Enabling 7,500wph Productivity by a Novel Screen Printing Process

Marco Galiazzo

R&D Lab Manager, Applied Materials Baccini

Metallization & Interconnection Workshop, Konstanz - May 13 2019

Forward-Looking Statements and Other Information

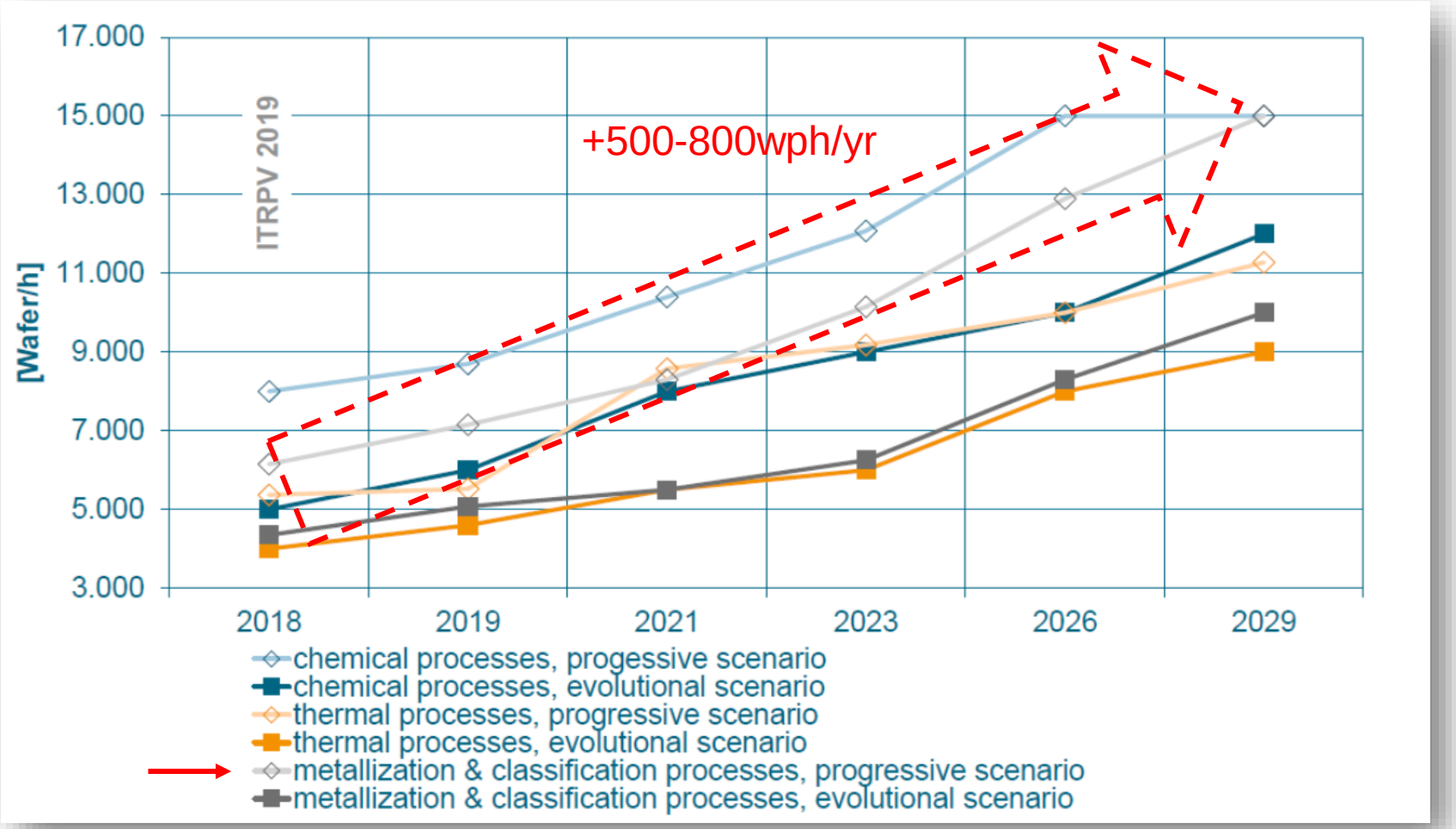
This presentation contains forward-looking statements, including those regarding industry outlooks, technology transitions, and other statements that are not historical facts. These statements are subject to risks and uncertainties that could cause actual results to differ materially from those expressed or implied by such statements and are not guarantees of future results or performance. Information concerning these risks and uncertainties is contained in Applied’s most recent Form 10-Q and other filings with the SEC. All forward-looking statements are based on management's current estimates, projections and assumptions, and Applied assumes no obligation to update them.

