# 3D Printing of materials of relevance for the microelectronic industry

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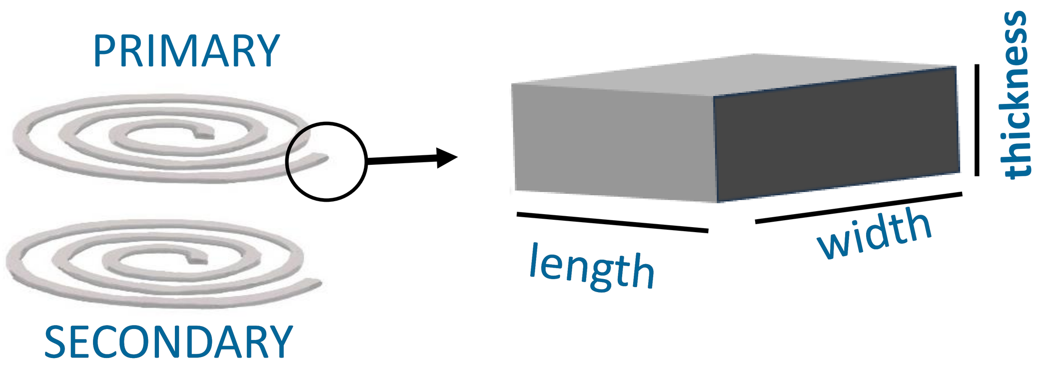
## Abstract

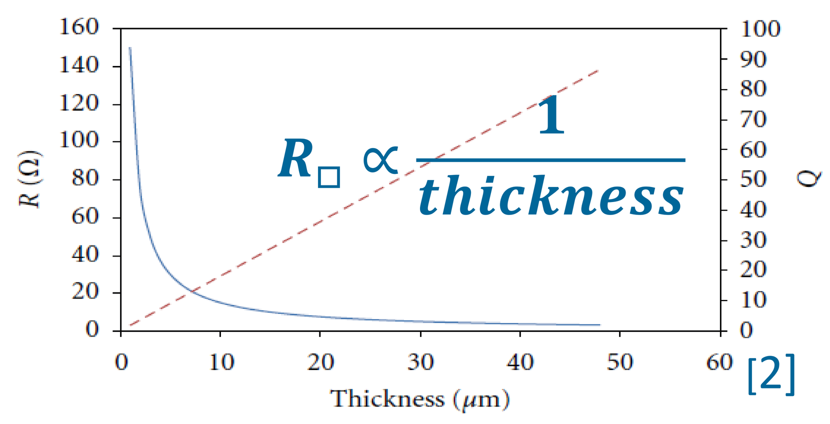
The electrical performance of additive manufactured devices (know also as 3D printed device) are increasing, whereas they are characterized by other types of interesting performances [1]. Inkjet printing manufacturing of electronic components with micrometric sizes with innovative tools is investigated.

## Project aims




### > PRINTED INDUCTORS REQUIREMENTS

- $w_{Track}$ = 80 µm
- $d_{Between\ tracks}$ = 15 µm
- $R_{\square}$ = 5 mΩ/□
- L = 40 nH
- Q = 10

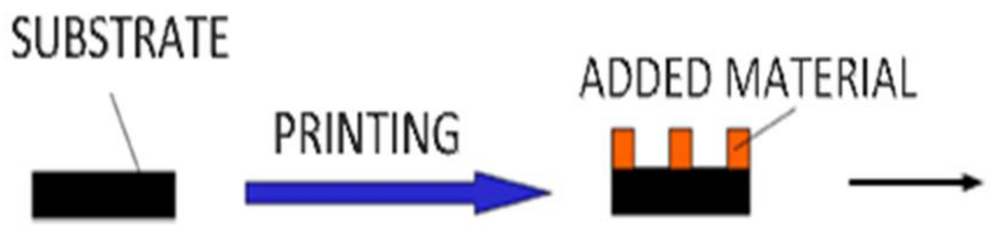


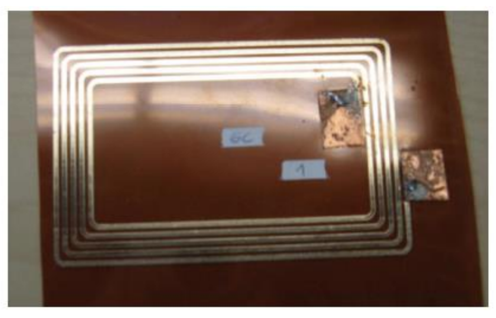

[2]

