Micro structuring of photoresist with femtosecond laser pulses

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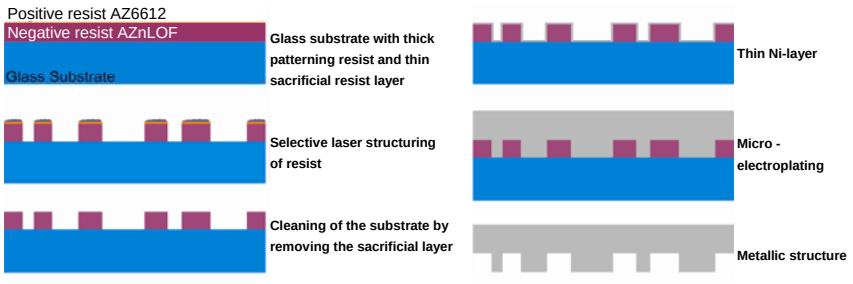
Abstract

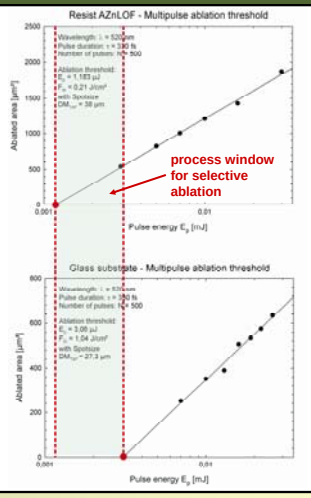
Femtosecond laser pulses permit laser ablation almost free of any heat load to the material, which allows the structuring of various materials with high resolution and good edge definition. We present recent results on selective laser ablation of thick photoresists (AZ-Types) from dielectric substrates, capitalizing on the different ablation thresholds of the resist layer and the substrate material. The laser used was an ultrafast pulsed Yb:Glass regenerative amplifier with a pulse duration of 300 fs (HighQLaser). By carefully choosing the pulse fluence to be in the window between the ablation thresholds of the resist and the substrate (glass), respectively, we were able to structure thick photoresist selectively without affecting the substrate.

To overcome the problem of debris on the surface during the ablation, an additional thin resist layer was applied which could be developed and removed together with the debris without damaging the subjacent shaping resist. Subsequent sputter and micro-electroplating steps permit the fabrication of metallic structures of micrometer size.

Manufacturing process



Process window for selective ablation



Laser system

*femto*REGEN (HighQLaser)

Yb:Glass DPSS Laser
Pulse duration: 330 fs
Wavelength: 520 nm

Threshold determination

$$\phi(r,z) = \phi_0 e^{-2r^2/w^2}$$

$$\Downarrow$$

$$A_{th} = \frac{A_L}{2}\ln\left(\frac{\phi_0}{\phi_{th}}\right)$$

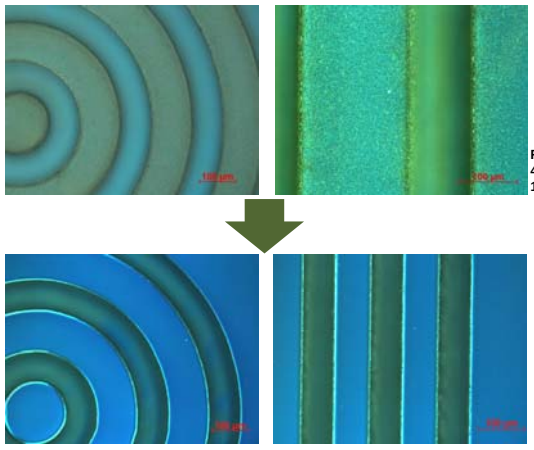
The ablation spot area is a linear function of the logarithm of the pulse energy (ϕ_0 prop. E_p)

Beam diameter: Determined by the gradient

Ablation threshold: Intersection with the energy-axis

Multipulse threshold fluence
Substrate: 1,04 J/cm²
Resist 0,21 J/cm²

Debris removal with sacrificial resist layer



Resist thickness: 45 µm
4x scanning
1 mm/s @ 5 kHz

Debris is completely removed from the top surface

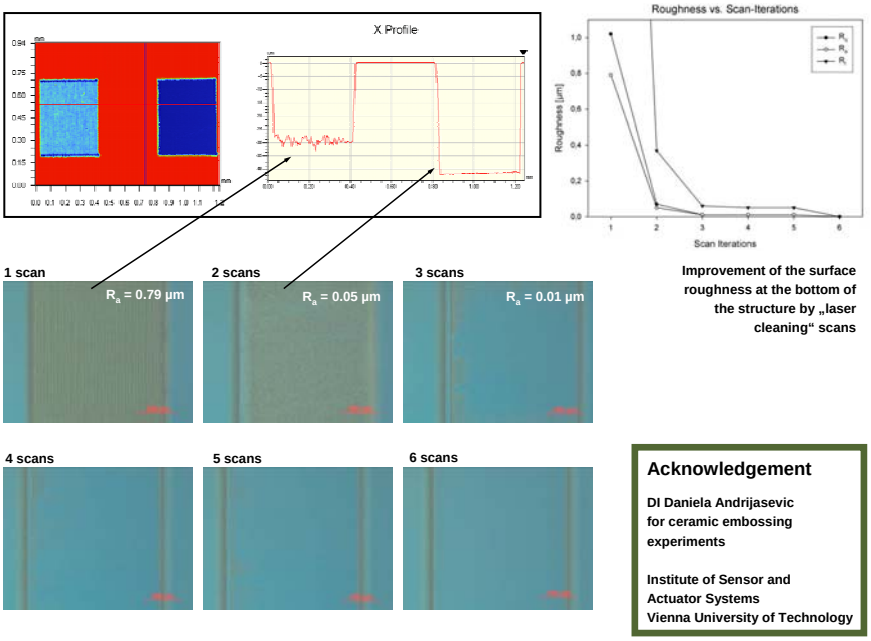
Pattern transfer

Structured photo resist AZnLOF on glass wafer

Nickel test structure by micro-electroplating

Pattern transfer in green Al_2O_3 ceramic by embossing

Bottom surface roughness



Improvement of the surface roughness at the bottom of the structure by „laser cleaning“ scans

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FHplus

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