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Impact of laser opening on plated copper based contacts for n type monocrystalline silicon solar cells

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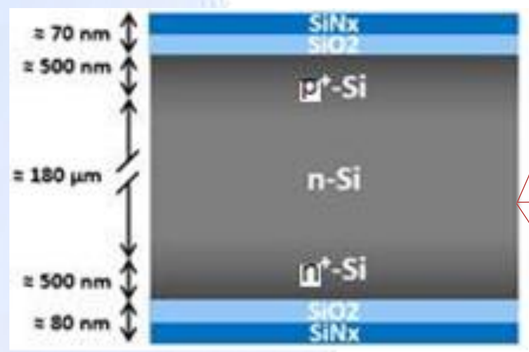
Context and purpose of the study

LASER ablation is the most widely technique used to open dielectric layer before plating in the field of PERT and PERC silicon solar cells. Compared to photolithography and screen-printing this technique has many advantages: narrow contact opening, fast process, reduction of material losses and less risks of contamination[3]

Non-optimized laser parameters can lead whether to silicon substrate damaging or to not enough etch the dielectric layer. As a result, the further metallization could be impacted and the solar cell efficiency may be reduced. Understanding laser etching process is necessary to optimize the etching parameters and therefore to reduce the impacts on the solar cell parameters.

In this study, we will compare damages induced by UV-ns and UV-ps LASER. Although green lasers are used in the industry, the UV lasers are also considered because they damage less the samples. Post laser cleaning is also studied.

Materials and procedure



ISC bifacial solar cell (N-PERT) textured on front side and polished on rear side

Laser opening
(UV-ns LASER at INL and UV-ps LASER at Innolas)

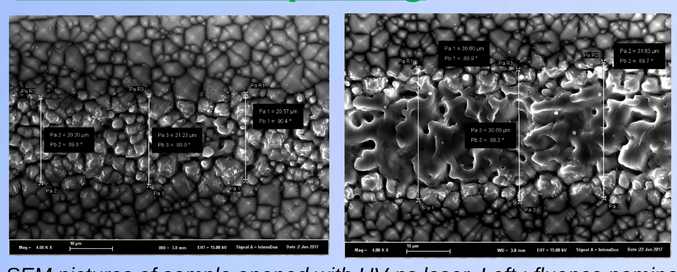
Post laser cleaning
(HF or sodium bifluoride on UV-ps laser opened cells)

Metallization Ni/Cu

Characterization: confocal microscope laser, SEM, photoluminescence

Results

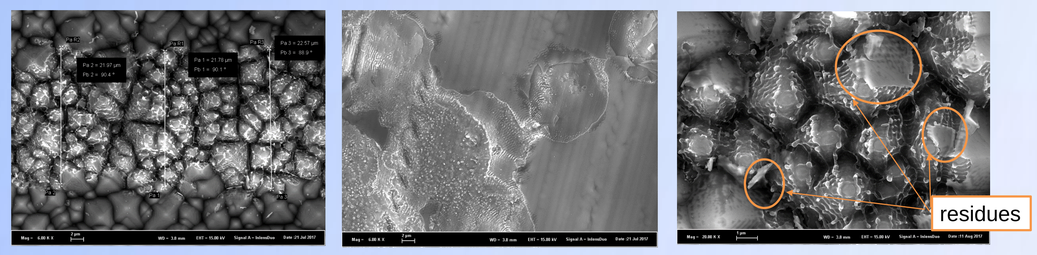
UV-ns laser opening



SEM pictures of sample opened with UV-ns laser. Left : fluence nominal value; Right : fluence nominal value x 2

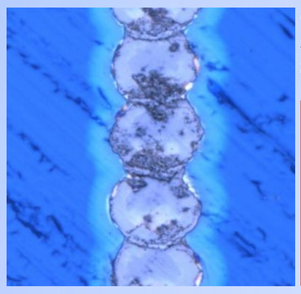
- Ablation process : Melting + evaporation through silicon **thermalization**[1][2]
- Damaged pyramids especially at high fluence
- Etching width with optimized parameters close to 20 µm

UV-ps laser opening



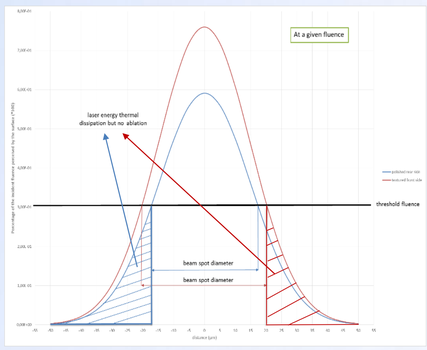
SEM pictures of sample opened with UV-ps LASER. Left and right (textured side) : 500 kHz, 8m/s,45 % power (= 0,26 J/cm²) / center (polished side) 500 kHz, 8m/s, 40% power (= 0,13 J/cm²)

- Ablation process: Mechanical → lot of residues → **post-laser cleaning recommended**
- Less damage pyramids compared to UV-ns LASER
- Etching width with optimized parameters close to 20 µm



Confocal microscope laser picture of polished side opened with UV-ps LASER: 500 kHz, 8m/s, 40% power, *magnification *200*

