Contact printing technique
- Flexo plates in polymer, non expensive, easy change
- Layer thickness :  $100 \text{ nm} < e < 2 \mu\text{m}$
- Typically 50-500 cps
- Material : OSC, dielectrics, conductive ink





## Ink Jet printing (OMNIJET)

- Non-contact printing technique
- Drop On Demand – 16/128/256 nozzles
- Layer thickness  $\sim 10 \text{ nm} < e < 1 \text{ }\mu\text{m}$
- Material: low viscosity fluids 5-20 cP with or without nanoparticles

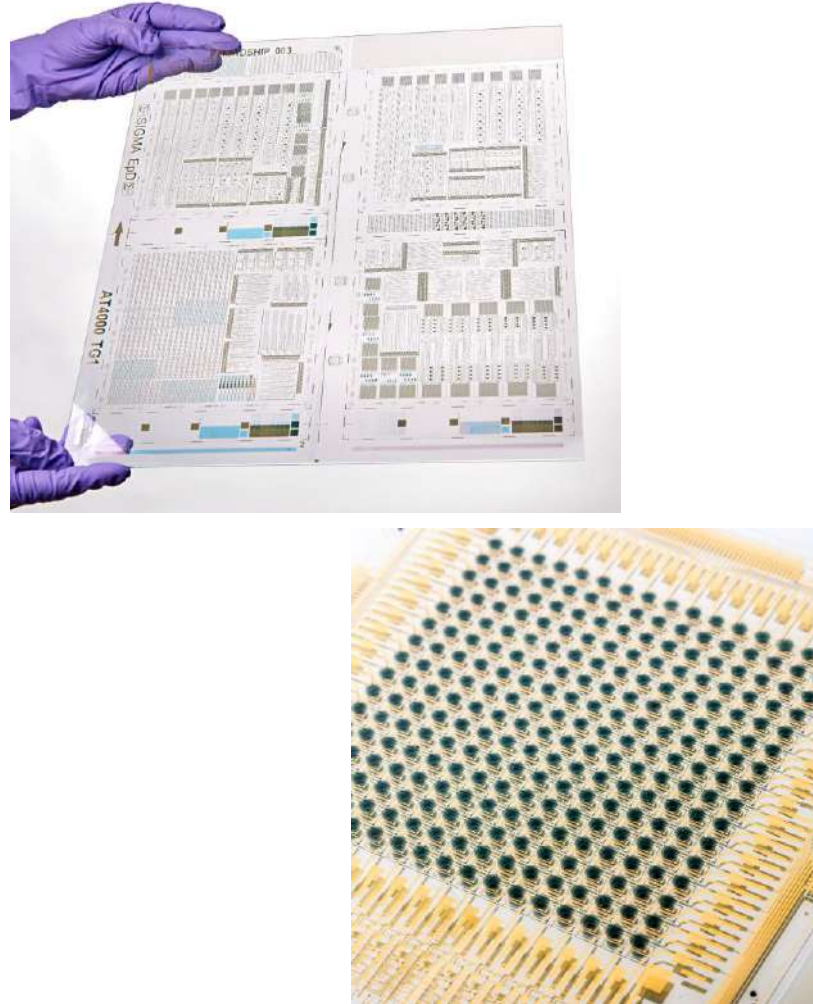


Printing techniques	Ink viscosity (cP)	Thickness	Feature size	Comments
<b>Screen-printing</b>	50-50 000	0,05 $\mu$ m – 100 $\mu$ m	~100 $\mu$ m	Robust, simple, thick layer, large feature size, high ink viscosity
<b>Slot-Die</b>	1-100	0.1 $\mu$ m – 200 $\mu$ m	-	Fast printing, High homogeneity, blanket coating
<b>Gravure</b>	~400	<0,05 $\mu$ m – 1 $\mu$ m	~50 $\mu$ m	Fast printing, direct contact of the anilox
<b>Flexography</b>	50-500	0,1 $\mu$ m - 2 $\mu$ m	~100 $\mu$ m	High throughput, low viscosity ink
<b>Inkjet</b>	5 - 20	0,01 $\mu$ m – 1 $\mu$ m	20 – 50 $\mu$ m	Non contact, small ink quantities, digital printing, low viscosity, slow speed, high resolution

