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Laser-induced Selective Metal Plating on PP and PC/ABS Polymers Surface

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**3-D MID congress
2016**

September 28-29, 2016

- **Motivation:** Molded interconnect devices
- **Laser direct structuring (LDS)**
 - Experimental setup
 - Sheet resistance measurements for plating quality investigations
 - Activation threshold
 - Spatial plating selectivity
 - Summary
- **Selective Surface Activation Induced by Laser (SSAIL)**
 - Method
 - Spatial plating selectivity
 - Summary

Experimental setup

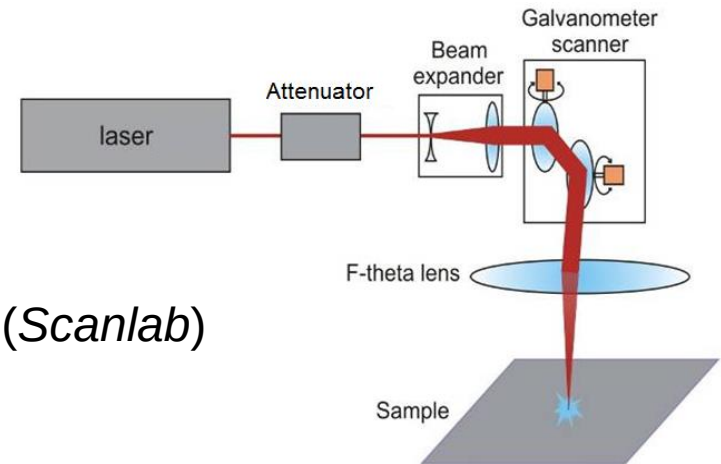
Materials:

- PP Hostacom CR 1171 G1 + multi-walled Carbon Nano Tubes [CNT]
- PC/ABS Bayblend T65 XF + multi-walled Carbon Nano Tubes [CNT]

Concentration of additives: 2%; 2,5%; 5%; 7,5% by mass.

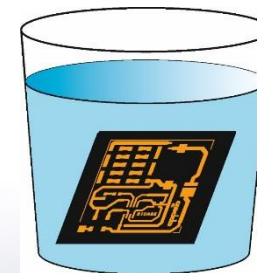
Laser processing:

- Nanosecond laser: Baltic HP (*Ekspla*), pulse duration 10 ns
- Picosecond laser: PL10100 (*Ekspla*), pulse duration 10 ps
- Wavelength: 1064 nm; 532 nm.
- Pulse rep. rate: 10-100 kHz
- Beam control: Galvo-scanner hurry scan II 14 (*Scanlab*)
- Scanning speed up to 3 m/s.
- Gaussian beam spot radius: 25-50 μm ($1/e^2$)



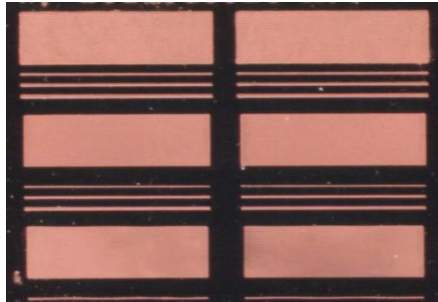
Electroless plating:

- Copper sulfate.
- Ligand: 1) potassium sodium tartrate; 2) **ligand X**
- Buffer: sodium hydroxide, sodium carbonate
- Reducer: formaldehyde



Results

Nanosecond pulses



~~Picosecond pulses~~

NO ACTIVATION !

