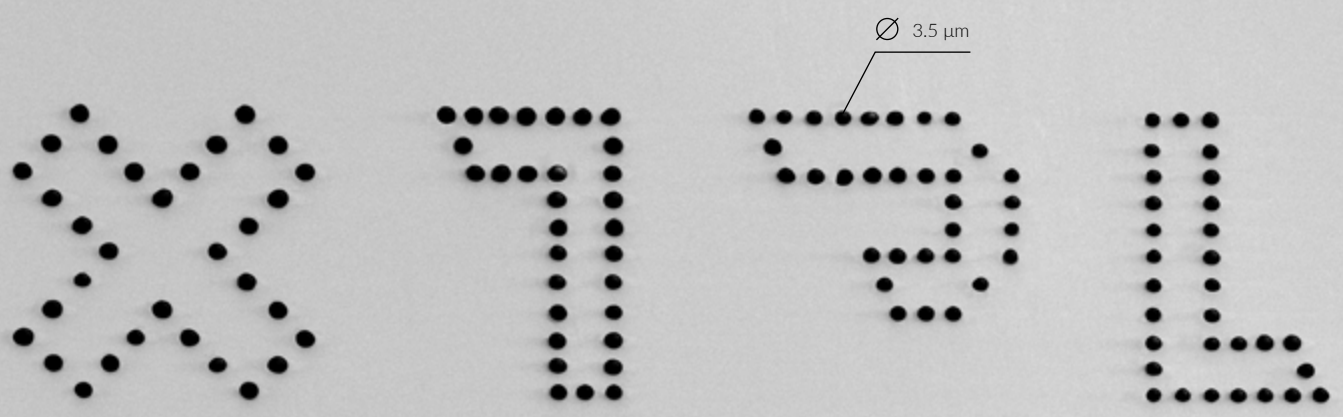


# XTEL

shaping global nanofuture



20 µm

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## ADDITIVE MANUFACTURING FOR FLAT PANEL DISPLAYS

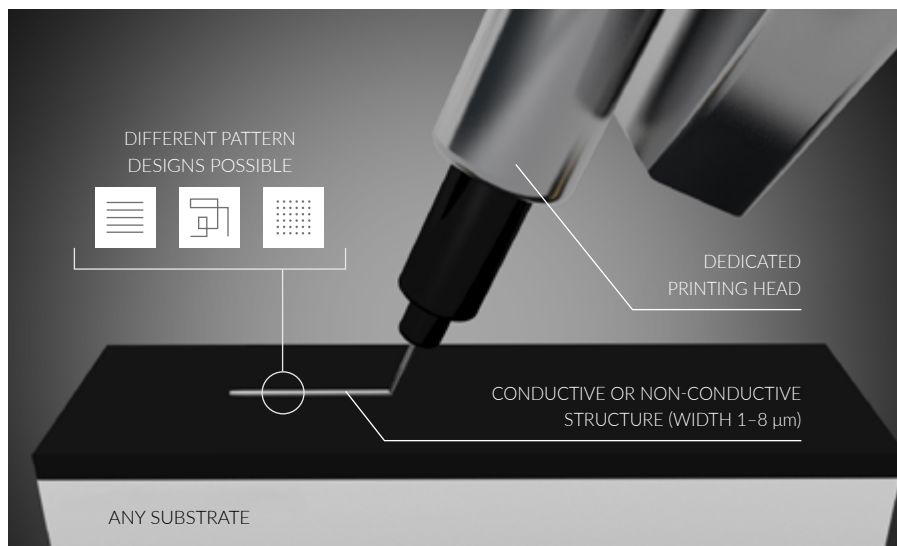
TECHNOLOGY PROVIDER FOR ULTRA-PRECISE PRINTING

Feature size reduction solutions (1-8 µm)