### Screen-printing



### Gravure printing



### Slot-die coating





## Surface energy (contact angle)



## Thickness measurement (ellipsometer, profilometer)



## Surface analysis (WYKO interferometer)



## Electrical tests on devices



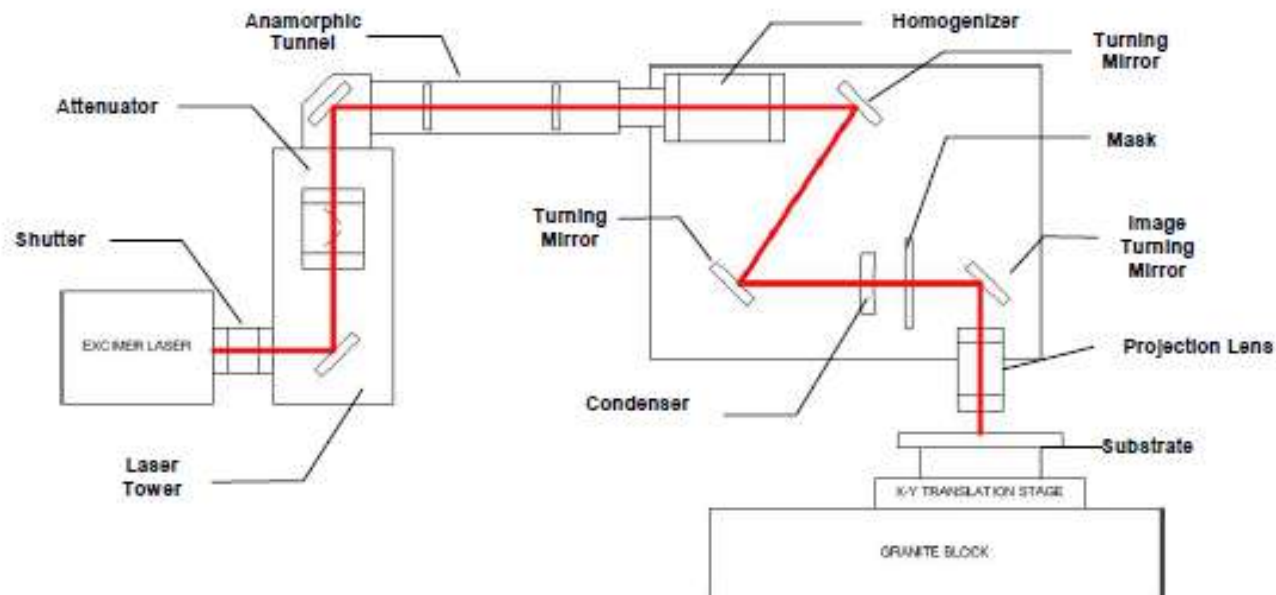
## Sputtering:

- TCO: ITO, ZnO
- Metal: Au, Ti, Cr, Mo, Al, Cu, Ni
- Thickness: 10nm to 1 $\mu$ m
- RF, DC