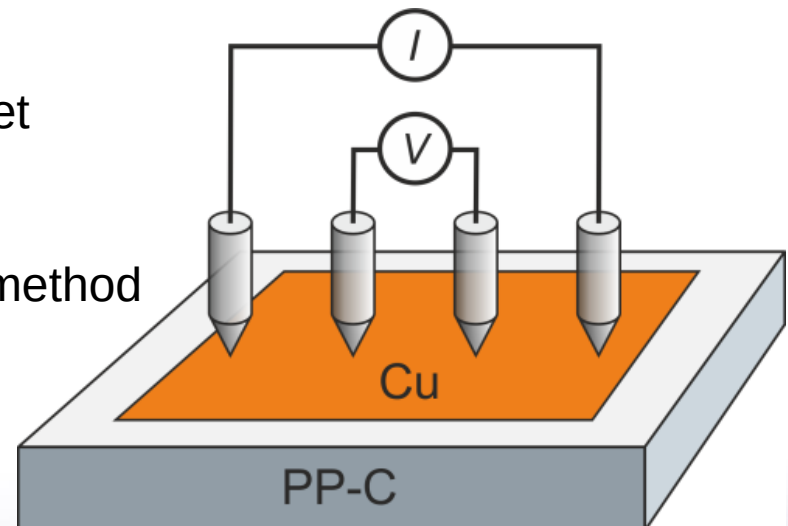


Measuring sheet resistance



Equipment: Keithley 2200

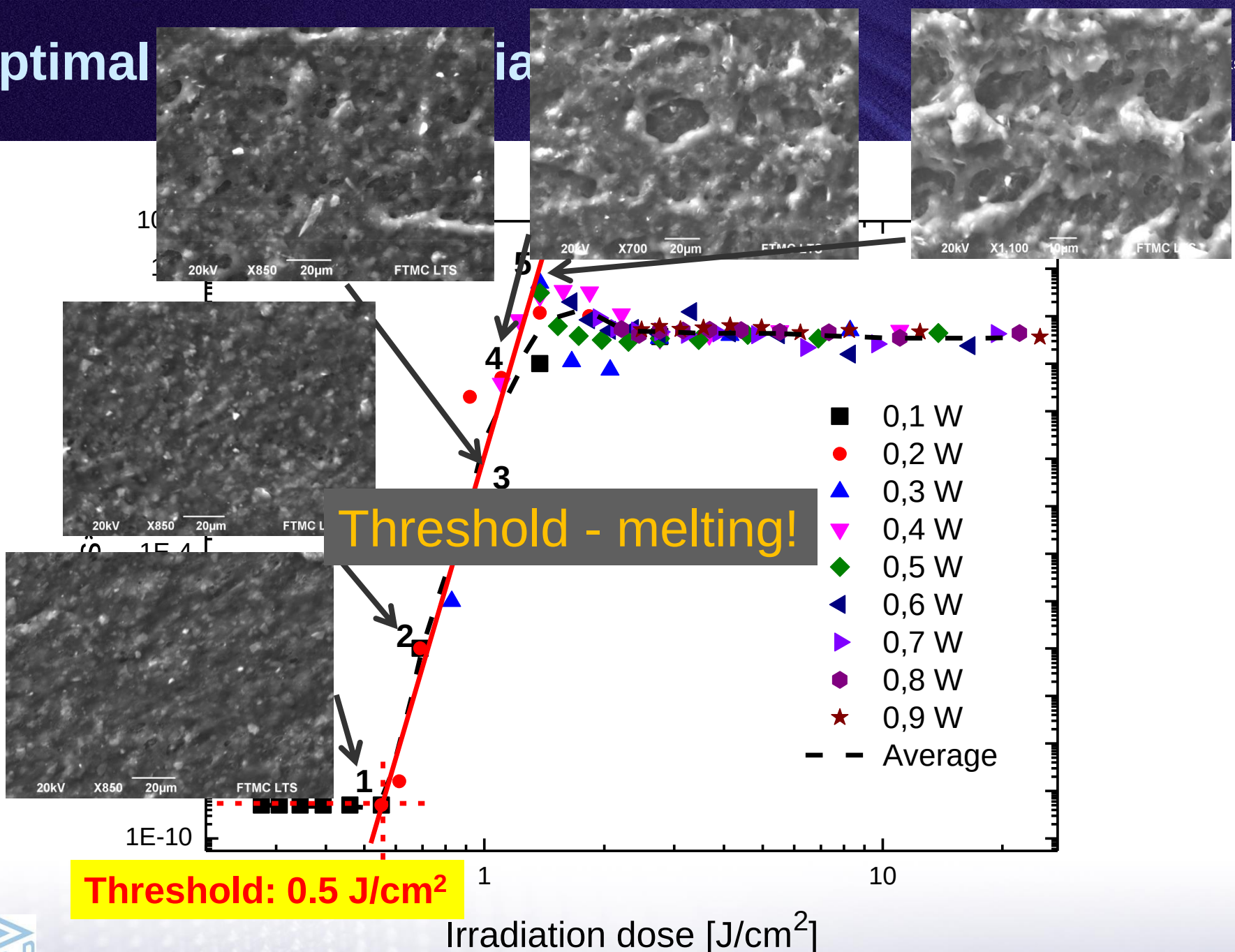
Scheme of sheet
resistance
measurements
Using 4 probe method