### > THICKNESS INCREASE

Lower $R_{\square}$ by increasing thickness with simple more layers deposition

### INNOVATIVE PRINTED INDUCTOR



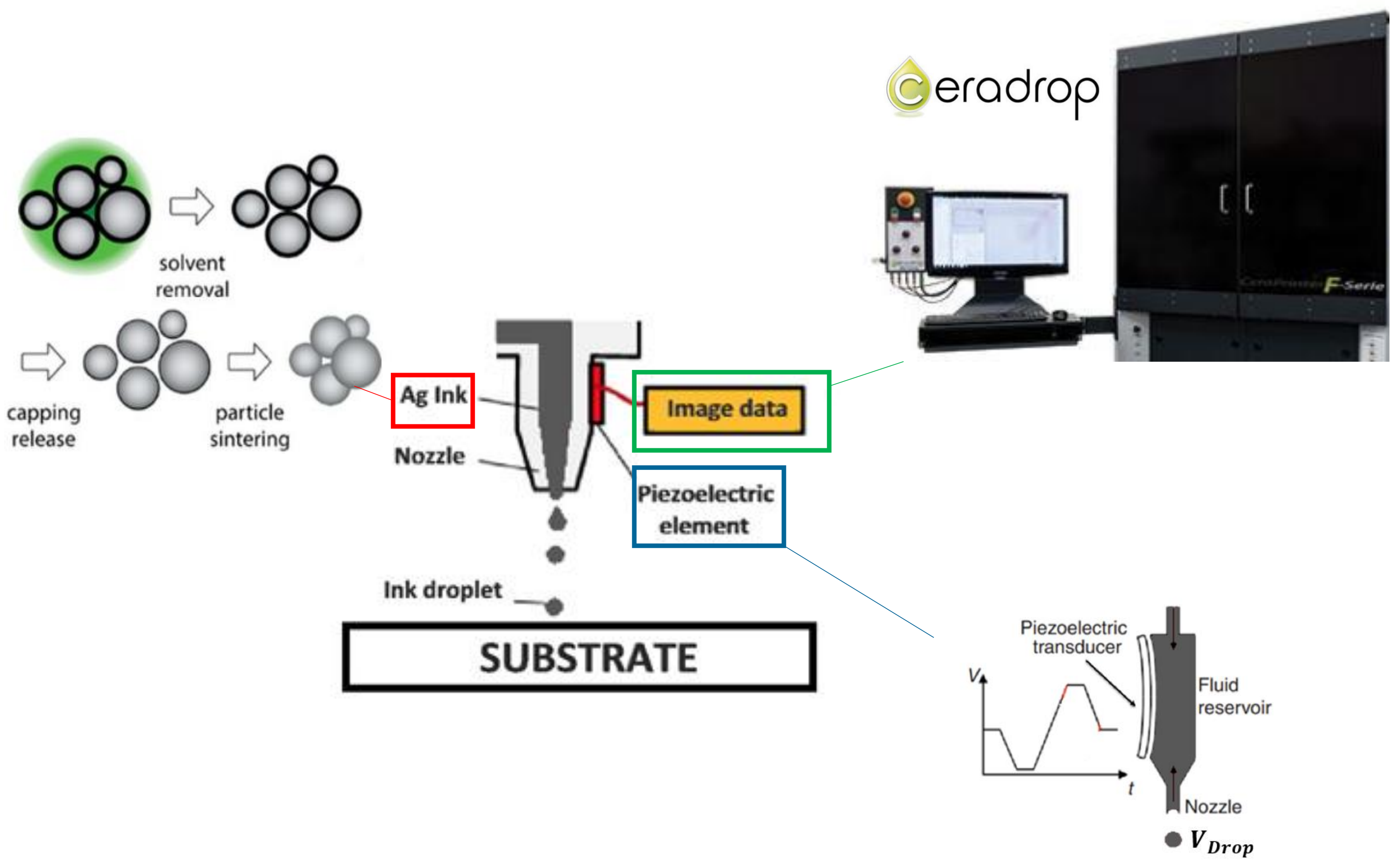



[2]