Outline

- Metallization roadmap
- 7,500wph: fundamental challenges
- New Tempo™ Presto
  - Architecture
  - Printing Process
- Paste Saving developments

Industry Roadmap: key drivers

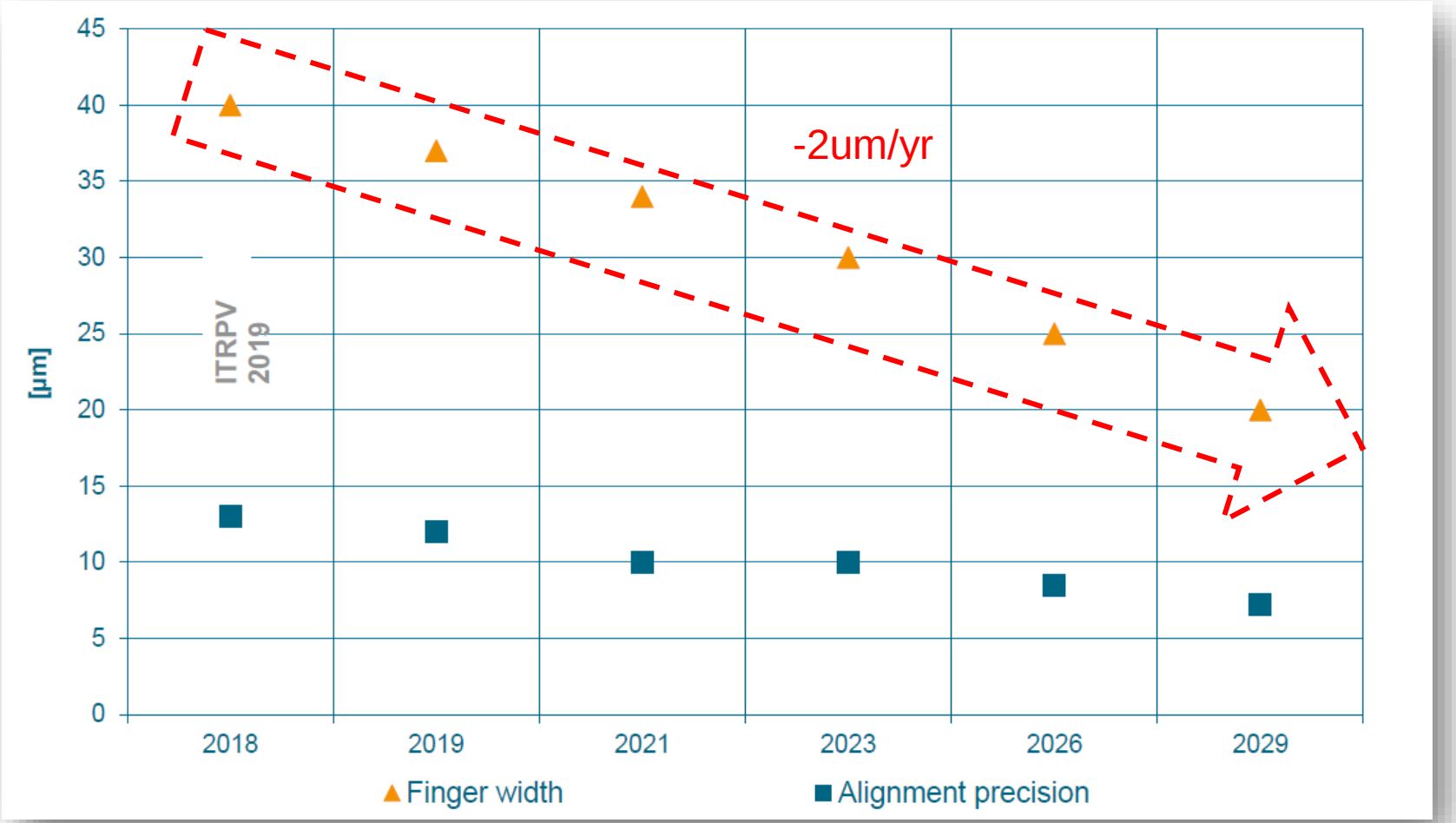
- Throughput
  - 7,000wph in 2019 (progressive)
- Resolution
- Paste Saving