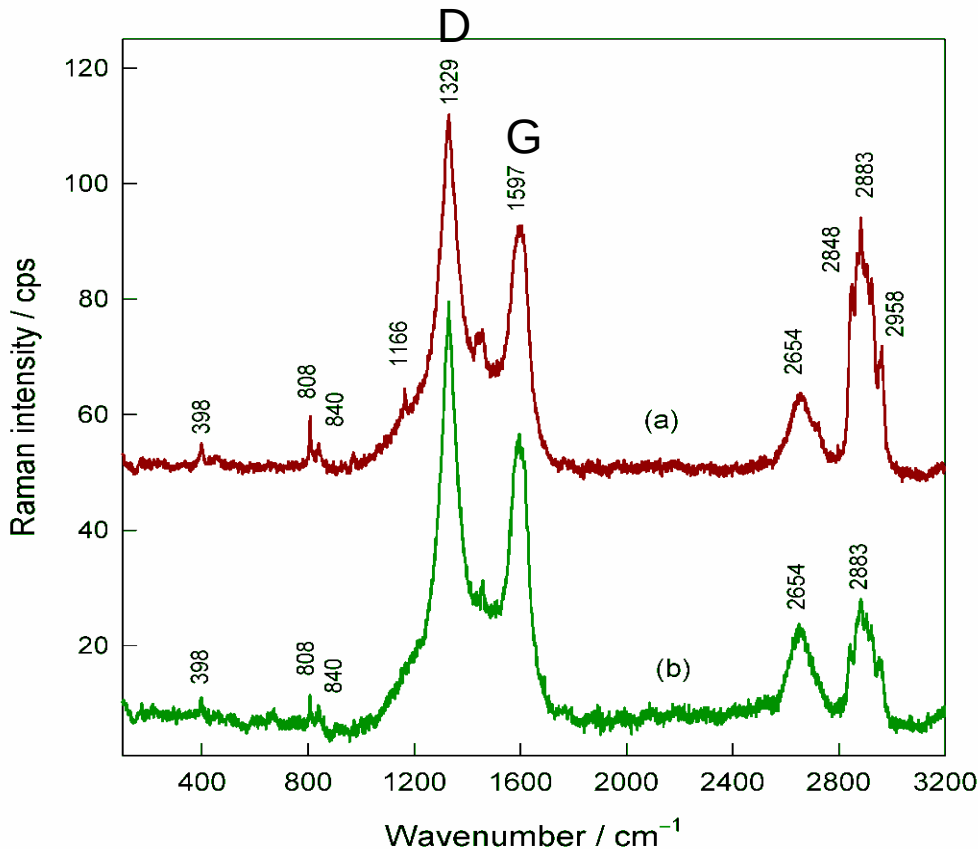
Optimal

ia

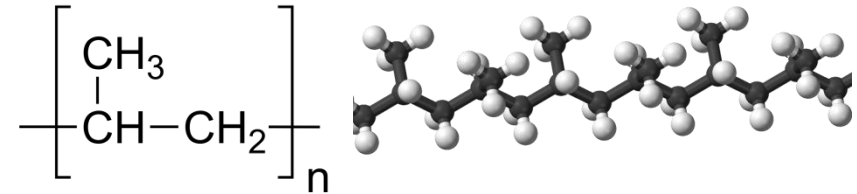
SLV



Raman analysis of PP



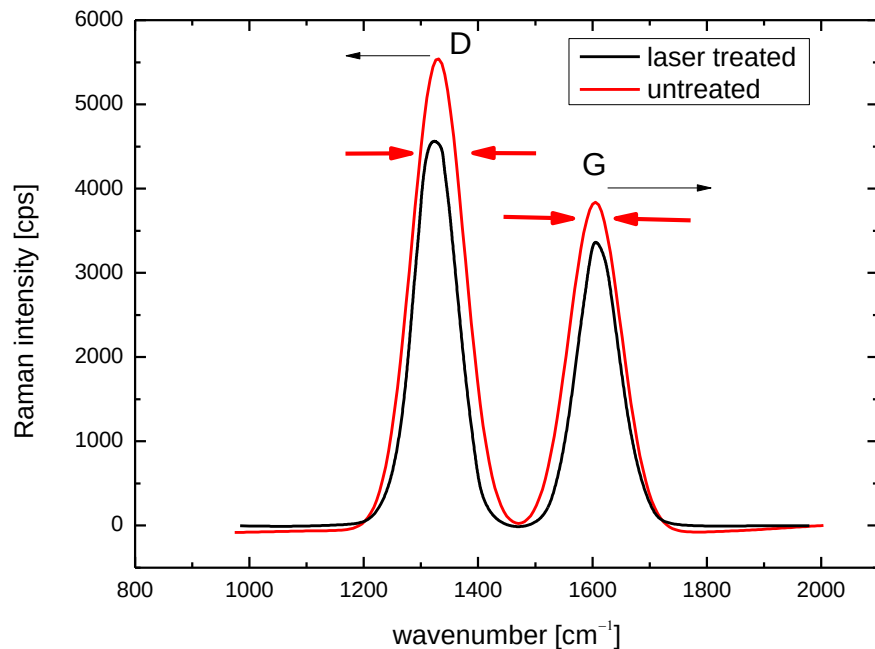
Raman spectra of PP/carbon additives (a) **before**, and (b) **after laser treatment**.



- 808; 840 cm⁻¹ PP crystalline phase
- 1166 cm⁻¹ Stretching vibration of C–C bond
- 1329 cm⁻¹ D band, aromatic ring breathing mode
- 1597 cm⁻¹ G in-plane stretching vibration of aromatic ring
- 2654 cm⁻¹ 2D band
- 2848 cm⁻¹ CH₂ symmetric
- 2883 cm⁻¹ CH₃ symmetric
- 2958 cm⁻¹ CH₃ asymmetric

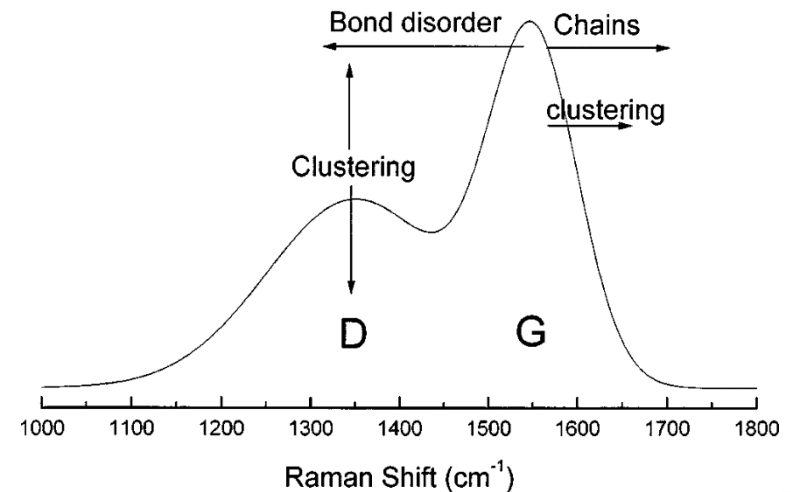
Decrease in 808, 840 and 2883 cm⁻¹ represents disassemble of polymeric structure

Raman analysis of PP



	Treated	Untreated
$I(D)/I(G)$	1.46	1.37
D_{position}	1333.6 cm^{-1}	1337.2 cm^{-1}
G_{position}	1592.4 cm^{-1}	1586.4 cm^{-1}
D_{FWHM}	97.3 cm^{-1}	108.4 cm^{-1}
G_{FWHM}	95.1 cm^{-1}	108.5 cm^{-1}

- Narrowing width of D and G band – decrease number of defects
- Increase of $I(D)/I(G)$ – grow in the crystalline cluster size and formation of disordered nanocrystalline structure
- Positive shift of G – clustering



A. C. Ferrari et al., *Physical Review B* 2, 61 (2000).

Sheet resistance measurement of non metalized surface

Concentration of additives	7.5 %		5 %		2,5 %	
Laser treatment	yes	no	yes	no	yes	no
Sheet Resistance	1.6e5	2.2e7	1.65e5	2.3e7	1.66e5	2.3e7

Results:

- Does not work with picoseconds
- Has a sharp threshold of irradiation dose
- SEM analysis represents threshold as melting

Hypothesis:

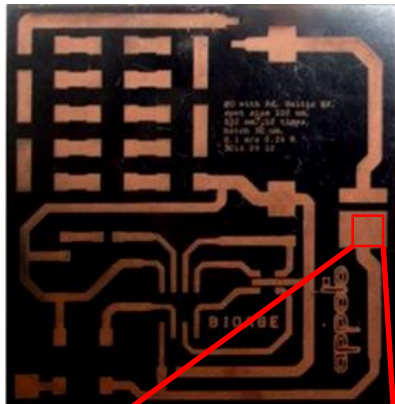
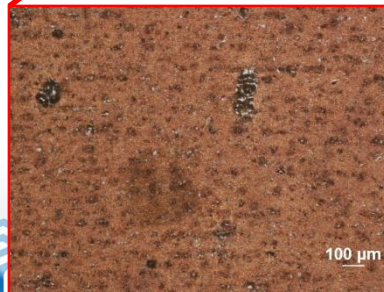
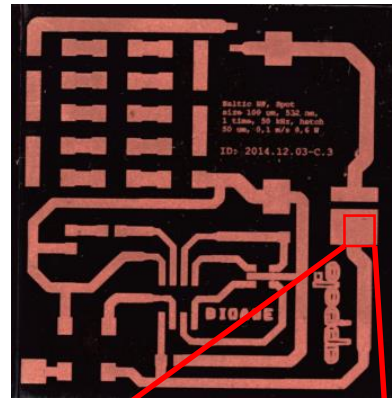
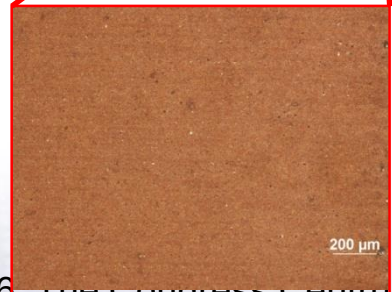
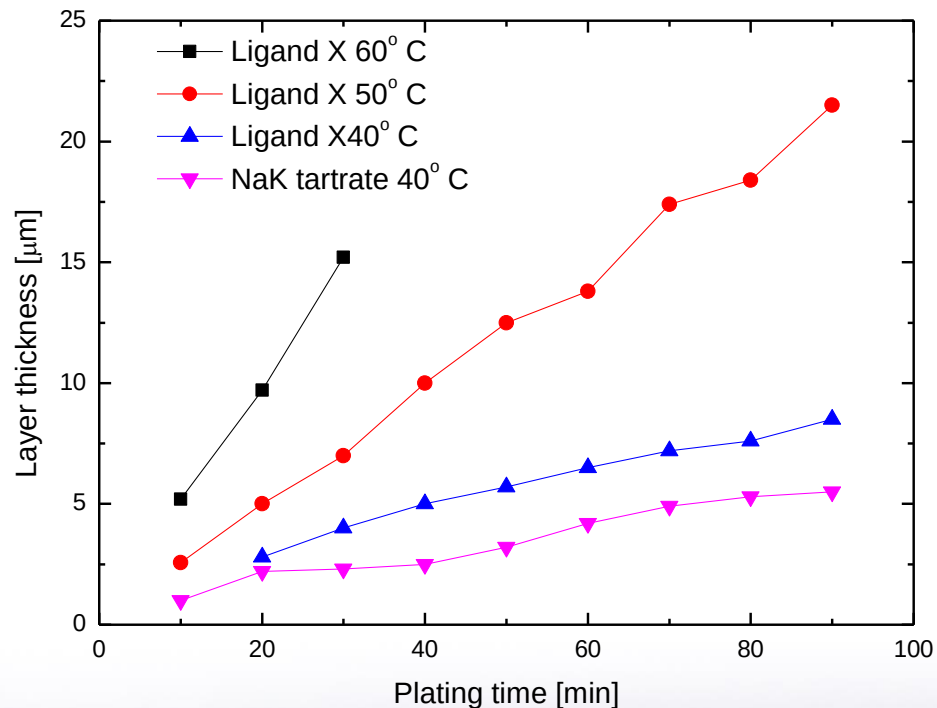
Structural changes?