## D.O.D. methodology

### > IMPLEMENTED INKJET PRINTING

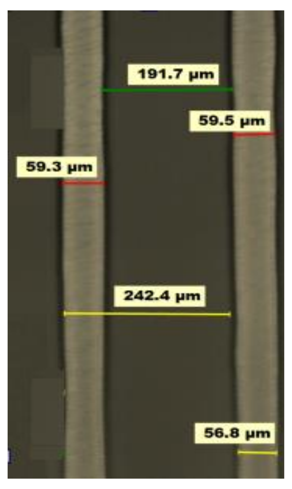
Piezoelectric Drop on Demand printing with cartridges filled with silver nanoparticles ink and controlled by Ceraprinter F-series




### > MATERIALS FEATURES

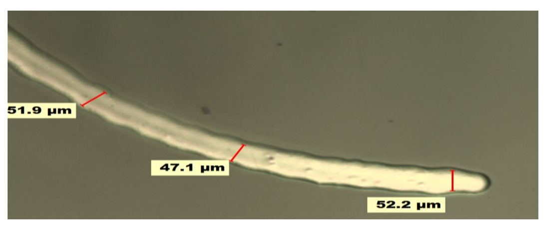
- $\sigma_{Ag\ Inks} \cong 0.4 \times \sigma_{Bulk\ silver}$
- $D_{Ejected\ drop} \cong$ 22 µm

## First outcomes




✓w < $w_{target}$

✓Low width variability ($\sigma_w \cong$ 16 µm )



✓Success independently from track orientation

$R_{sheet\_min}$: 0.36 Ω/□*

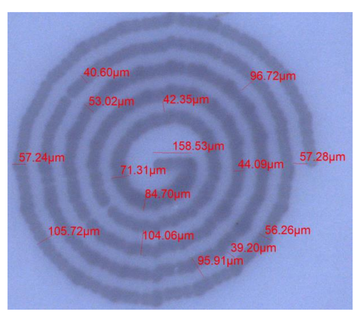
$w_{min}$: 43 µm

$A_{max}$: 111 µm²

$t_{max}$: 1.07 µm

PIGMENT ON HP PAPER

PRINTER PERFORMANCES RELIABLE EVEN FOR CURVE PATH AND MORE LAYERS



$d_{BetweenTurns}$ = 0.065 mm
6 LAYERS

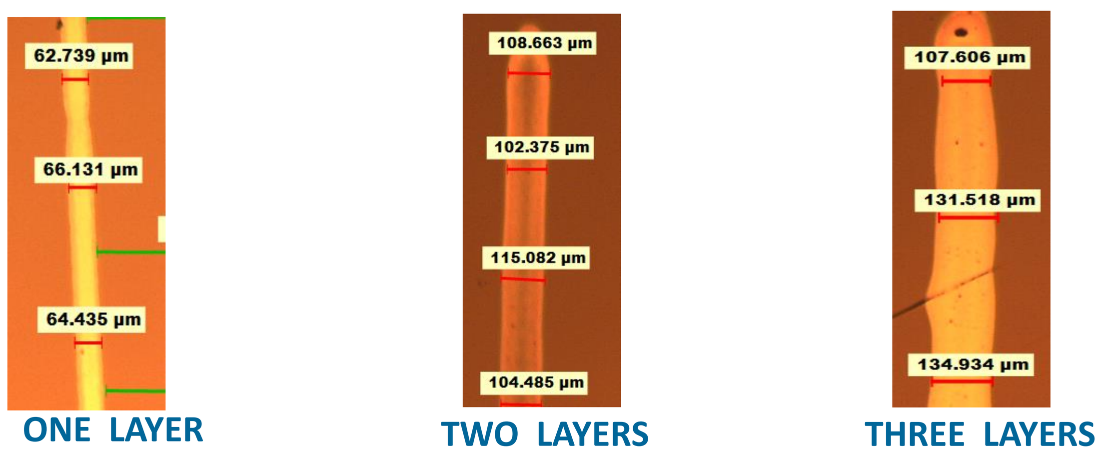
*: Maximum thickness for tracks suitable for resistive measurements up to 0.25 µm