## Mask projection excimer laser ablation:

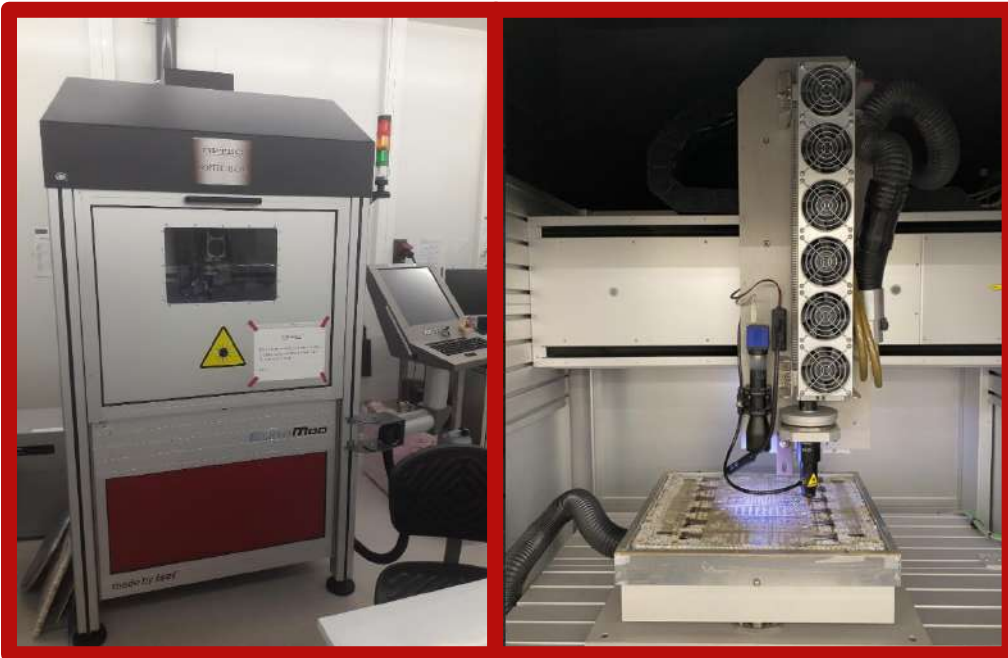
- Pattern resolution: down to  $5\mu\text{m}$  (upon material)
- Alignment:  $\pm 5\mu\text{m}$
- Ablated Material: Metal, TCO, polymer ...





## Laser cutting

- CO<sub>2</sub>
- P = 45W @ 10,4μm
- Speed: 1 to 100 mm/min
- Optical alignment by camera : +/- 50μm
- Materials: plastics (PET, PI, PEN, PC...) up to 3mm thick



