Progress on screen-printed metallization by improving the screen manufacturing process with laser technology

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Mitigating the consumption of silver in the metallization process of silicon solar cells by reducing the width of screen-printed front-side contacts is imperative to conserve costs and valuable resources. In this work, we address these challenges and attempt to diminish them by creating screen-openings with laser technology. Integrating laser technology with screen manufacturing could lead to the development of highly precise screens and greater flexibility in the screen structuring process. In this study, an ultraviolet (UV) laser is employed to create openings on either the print or substrate side of the screen. By applying the laser on the print side, we have successfully achieved an opening width of ≈ 12 µm for the printing channel on the substrate side ($w_{ch,s}$). By optimizing the laser parameters, openings smaller than 10 µm could also be realized in future experiments, further reducing the usage of silver.

Introduction and Motivation

Screen-printing goals:

- Further reduce finger width [1] and save silver
- Optimize screen manufacturing: increase screen lifetime and reduce cost

Approach:

- Structuring of barrier layer by laser ablation instead of the traditional screen fabrication process

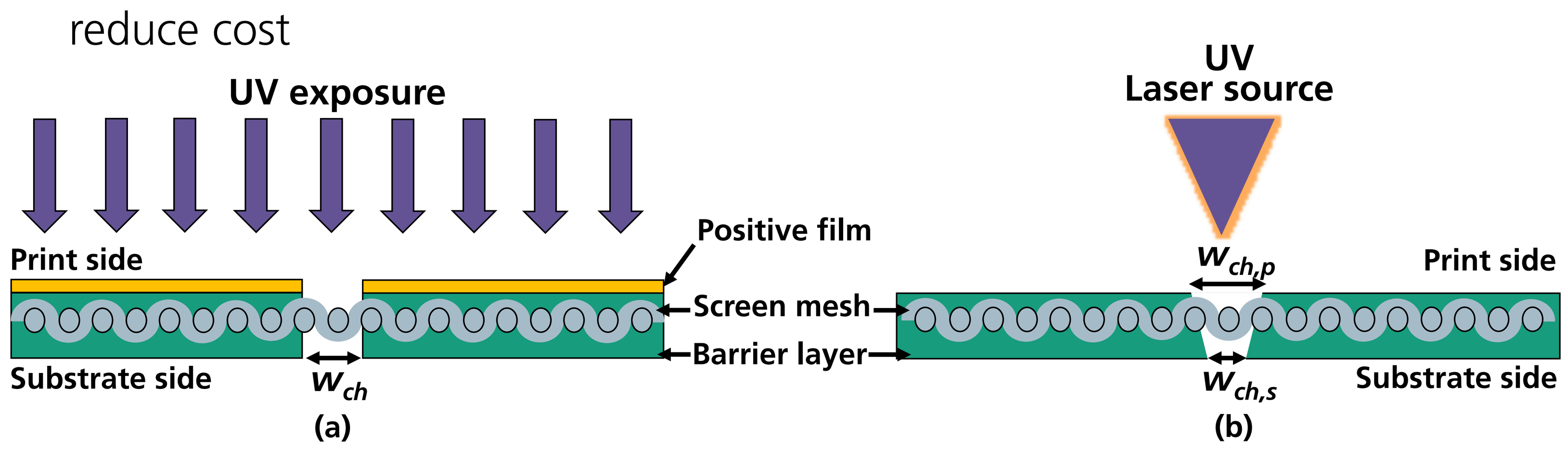

Fig. 1: Schematic representation of screen openings created by (a) conventional UV exposure (b) laser process – on the print side of the screen

Conventional method:

- UV exposure with positive film
- No tapering of printing channel
- Restricted flexibility: Cost – intensive to change cell layout of the screen, new screen would be required

Laser processing:

- Flexibility to laser any barrier layer material
- Tapering effect can be tuned
- Tunable wires texturization, for improved paste transfer
- Precision: Could be used to create openings between wires

