Enhancing Solar Cell Metallization through Laser-Optimized Screen-Printing Technology

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A potential strategy to further enhance the screen-printing process is by reducing the width of printed electrical contacts and minimizing silver consumption by using an ultraviolet (UV) picosecond laser to structure the screen openings. In this work, we successfully lasered a busbarless grid layout with 120 finger openings onto a knotless (0°) screen with a mesh count of 520 wires/inch and wire diameter of 11 µm in just ten minutes and sixteen seconds, significantly decreasing the time required to structure a screen. The average width of the printed contact from the lasered screen on a silicon heterojunction (SHJ) wafer was w_f = 23 µm, comparable to 21 µm from a reference screen.

Introduction and Motivation

Screen-printing goals:

- Reducing silver consumption [1] and width of electrical contact [2]
- Improve screen fabrication process: increase screen lifetime and reduce cost

Approach:

- Structuring of grid layout on a dual barrier layer composed of polyimide (PI) and liquid photopolymer by means of laser ablation

Advantages:

- PI: increase screen lifetime
- Liquid photopolymer: flexible layer to ensure a thorough channel edge sealing

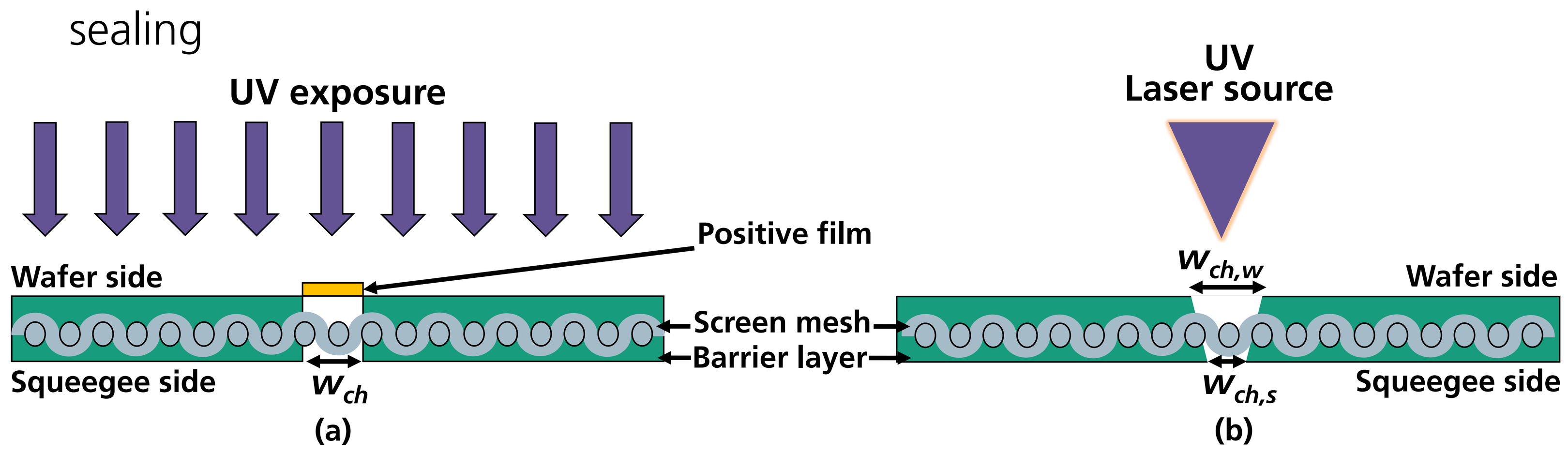

Fig. 1: Schematic representation of screen openings created by (a) traditional process (b) laser process – on the wafer side of the screen [3]

Experimental Approach

Part A: Screen structuring via laser processing

- Laser parameter variation test conducted by varying the pulse energy (E_p), pulse pitch (p_p), line to line pitch ($l2l$), number of passes (r) and repetition rate
- Laser structuring full grid layout on Screen A with optimal laser parameters

Part B: Screen-printing of laser structured screens

- Screen-printing M2 SHJ precursors with Screen A and Screen B (reference) using a low temperature (LT) paste and at varied printing speeds ($v_{printing}$)
- Finger width (w_f) and height (h_f) measured: 45 points per group