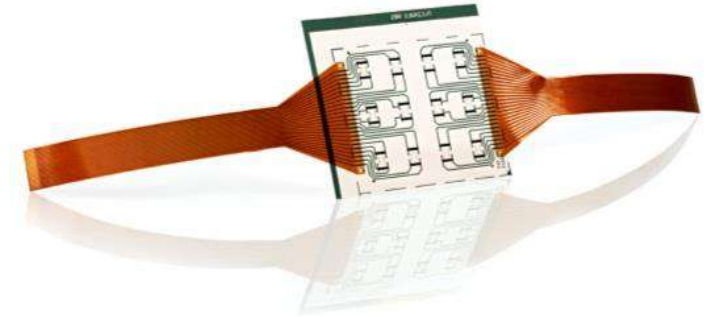
## S2S film lamination

- Alignment: +/- 100 μm



## ACF bonding

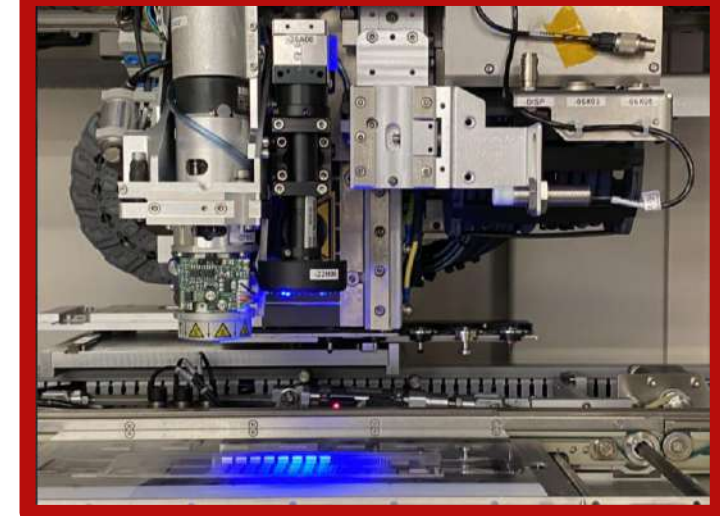
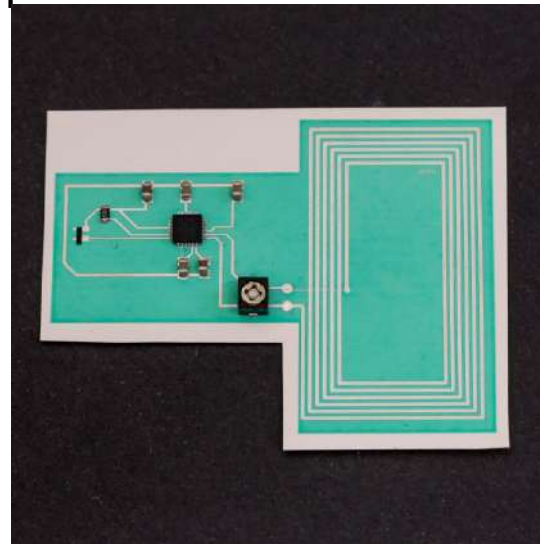
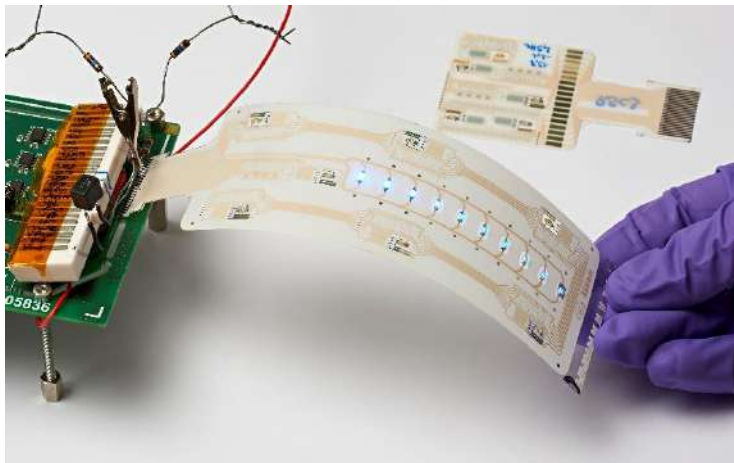
- Pulse heat thermomode : 50mm x2,5mm
- Manual alignment down to an interconnection pitch of 100 $\mu$ m
- Flex on plastic / glass / PCB / silicon





## Pick & Place

- Highest accuracy: +/- 10 $\mu$ m
- Die size: 0,17mm – 50mm
- Die thickness: 0,02mm – 7mm
- Bond force: up to 7,5kg
- Bonding heat: up to 350°C
- Work area 320mm x 380mm
- Integrated pressure / time dispensing system
- Capabilities: die from wafer, waffle pack of feeder





## Thermoforming

- High pressure thermoforming (up to 120 bars) for high geometrical accuracy
- Localized radiative heating with temperature control on foil by IR camera
- High production throughput (~ 20s per sheet)
- Materials: thermosetting polymers from 125 $\mu$ m to 1mm thickness