Tartrate vs Ligand X

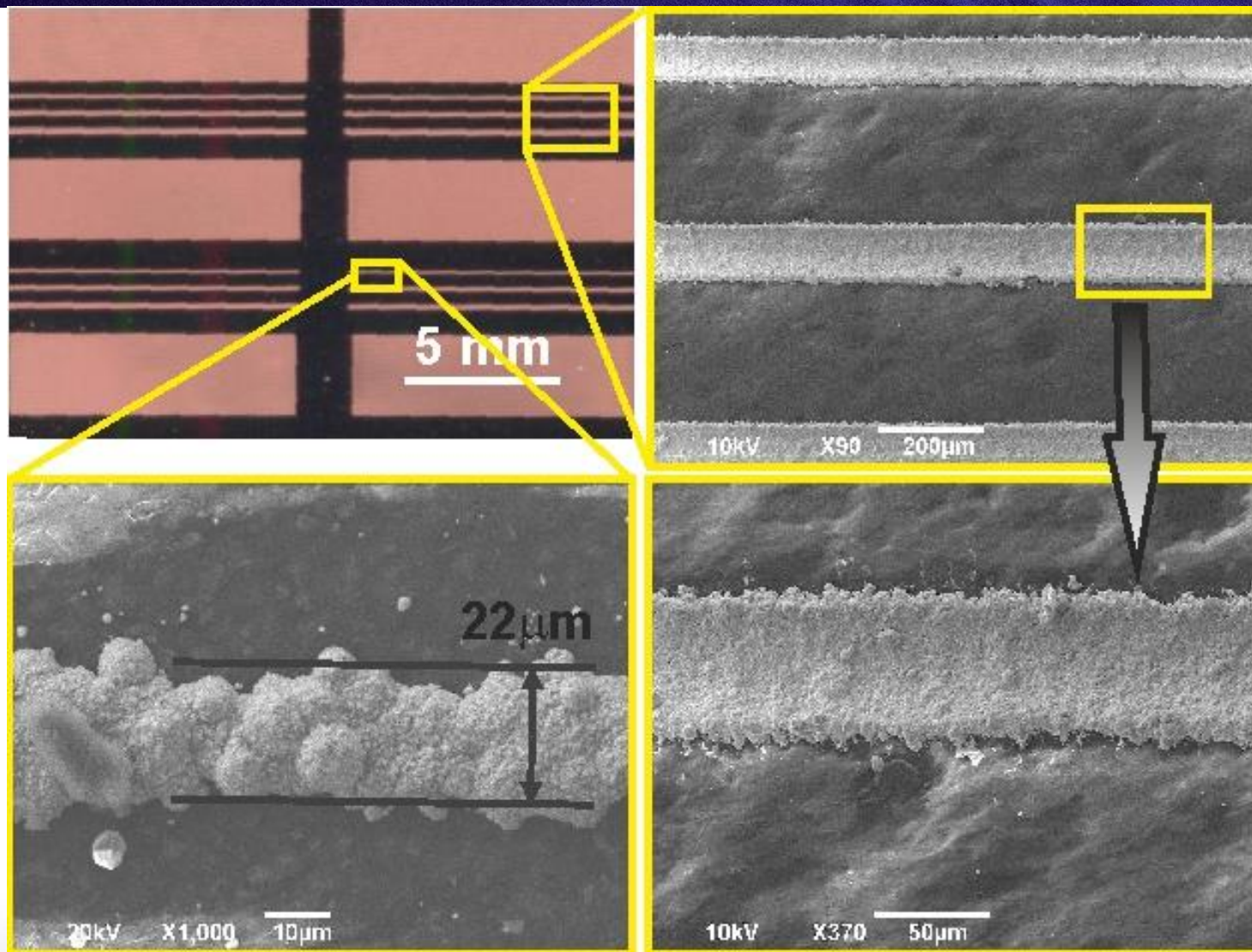
Substitution of ligand – increase plating quality and thickness