APPLIED MATERIALS

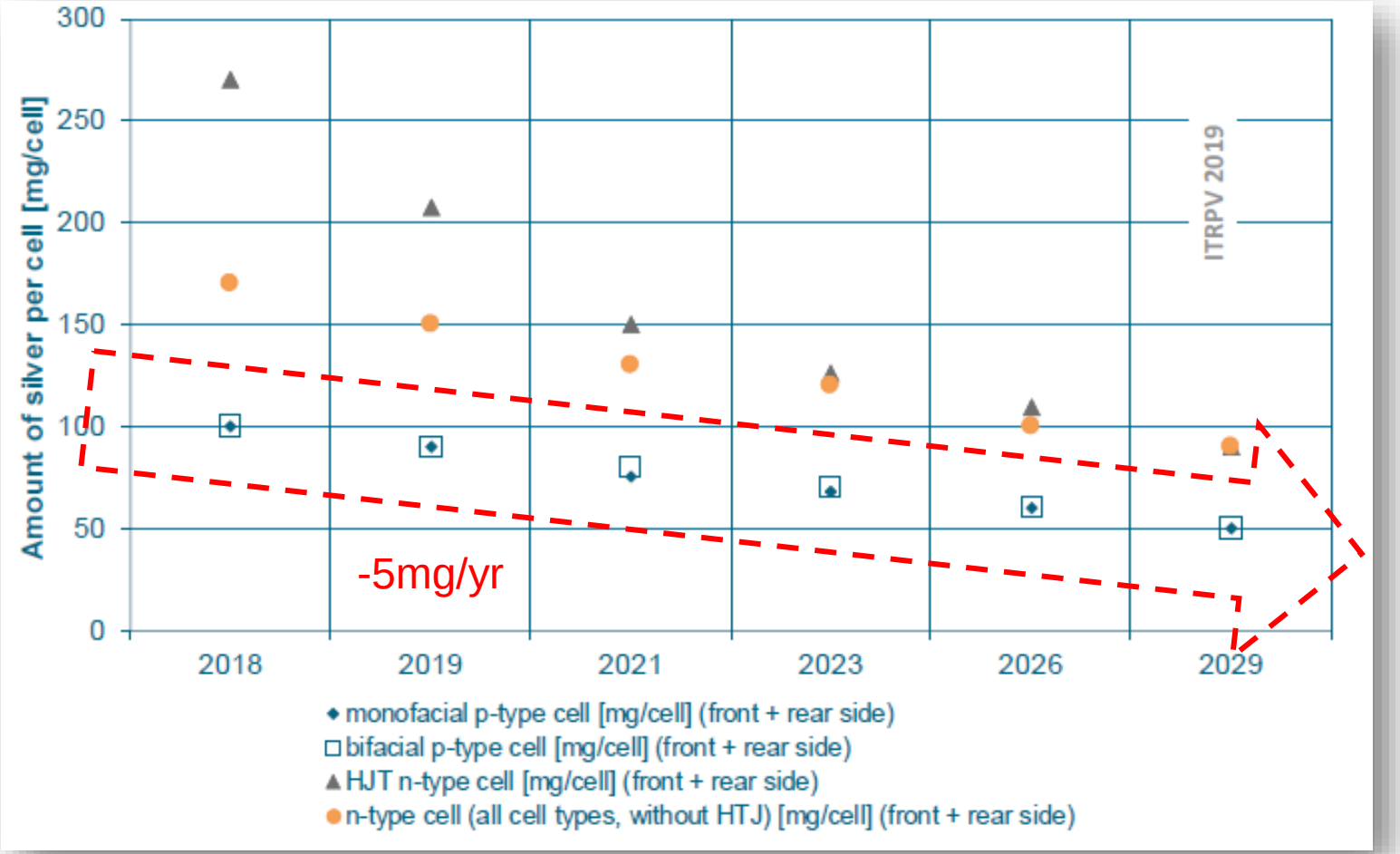
Industry Roadmap: key drivers

- Throughput
  - 7,000wph in 2019 (progressive)
- Resolution
  - 35-40um in 2019
- Paste Saving