## TECHNOLOGY

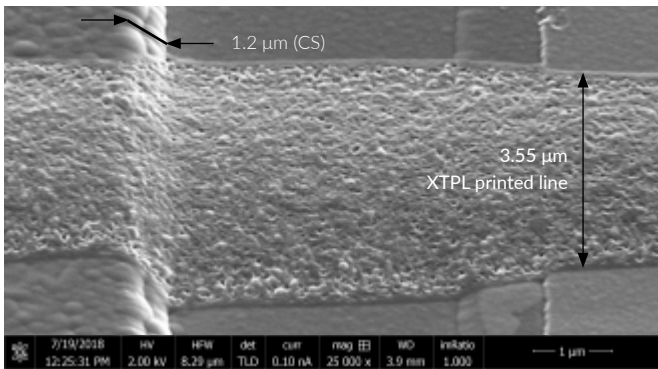
Innovations in additive manufacturing developed by XTPL enable ultra-precise printing of nanomaterials. Our technology derives from solving interdisciplinary challenges spanning the fields of solid state physics, inorganic chemistry, nanotechnology, machine learning, mechanics and control electronics. Unique XTPL printing system allows for precise deposition of an in-house formulated nanoinks on a variety of substrates. Shape, length and spatial density of the micron-scale features obtained using our method are all customizable and can be adapted to a number of industrial and research applications. This unprecedented precision and versatility positions XTPL as a global player in the growing field of nanoprinting.



## ULTRA-PRECISE DEPOSITION (UPD)

XTPL printing head equipped with a special nozzle deposits nanoink on the substrate using unique ultra-precise deposition (UPD) technology. Our breakthrough additive method provides a variety of possible patterns: straight lines, as well as trails and microdots. The width of printed structures reaches values as low as 1  $\mu\text{m}$  (micrometer).

## PRINTING METHOD CHARACTERISTICS



XTPL method is capable of printing on most substrates used in the FPD industry: conductive and nonconductive, flexible, flat and 2.5D, e.g. glass, silicon wafers, kapton, PEN, PC, PDMS, PET. There is no electric field required for printing, which fully eliminates the risk of damage to the substrate and other electrically active components.



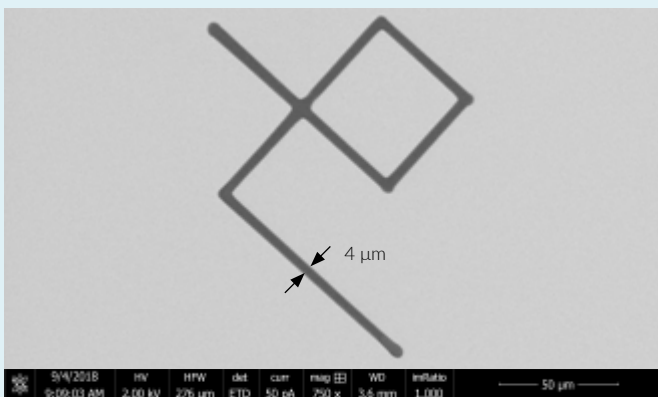
Our unique printing method is compatible with a large variety of materials e.g. conductive inks, nanoparticle based suspensions, semiconductor based suspensions, insulating inks, resists, solvent based inks and biological materials. In order to achieve outstanding results XTPL creates its own conductive nanoink formulas based mostly on metallic nanoparticles (Ag, Au and Cu) and semiconductors ( $\text{TiO}_2$ ).