Standard Cu bath

Cu bath with special ligand



Selectivity of copper plating

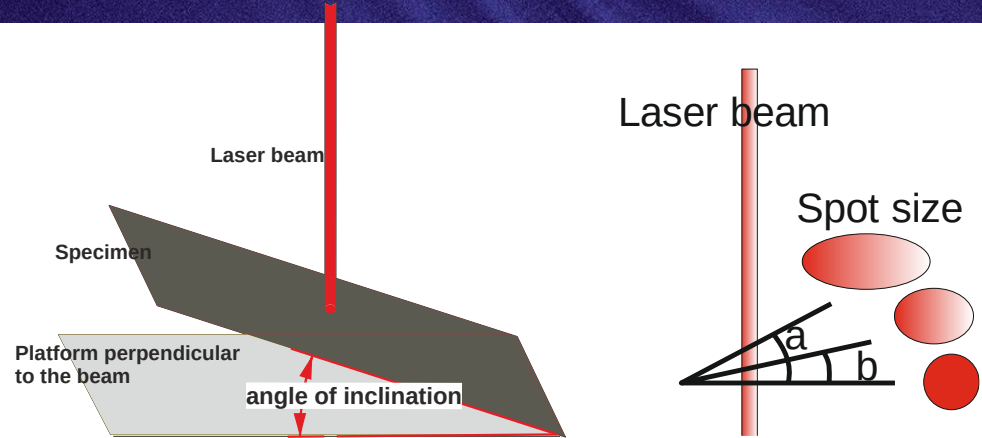
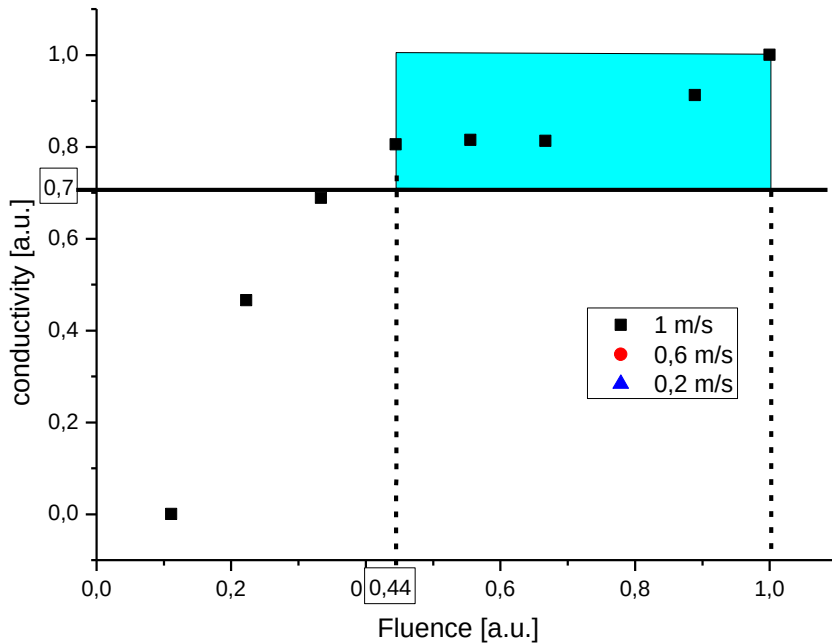
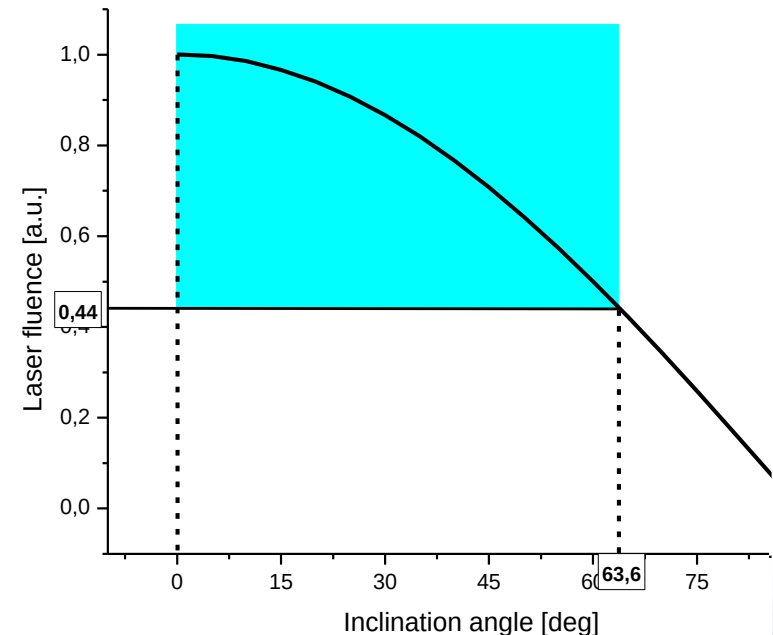