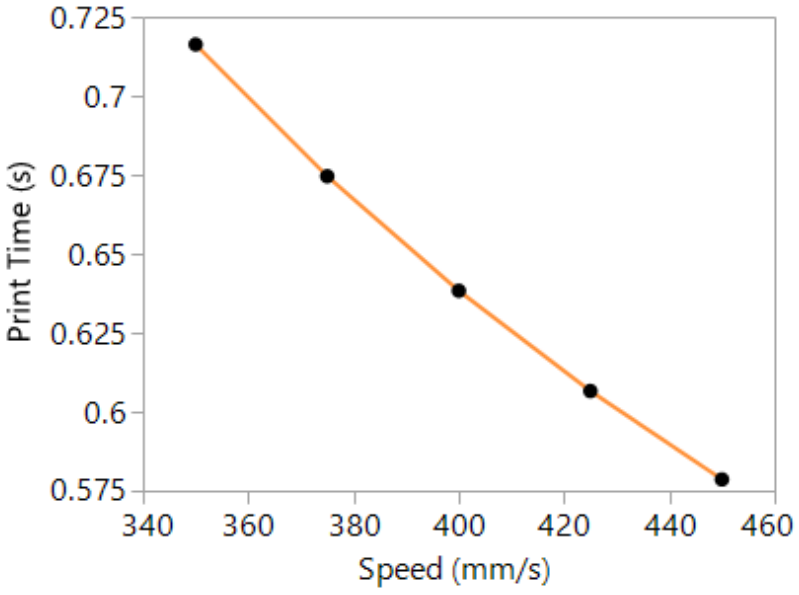
Industry Roadmap: key drivers

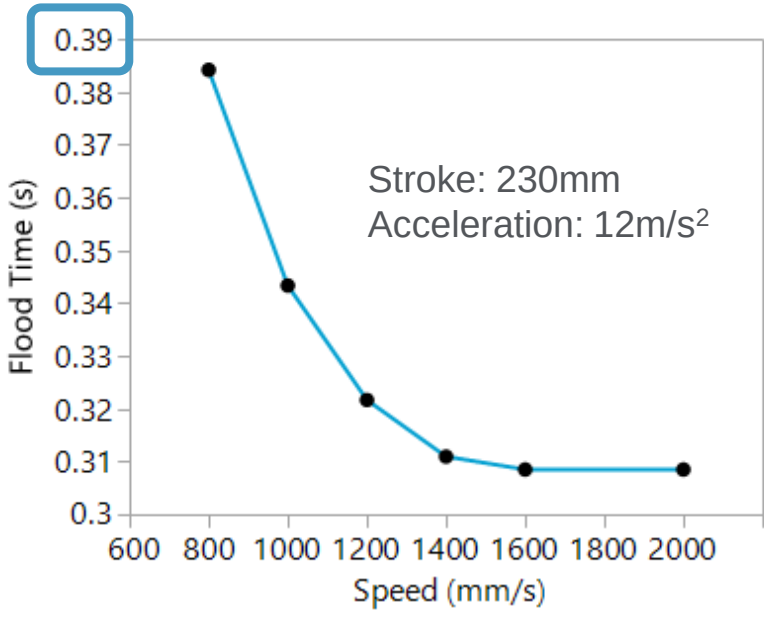
- Throughput
  - 7,000wph in 2019 (progressive)
- Resolution
  - 35-40um in 2019
- Paste Saving
  - 90mg Ag for p-type

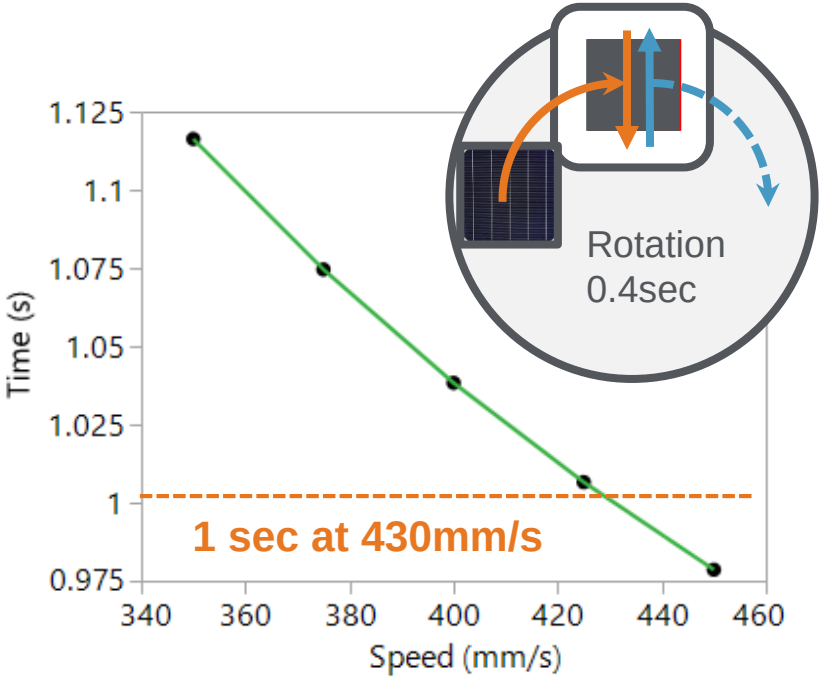


1sec Cycle Time with Rotary Table

- Cycle Time = Printing Time + Table Rotation
- Printing Time linearly decreasing with Printing Speed, Stroke Length
- Flood Time is masked if equal or lower than Table Rotation (flood speed >800mm/s)
- In order to get to 7,200wph Printing Speed has to go >430mm/s