## XTPL VALUE PROPOSITION FOR FLAT PANEL DISPLAYS (FPD)

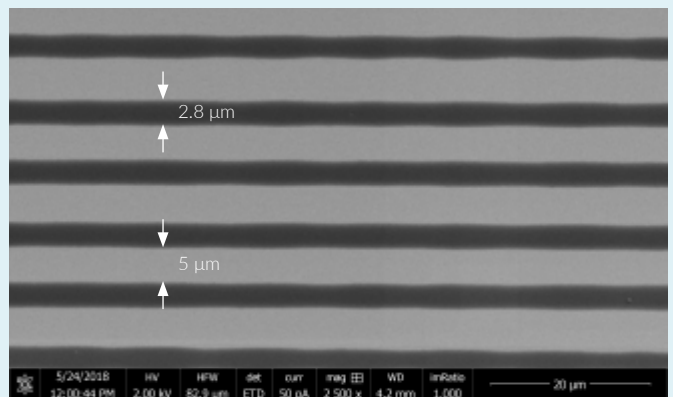
Modern additive printing has proven to be indispensable for rapid prototyping and it is now making a strong impact on the manufacturing as well. XTPL provides disruptive technology for adding conductive & nonconductive structures on the individual micron scale (1-8 μm) with unparalleled precision. Our innovative additive process allows for ultimate simplicity & versatility - it requires no electric field, which fully eliminates the risk of damage to the substrate and other electrically active components. XTPL solution responds to the market need of progressing miniaturization and at the same time provides a cost-effective & scalable method.

## FEATURE SIZE REDUCTION

The feature size of printed structures is one of the key parameters of XTPL additive technology. The trend towards miniaturization of components is prevalent in FPD sector. It means that the emission efficiency must be increased along with the decreasing thickness of the display. The XTPL solution enables micron scale structures, which enables higher pixel density of the finished products. In particular the resolution, brightness and lifetime parameters of the final display are improved.



Trail printed with 4 μm line width

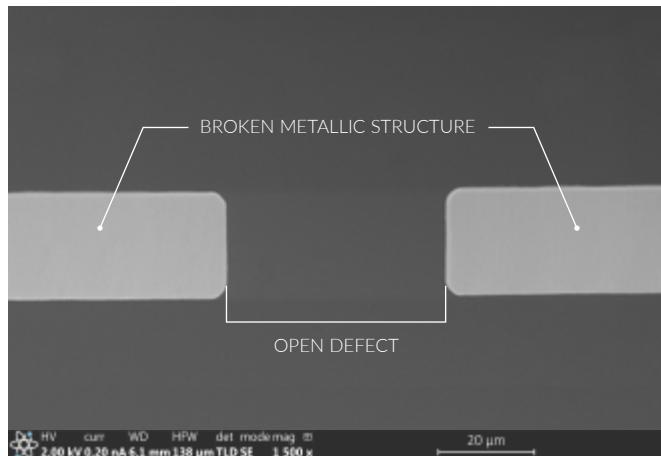


Parallel lines printed with approx. 3 μm width and 5 μm distance between the lines

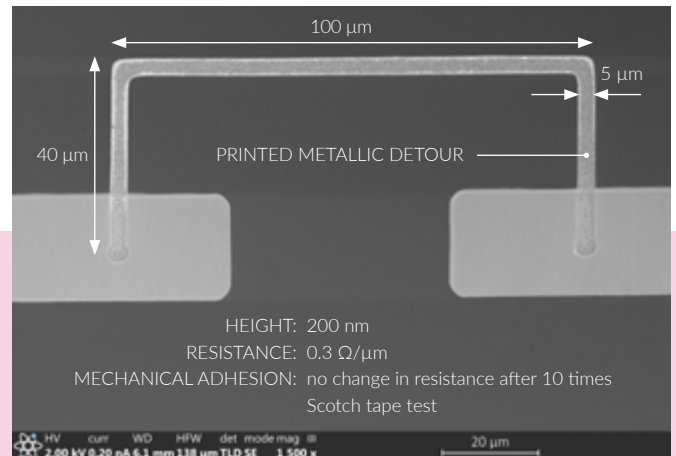
# INDUSTRIAL YIELD IMPROVEMENT

One of the challenges faced by the modern FPD manufacturing lies in the fact that fine conductive structures on the individual micron scale are prone to damage. This is a major factor contributing to the decrease of the production yield. XTPL has developed an advanced additive method for open defect repair (ODR) that responds to manufacturers requirements.