Experimental Approach

Laser parameter variation test on barrier layer/capillary film

Laser structuring screen – substrate side

Laser structuring screen – print side

Screen printing test

Finger width measurement

Fig. 2: Summary of the experimental plan

Results

Laser-structured barrier layer/capillary film

- Red zone (*Fig 3b*): Indicates where laser has cut through the barrier layer

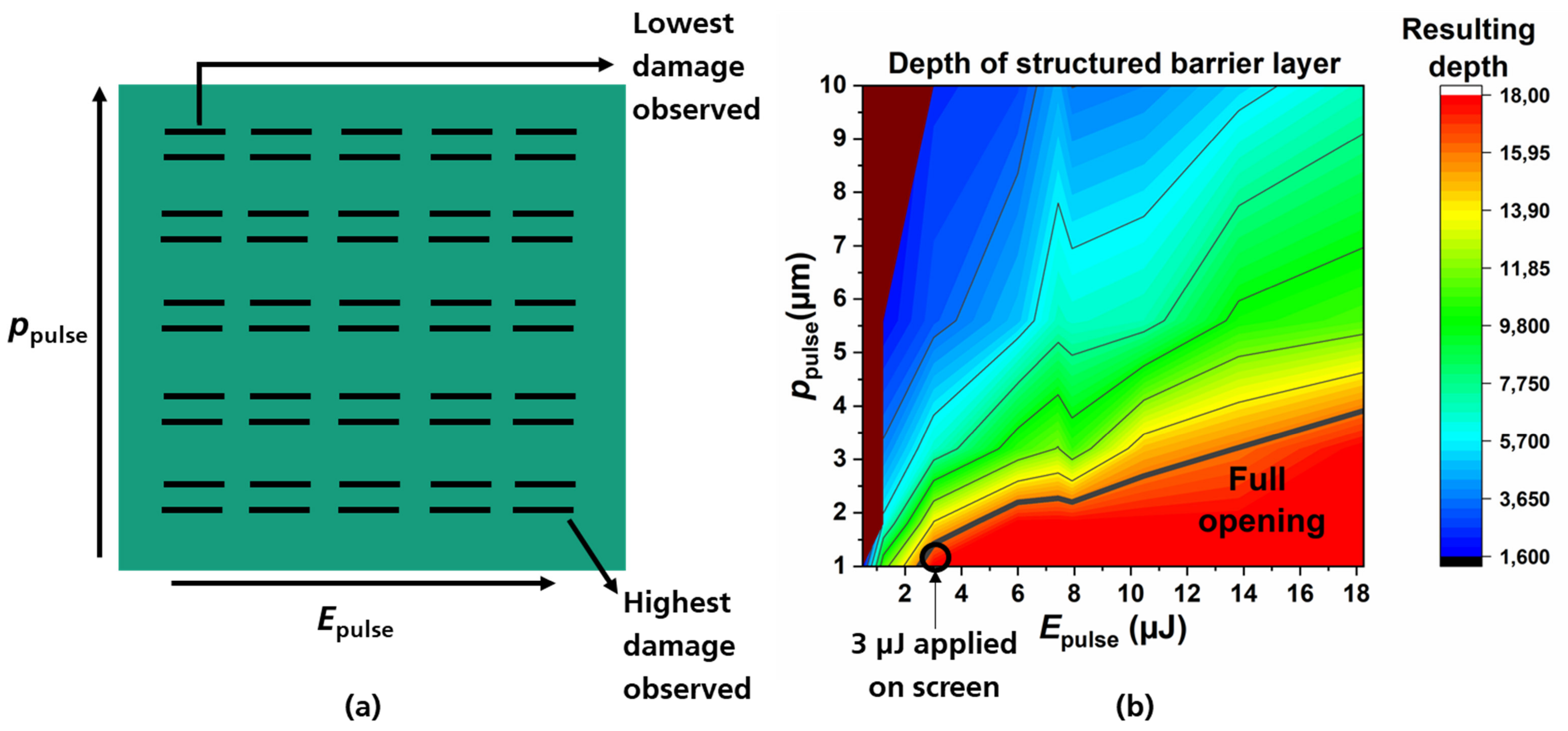

Fig. 3: (a) Laser parameter variation test applied on an 18 µm barrier layer (b) Variation in depth

Laser-structured screen: substrate side

- Laser with E_{pulse} = 3 µJ, p_{pulse} = 1 µm applied on substrate side of the screen
  - Screen opening created with these parameters
- Tapering effect observed from laser - screen interaction