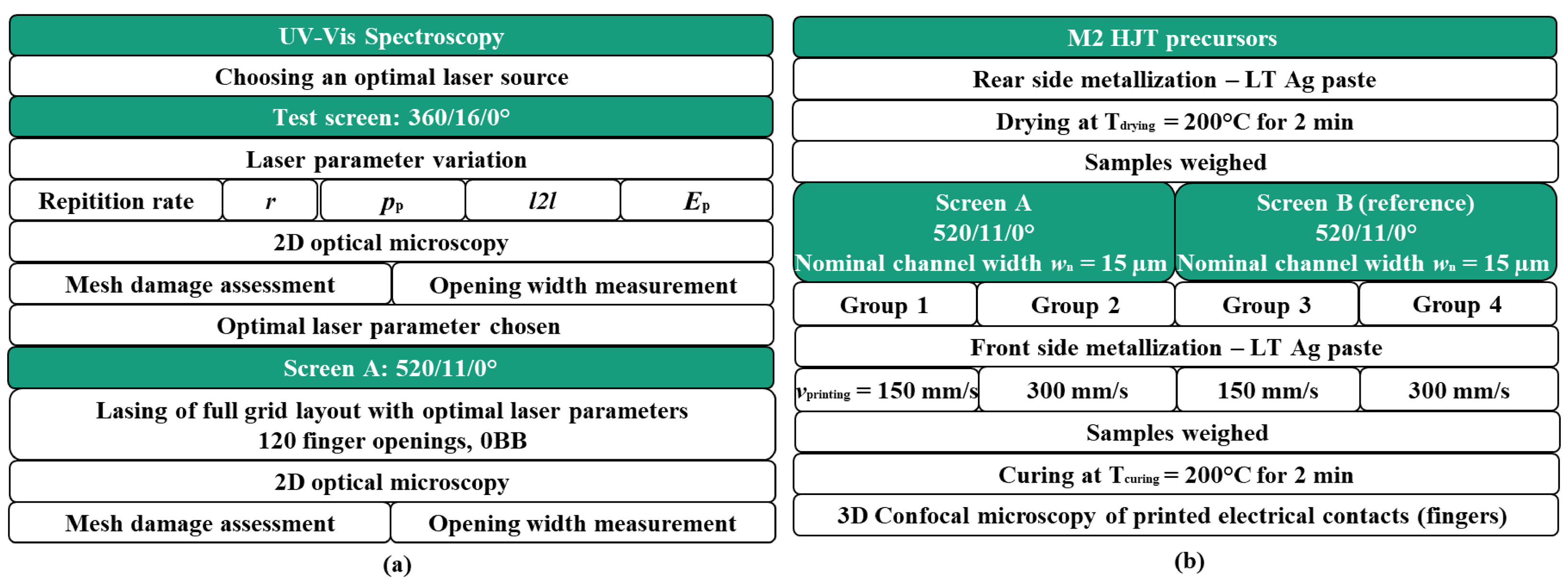

Fig. 2: Summary of the experimental plan for (a) Part A and (b) Part B

Results

Part A : Screen structuring via laser processing

- Successful laser structuring of full cell layout in 10 minutes 16 seconds
- Average taper ratio (TR) of lased channels: TR = $w_{ch,w}$/ $w_{ch,s}$ = 1.8