### BEFORE XTPL REPAIR

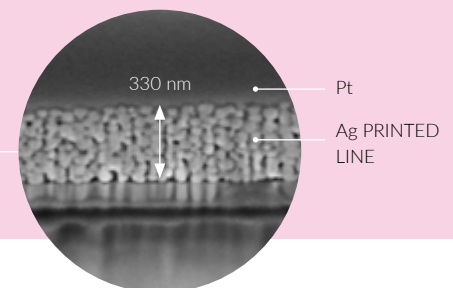
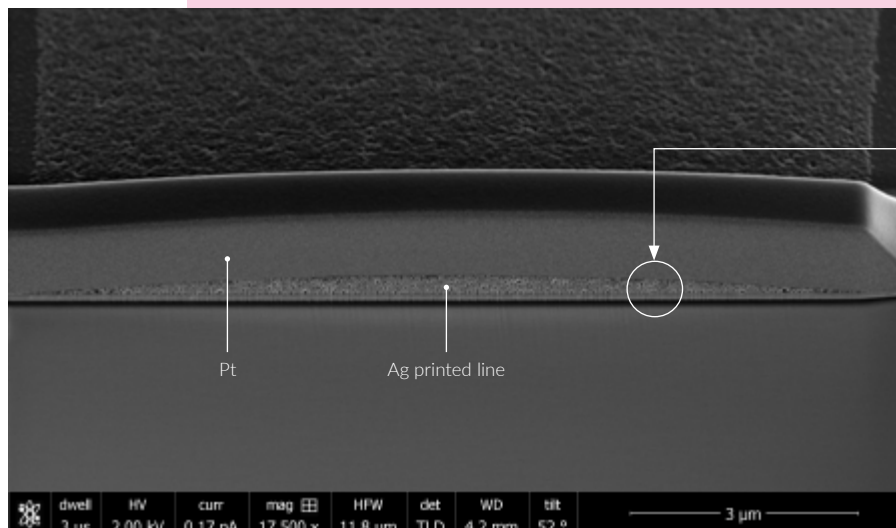


### AFTER XTPL REPAIR



## ADVANTAGES

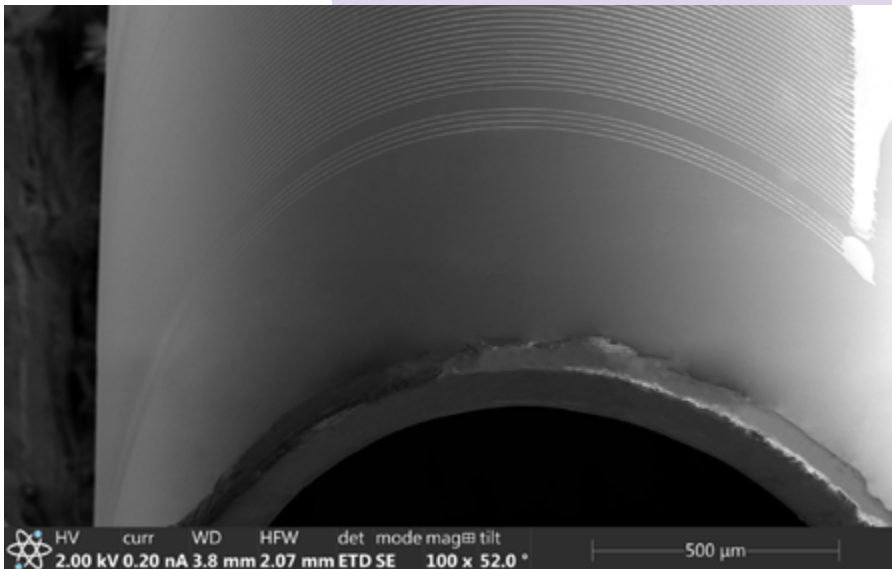
- **no electric field required for printing - no risk of damage to the substrate and other electrically active components**
- non-electrostatic alternative to the EHD technology
- repairing broken conductive lines at the production stage
- reduced takt time (TT)
- high spatial density of the printed features
- high adhesion to the substrate
- no toxic substances
- lower production cost for the manufacturers
- works on various substrates



Cross section (FIB) of a printed conductive line. Features printed using the XTPL technology have smooth edges which allows for deposition of continuous structures on top of them.