Controlling width of lines by changing laser spot size

28-29 September 2016, The Congress Centrum Würzburg, Würzburg, Germany

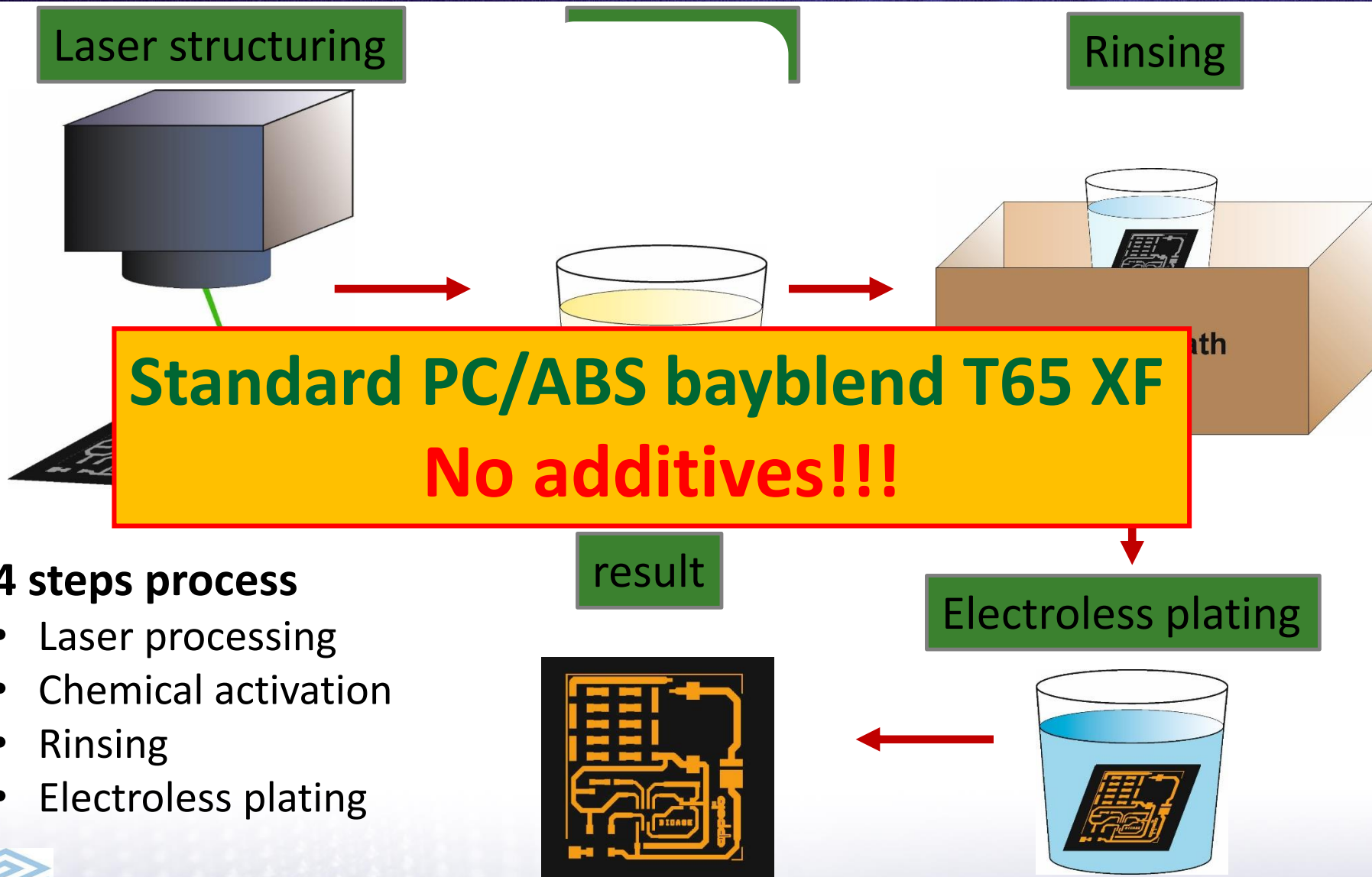
Structuring of inclined surface

- Spot size enlargement
- Reduce laser fluence



- LDS for PP, PC/ABS doped with carbon based additives additives works only with nanoseconds laser
- Laser activation for catalytic plating has a threshold of laser fluence
- Processing of curved surface up to inclination of 63° is available
- 3 m/s laser scanning speed is achieved (limited by scanner properties) for PP and PC/ABS
- Plated lines as narrow as $23\text{ }\mu\text{m}$ can be achieved

Selective Surface Activation Induced by Laser (SSAIL)



4 steps process

- Laser processing
- Chemical activation
- Rinsing
- Electroless plating

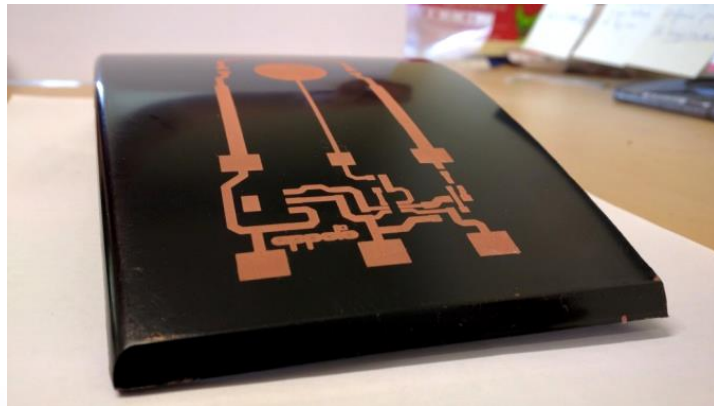
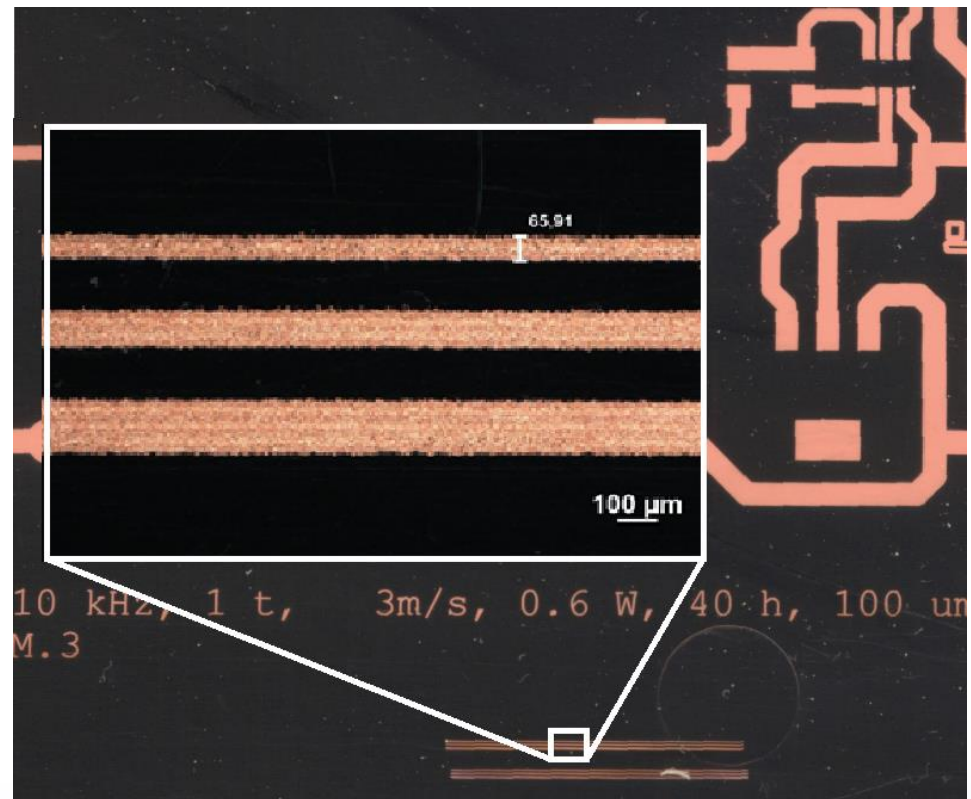
Selective Surface Activation Induced by Laser (SSAIL)



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Standard PC/ABS bayblend T65

High selectiveness
No LDS additives!!!