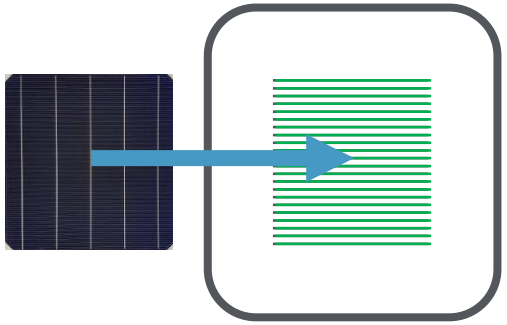


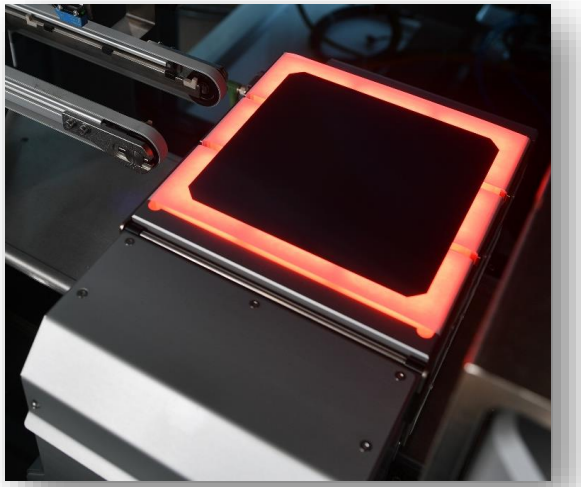


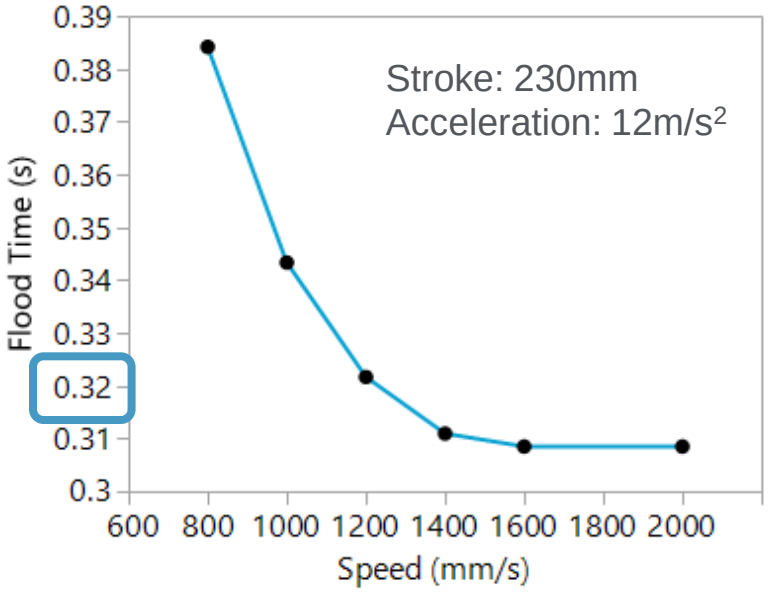
[BCS Simulation Data]

1sec Cycle Time with Tempo Presto

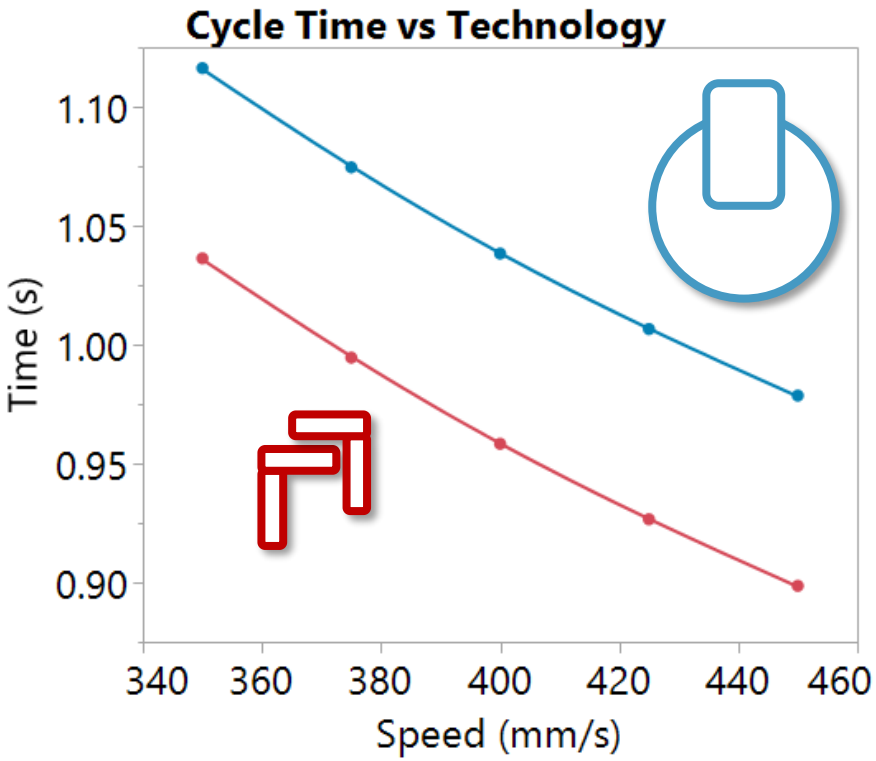
- New Tempo™ Presto automation based on 2 Linear Shuttles
- Transfer time 0.32sec vs 0.4sec table rotation (+550wph)
- Flood Speed >1,200mm/s