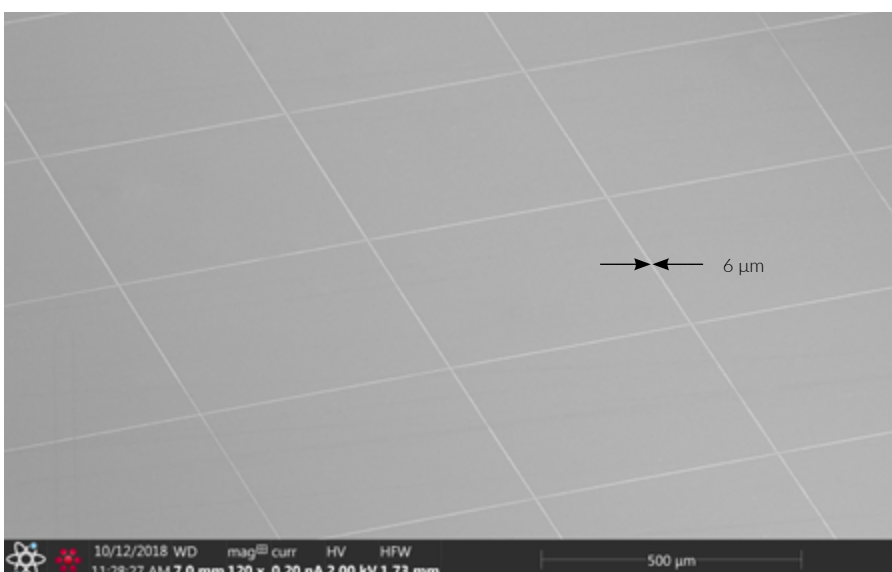
## MECHANICAL FLEXIBILITY

The introduction of flexible displays is currently a strong trend for producers who aim to meet the customers' expectations and offer the new generation devices. Due to the high production costs and low yield of flexible electronics, its introduction on a mass scale proves to be a challenge. XTPL offers solution in the form of ultra-precise, scalable and cost-effective printing technology that enables mechanical flexibility of new generation displays.



Electrically conductive silver lines printed on a flexible foil using the XTPL technology. Structures obtained using our method retain their properties throughout the deformation of the substrate, including excellent electrical conductivity parameters.

Due to the highest transparency of structures obtained with XTPL additive method, their excellent electrical conductivity parameters and mechanical flexibility our solution can potentially be applied as an alternative in transparent metal mesh manufacturing.



Segment of transparent metal mesh directly printed on the glass using silver based nanoink formulated in-house by XTPL. The width of the lines is 6 μm and interline distance is 500 μm.

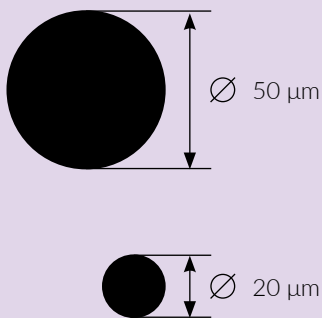


## ORGANIC MATERIAL DEPOSITION

XTPL technology can be potentially used in the future in OLED manufacturing to precisely deposit organic materials. Unlike the currently used fine metal mask (FMM) approach, structures obtained with our printing method do not exhibit shadowing effect with the increase of display size. This advance allows for reduced feature size irrespective of the scaling. Since our solution is purely additive, no organic material is wasted and there is no need for masks that have to be replaced between the deposition cycles. Currently used state-of-the-art ink-jet printers for the OLED industry deposit structures with a minimal diameter of 20  $\mu\text{m}$ , while XTPL technology provides microdots as small as 1  $\mu\text{m}$  in diameter. Additionally, the implemented XTPL ultra-precise deposition (UPD) allows for obtaining arbitrary shapes on any kind of substrate currently used in OLEDs.