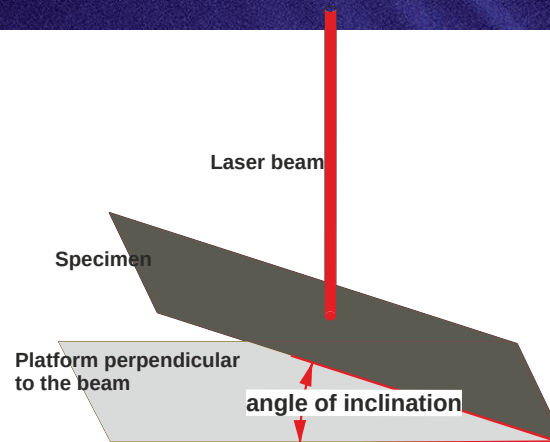
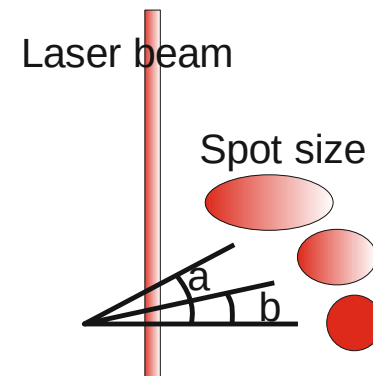
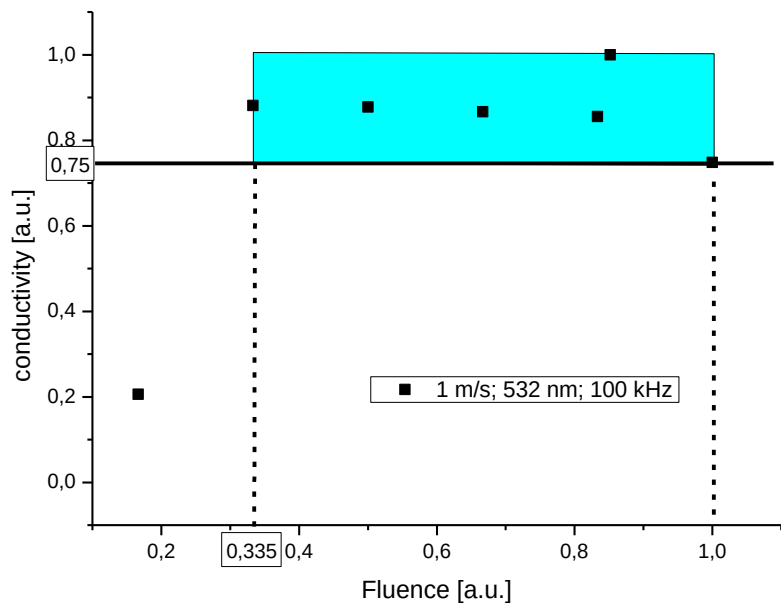
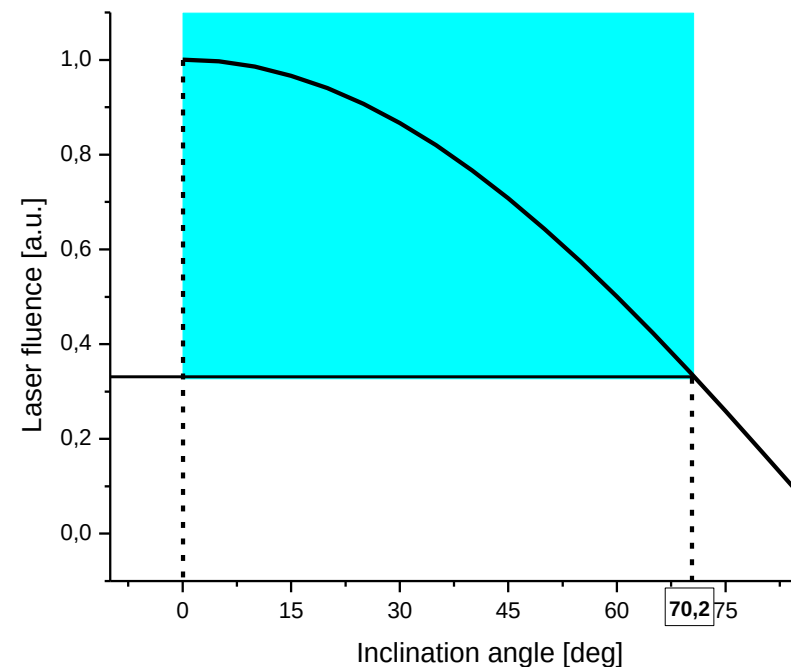