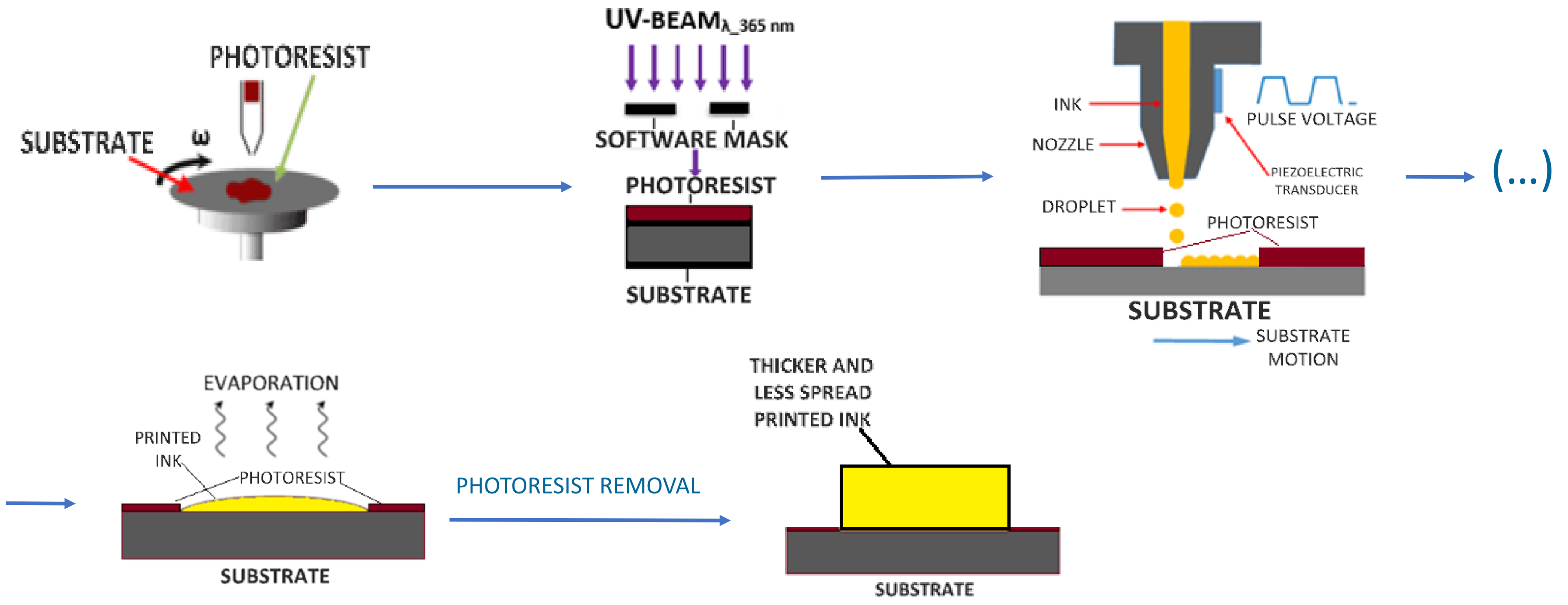
## Future developments

New inks and cartridge to be tried, printing paradigm to be enhanced

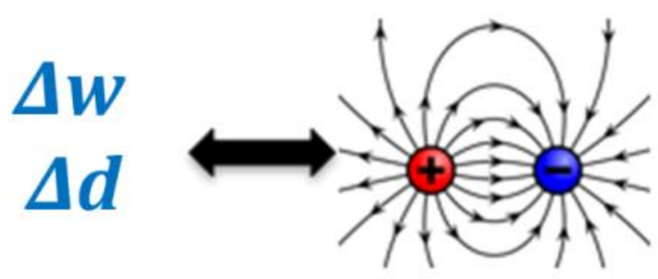
- $\sigma_{New\ Ag\ Inks} \cong 0.43 \times \sigma_{Bulk\ silver}$
- $D_{Ejected\ drop\ \_New\ cartridge} \cong$ 8.78 µm

To print inside grooved masks to decrease spreading upon consecutive depositions and to increase thickness.




Electromagnetic simulations to relate dimensional variations to electromagnetic frequency behavior

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## References

[1] Alejandro H.Espera Jt. et al., 3D-printing and advanced manufacturing for electronics, Progress in Additive Manufacturing 4, 245-267, (2019)

[2] L. Ortego et al., Inkjet-printed planar coil antenna anlysis for NFC Technology applications, International Journal of Antennas and Propagation, Arictle ID 486565, (2012)

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