### CURRENT INK-JET STANDARD

Minimal structure size 20  $\mu\text{m}$

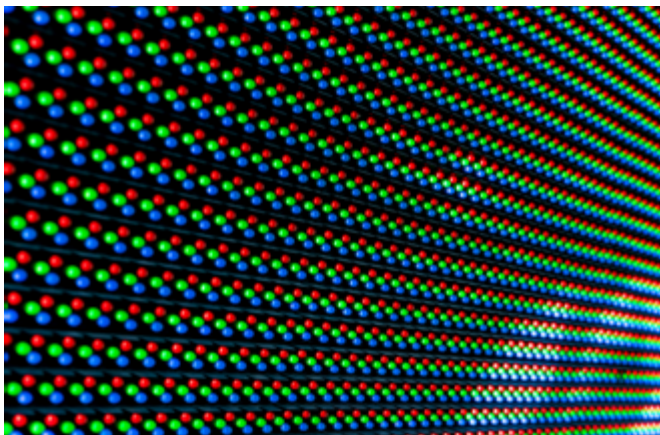


### XTPL METHOD

Minimal current structure size 1  $\mu\text{m}$

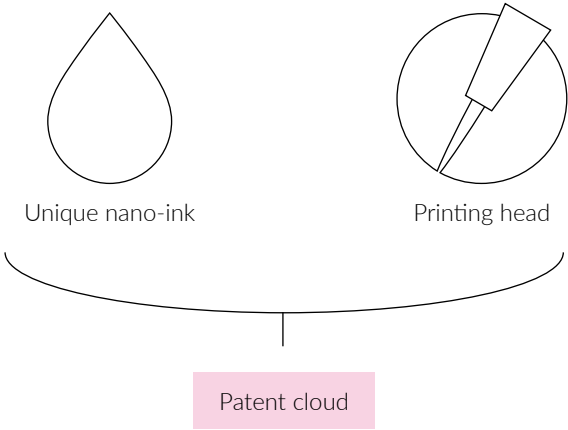


XTPL logo pattern composed of organic dye microdots with a diameter approx. 3.5  $\mu\text{m}$  deposited on the glass



## COLOUR FILTER (C/F) DEPOSITION

XTPL additive technology is well suited for C/F deposition during the manufacturing or repair stages of the OLED and LCD panel production process. Universality of our method allows for the deposition of a wide range of possible C/F materials as well as sizes and does not require any masking.



## INTELLECTUAL PROPERTY

XTPL offers a complete solution for printing electrically conductive & nonconductive structures on the individual micron scale. This includes proprietary technology, innovative printing heads and dedicated nanoinks. Patent protection is executed by the British law firm, Gill Jennings & Every LLP as well as American company K&L Gates.

## COMPANY

XTPL is a company empowering global manufacturers of new generation electronics by providing ultra-precise printing technology to be implemented on their production lines. Our team consists currently of over 40 people in Poland and USA: scientists and technologists with interdisciplinary expertise in: chemistry, physics, electronics, mechanics and numerical simulations (including 10 PhDs), as well as specialists in strategic management and commercialization, product development, implementing innovation, communication and capital market. XTPL is a publicly traded company, listed on the main market of the Warsaw Stock Exchange.

## CONTACT US, WE ARE OPEN FOR COOPERATION

XTPL constantly optimizes its innovative technology and adapts the process to various implementation requirements. XTPL aims to build partnerships and strategic alliances with well-established partners within the FPD sector and to cooperate in the form of joint development or technology transfer.





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