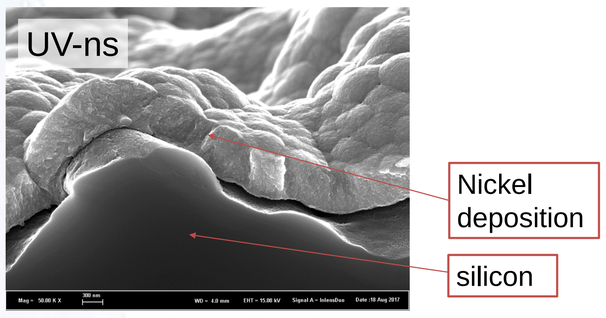
Light blue area probably corresponds to a **thermal affected area** (thinner SiNx)[1][2]



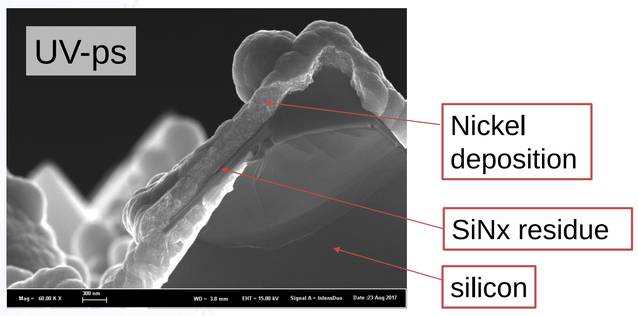
Gaussian representation of the LASER spot on the textured side and the polished side

Textured effect[1]→ diffusion mechanisms → more energy impacts the sample
Parameters must be different on textured and polished side

Ni Electroless metallization



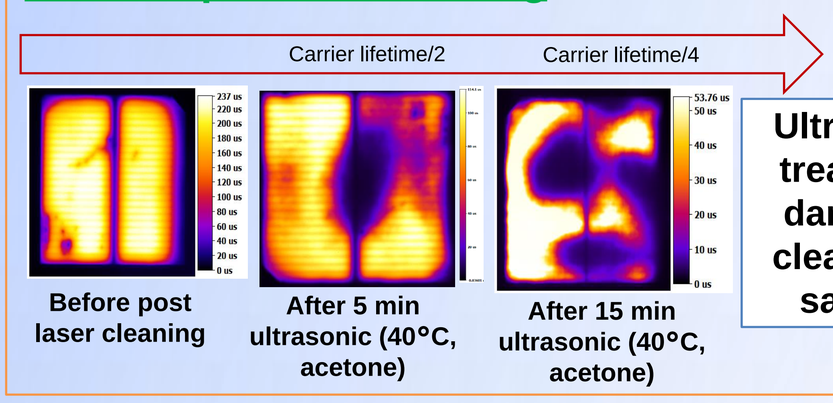
Sectional SEM pictures of sample opened with high fluence UV-ns laser (textured side) and metallized with nickel



Sectional SEM pictures of sample opened with high fluence UV-ps laser (textured side) and metallized with nickel

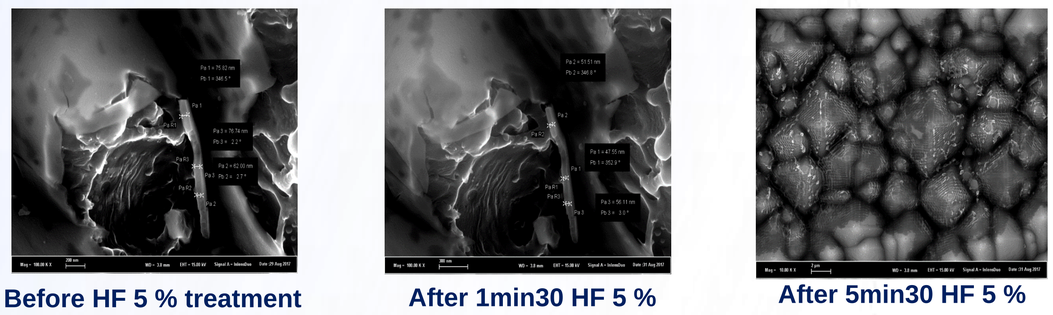
- Nickel deposition is dense
- After UV-ps LASER opening, **residues are trapped within the deposited metal**
- **More damages on pyramids with an UV-ns LASER**

Post UV-ps laser cleaning



Before post laser cleaning | After 5 min ultrasonic (40°C, acetone) | After 15 min ultrasonic (40°C, acetone)

Ultrasonic treatment damages clearly the sample



Before HF 5 % treatment | After 1min30 HF 5 % | After 5min30 HF 5 %

HF 5% etching rate: 0.25 nm/s. Not effective to remove selectively residues. Sodium bifluoride is preferred for deoxidation due to its selectivity for native oxide layer

Conclusions

- Ablation mechanisms with UV-ns LASER and UV-ps LASER are different:
  - The use of UV-ps LASER allows to preserve pyramid shape
  - LASER parameters have to be different on textured side and polished side
- Thermal effect is observed on the edge of LASER spots
- A non-damaging post laser cleaning to remove residues after UV-ns LASER opening has to be developed

Perspectives

- Characterization of LASER impacts on the Si bulk of the sample : silicon amorphization, creation of recombination centre, doping profile modification…
- Comparison of electrical parameters of cells with different LASER opening parameters
- Modelling of laser impacts
- Adherence measurements after metallization with UV-ns & UV-ps LASER opening

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References:
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