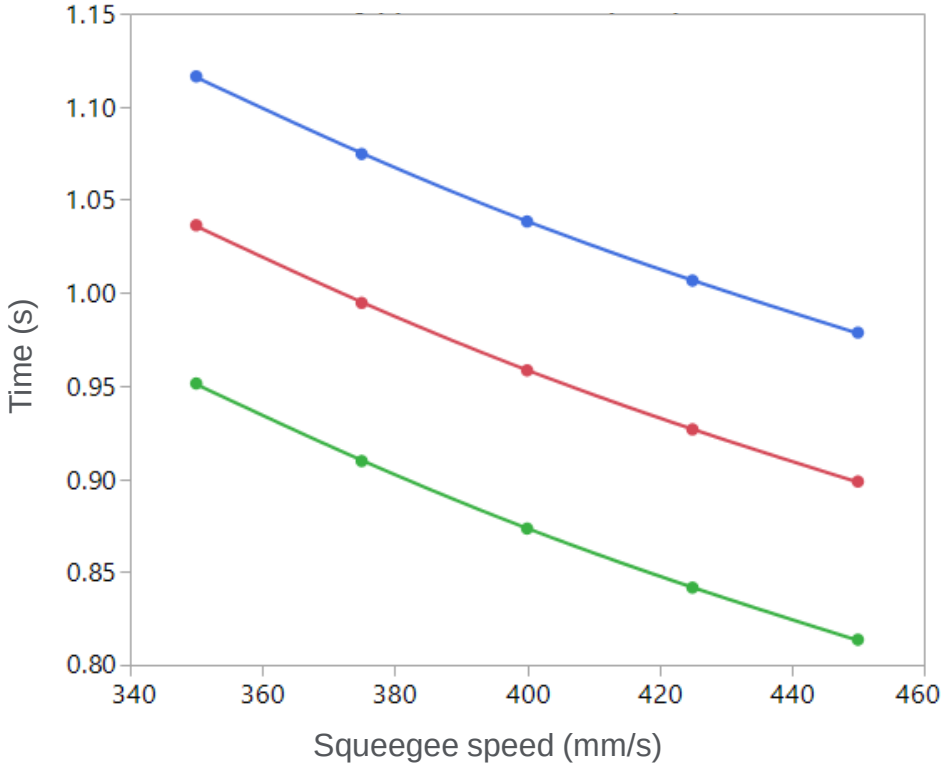


[BCS Simulation Data]