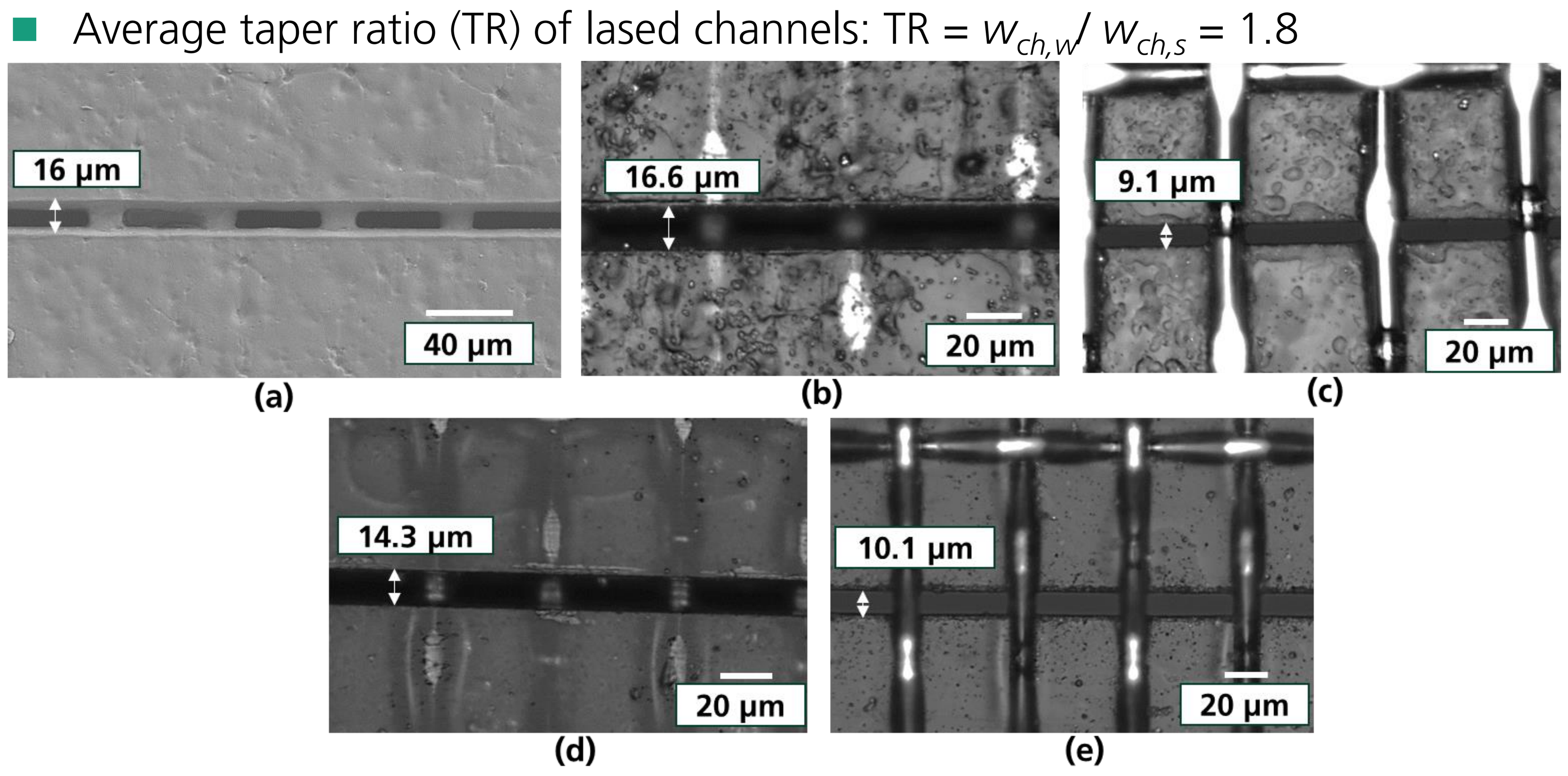

Fig. 3. Screen A: (a) SEM image of laser structured opening, image from (b) wafer side (c) squeegee side. Screen B: Opening from (d) wafer side (e) squeegee side

Screen	Mesh	Layout	Avg $w_{ch,w}$ (µm)	Avg $w_{ch,s}$ (µm)	TR
A	520/11/0°	120 F, 0BB	16.6	9.2	1.8
B	520/11/0°	120 F, 0BB	15.4	10.4	1.5

Table 1: Summary of average opening channel widths and TR for Screen A and Screen B