*Transparent capacitive sensor*



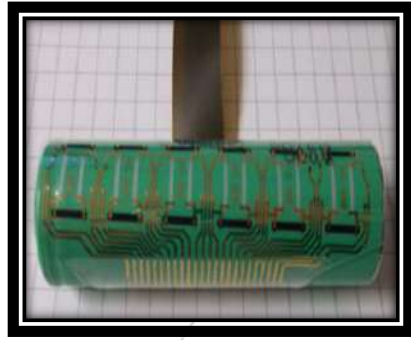
*Antenna*



**Consumer electronics  
(Piezoelectric components  
for haptic and loudspeakers)**



**Resistive sensors  
(Temperature, Strain)**



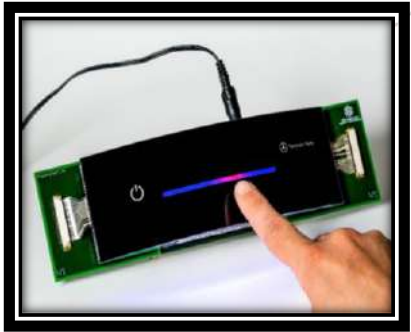
**Automotive**



**Large area sensing**



**Human machine  
interface**

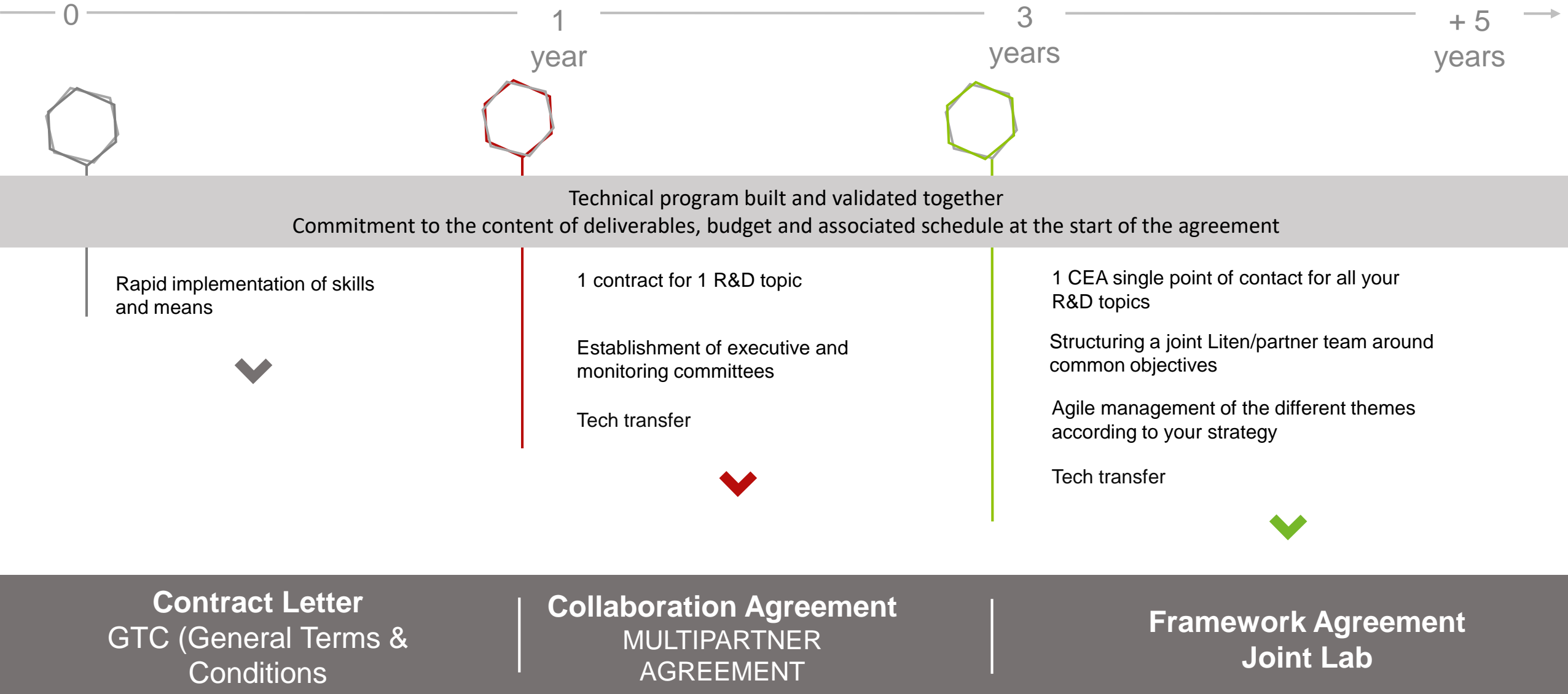


**Stretchable**



**Health monitoring**









Thank you very much for your attention!



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