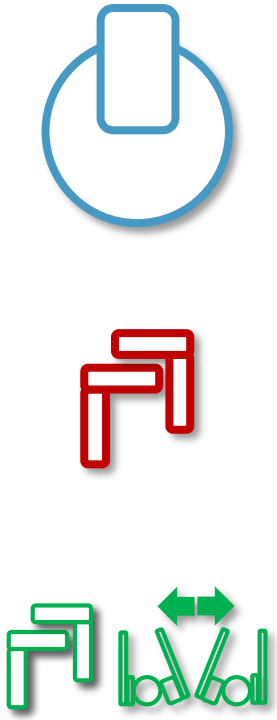


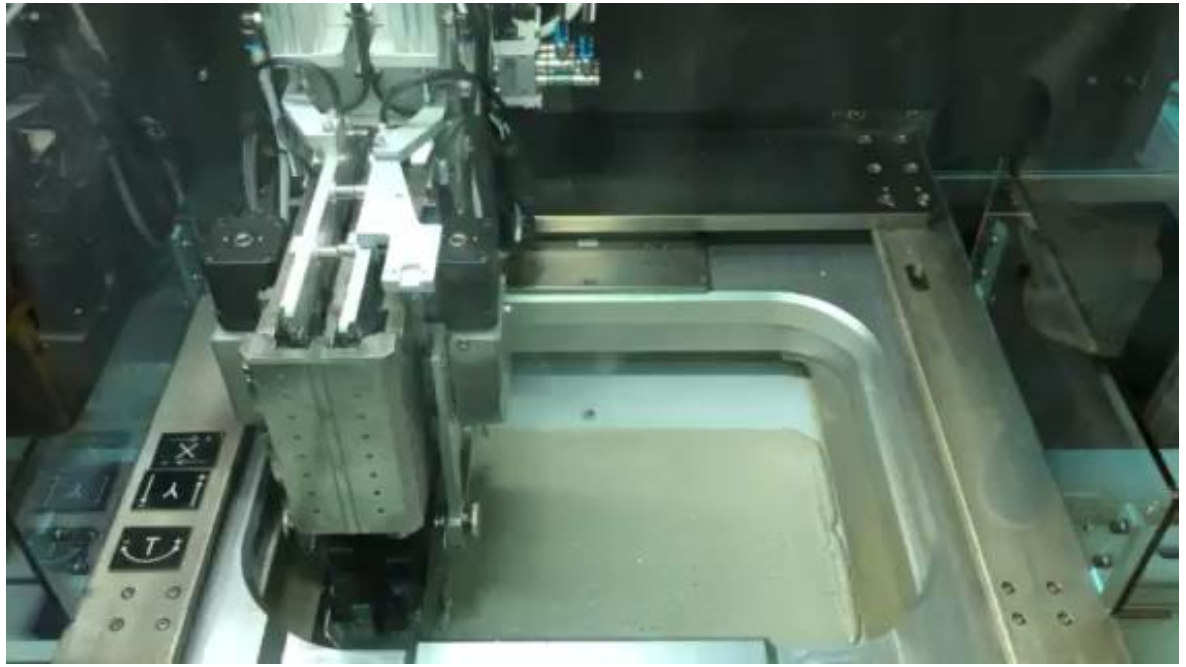
Volo Flood Concept – Patent Pending

- Volo Flood = 2 paste rolls = Print and Flood back and forth
- Printing Speed: from 430mm/s to 350mm/s for 0.95 sec Cycle Time (7,500wph)
- Applies to all printing steps, including backside Aluminum



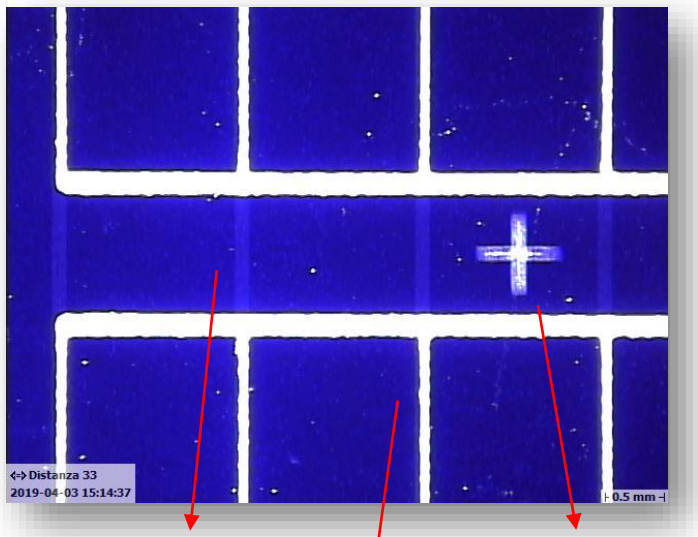
[BCS Simulation Data]





Better than 8um Precision

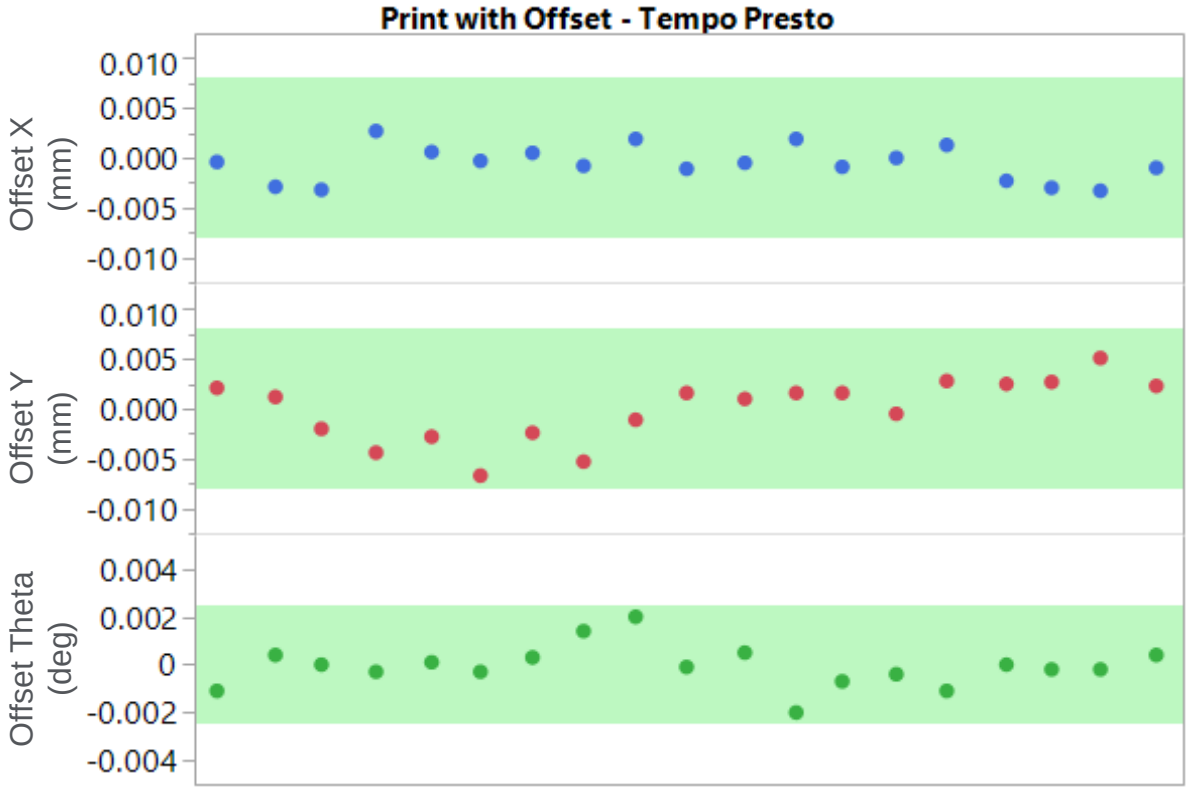
- Printing twice the same pattern shifted by a fixed offset
- Applies to bi-PERC, SE, FLDP cells