Structuring of inclined surface



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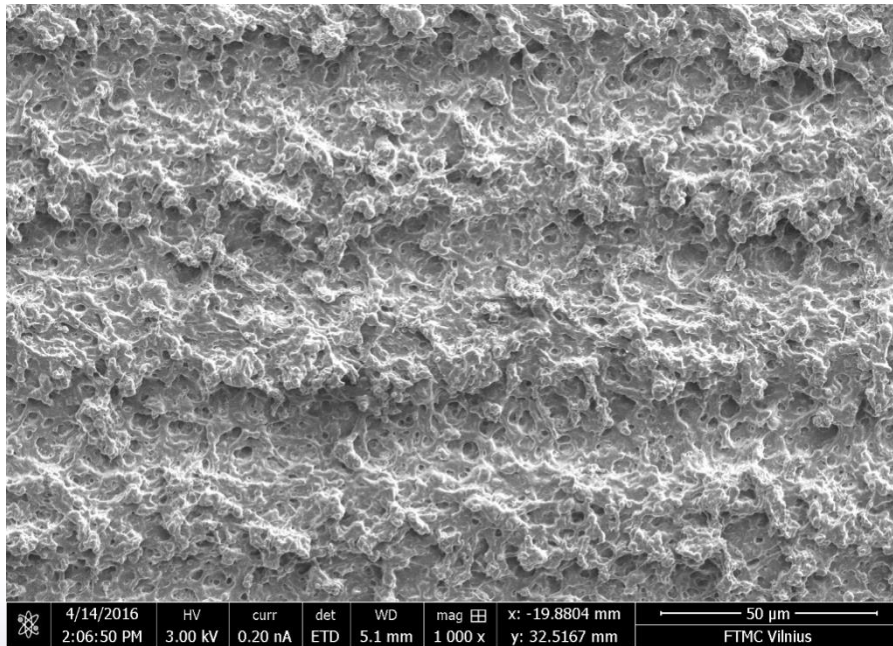
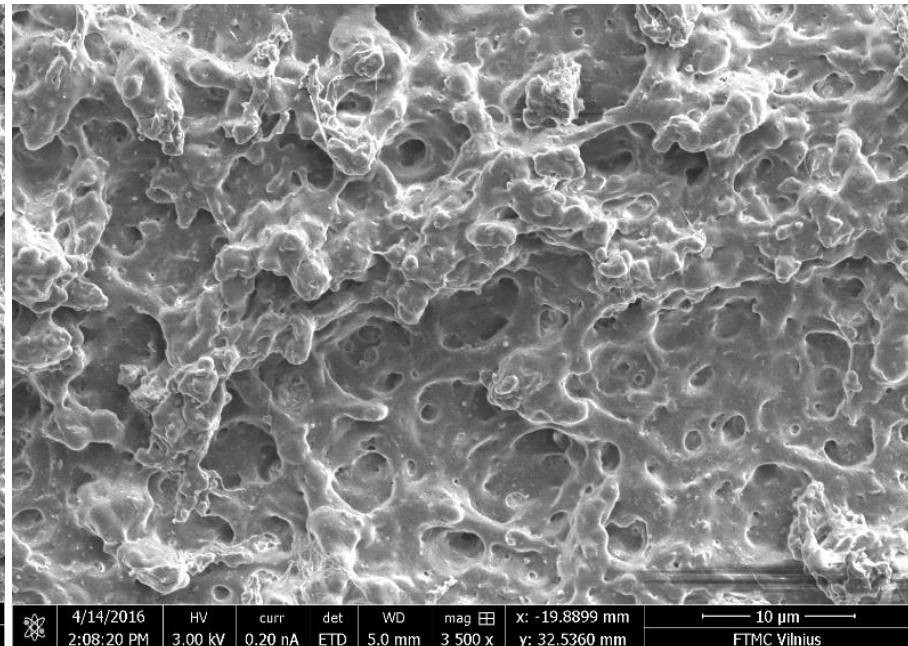
- Spot size enlargement
- Decrease in laser fluence



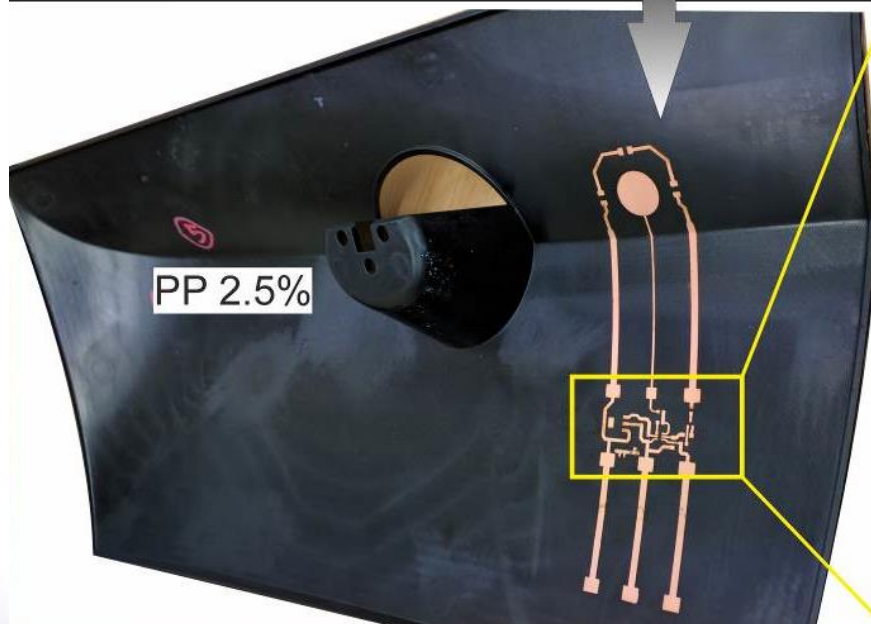
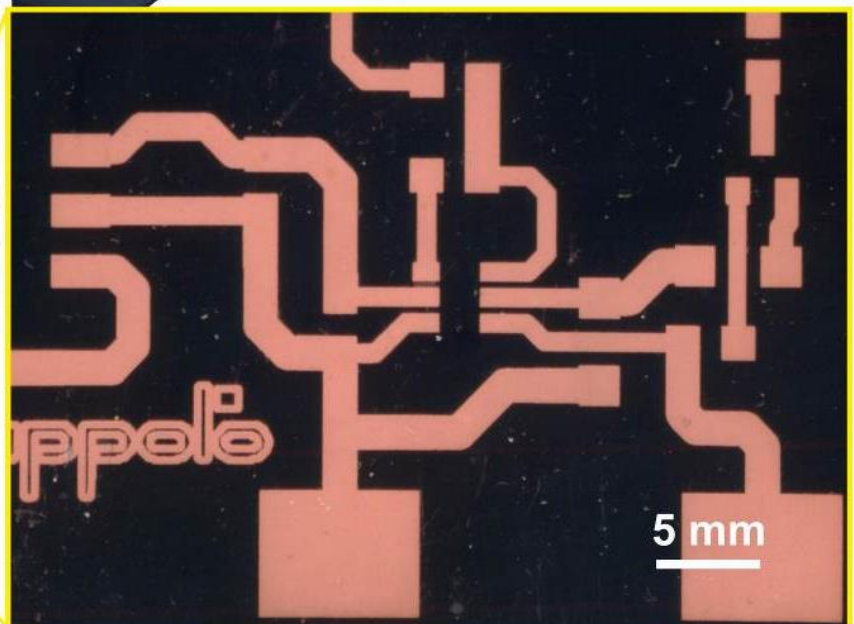
Adhesion (scotch tape test)

SSAIL PASS TEST 100%!!

Irradiation dose [J/cm ²]	Fluence [J/cm ²]	Pulse rep. rate (kHz)	Wavelength [nm]	Scanning speed [m/s]
2-16.7	0.17-2.1	10-100	1064; 532; 355	0.1-3



Demonstrators



- PC/ABS Bayblend T65 XF (**without any additives**) can be selectively metal plated using SSAIL method
- Processing of curved surface up to inclination of 70° is available
- 3 m/s laser scanning speed is achieved (limited by scanner properties)
- Scotch tape test results showed excellent adhesion

Thank you for attention

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<http://appolo-fp7.eu/>