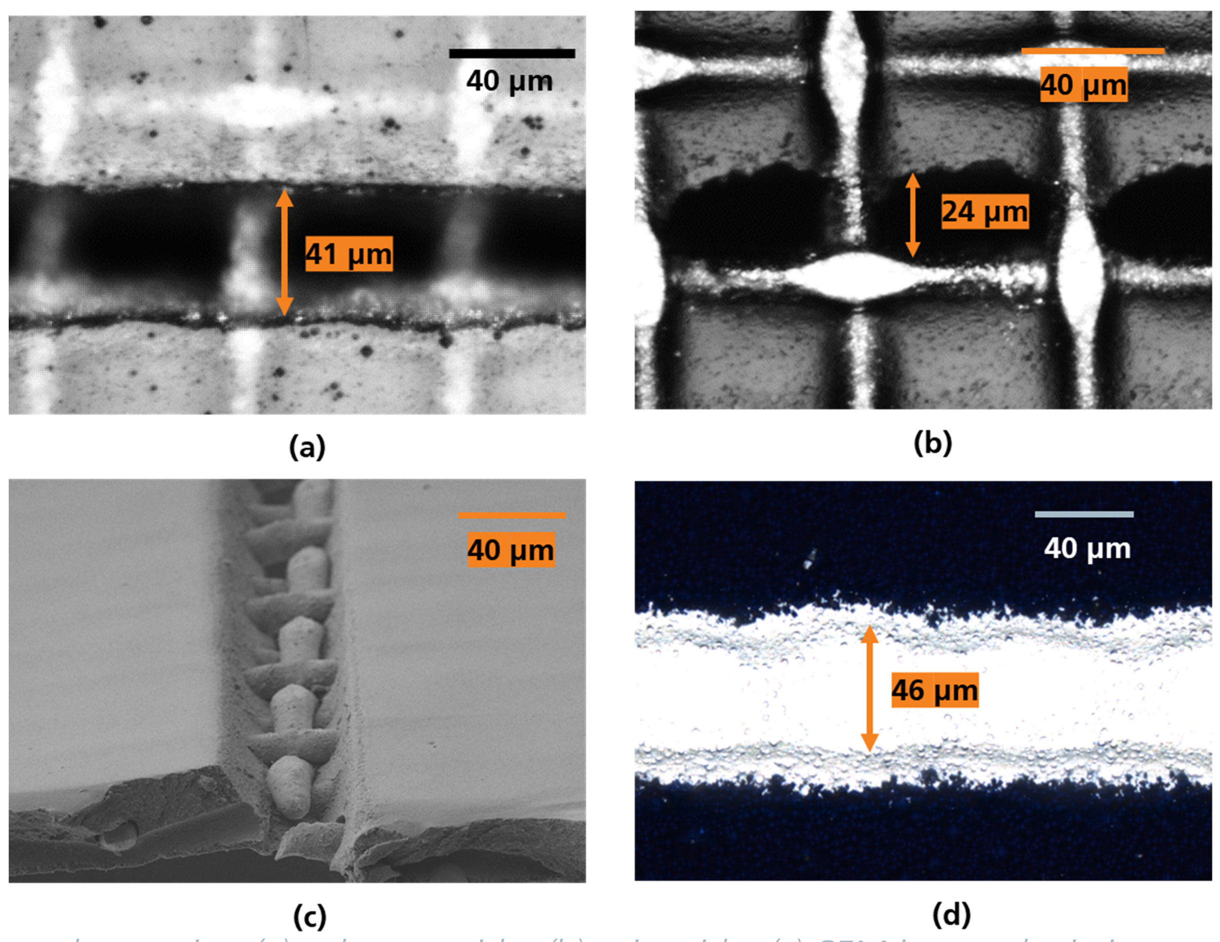

Fig. 4: Laser made opening (a) substrate side, (b) print side, (c) SEM image depicting tapering effect, (d) Finger printed from laser made opening

Laser-structured screen: print side

- Narrow opening of $w_{ch,s}$ ≈ 12 µm realized on substrate side of the screen

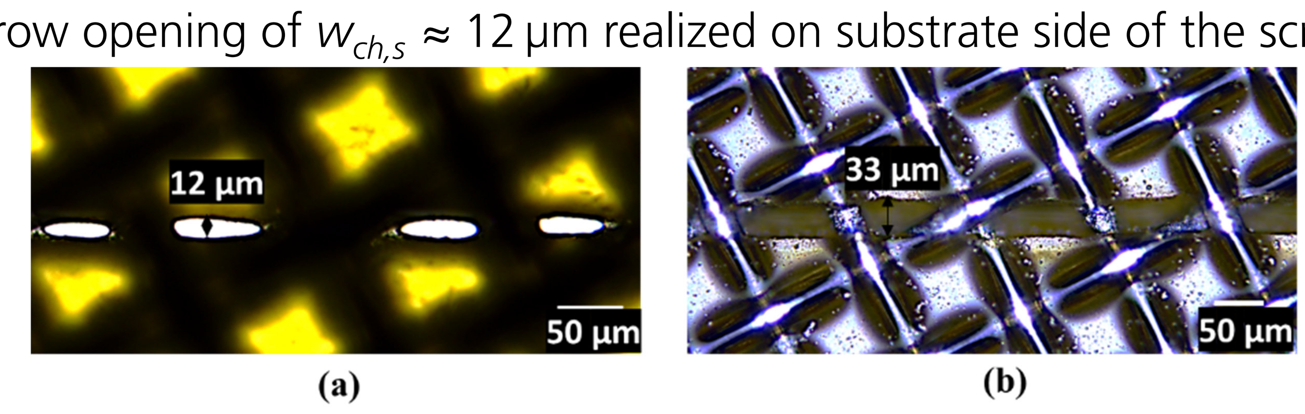

Fig. 5: Laser made opening (a) substrate side, (b) print side

Summary and Conclusion

- **Screen opening successfully realized by laser on substrate and print side of screen**
- **First printing tests successfully carried out**

[1] S. Tepner, A. Lorenz, 'Printing technologies for silicon solar cell metallization: A comprehensive review', Progress in Photovoltaics, Vol. 31, Issue 6, 2023

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