Part B: Screen-printing of laser structured screens

- Avg w_f = 23 ± 2 µm from Screen A, comparable to Screen B w_f = 21 ± 4 µm

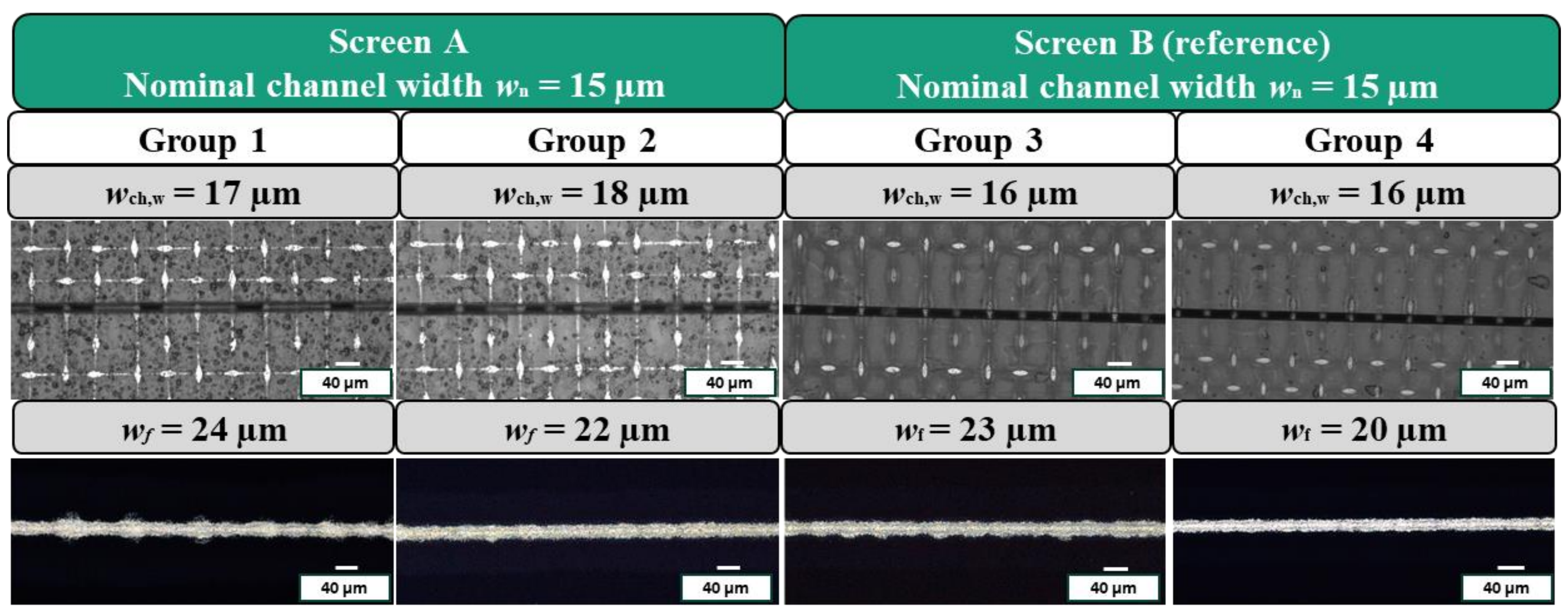

Fig. 4: Microscopic images of Screen A and Screen B and the fingers printed from respective opening

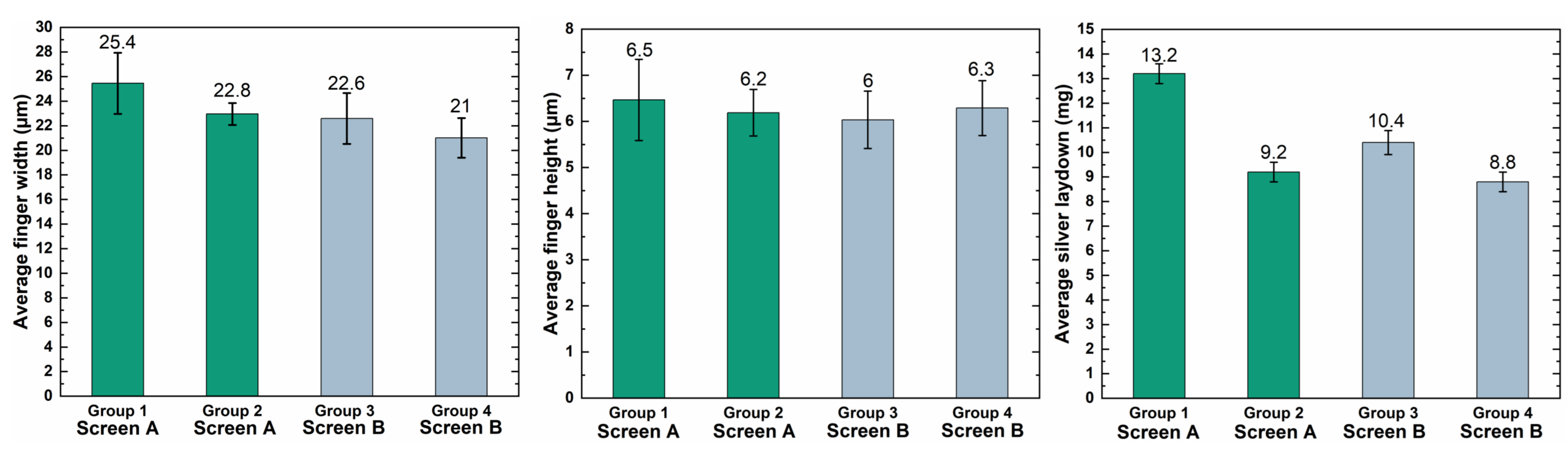

Fig 5: Average finger width, height and silver laydown of wafers printed from Screen A and Screen B

Summary and Conclusion

- Full cell grid layout successfully laser structured on a 520/11/0° screen with optimal laser parameters in **10 minutes**.
- Fine line front side metallization of SHJ solar cells with w_f = 23 ± 2 µm screen-printed from laser structured screen.

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

[2] Wenzel et al., Progress with screen printed metallization of silicon solar cells - Towards 20 µm line width and 20 mg silver laydown for PERC front side contacts, Solar Energy Materials and Solar Cells, Volume 244, 2022

[3] Adapted from A. Nair, et.al, 'Progress on screen-printed metallization by improving the screen manufacturing process with laser technology', EUPVSEC Lisbon, Poster, 2023

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