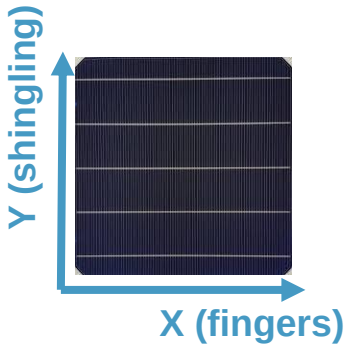


SE finger 90um

Ag finger 40um

SE fiducial





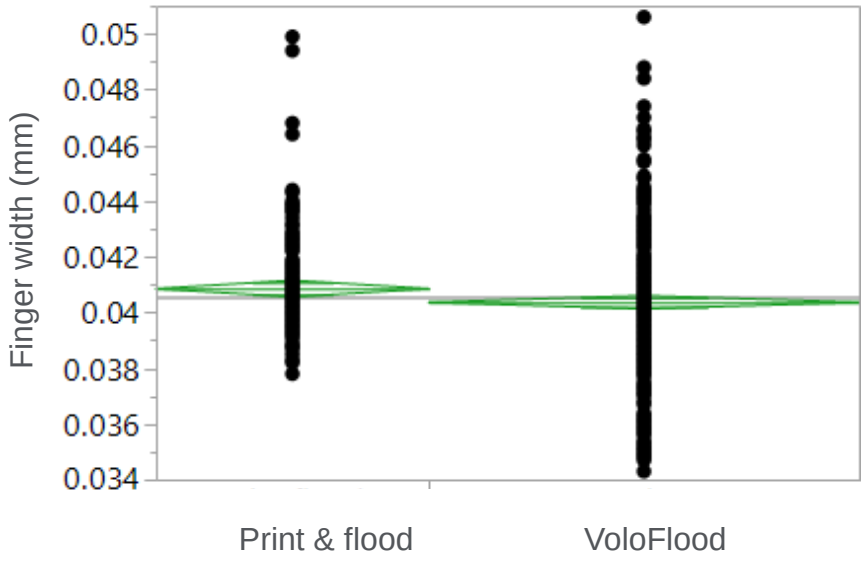
< ±8um

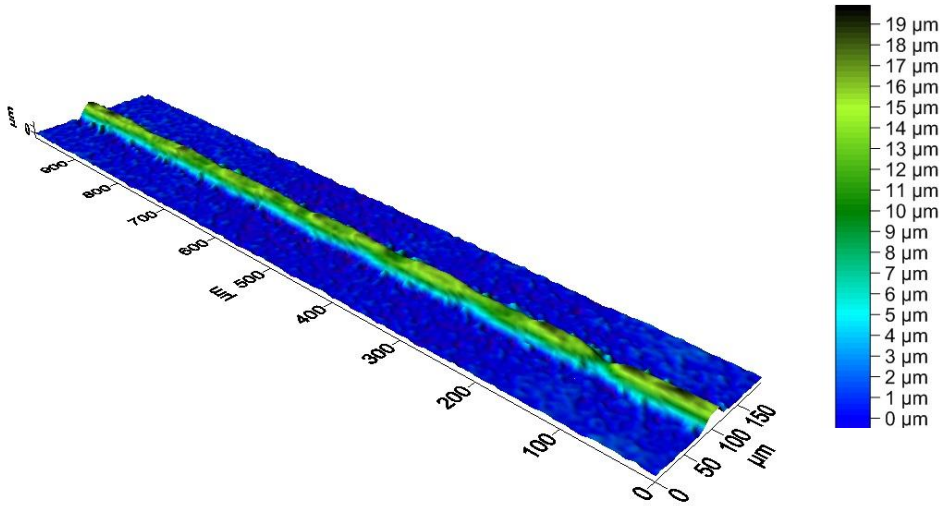
< ±8um

< ±2.5mdeg

Double Printing Lab Results with Volo Flood

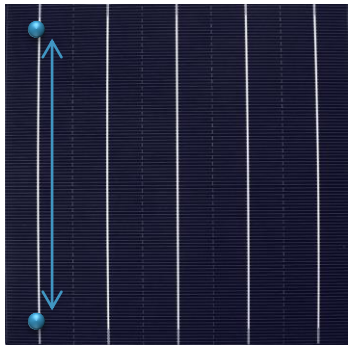
- Purpose: compare Print & Flood process and Volo Flood on Tempo™ Presto, with two different screens
- Under same conditions, comparable finger width is achieved by both systems

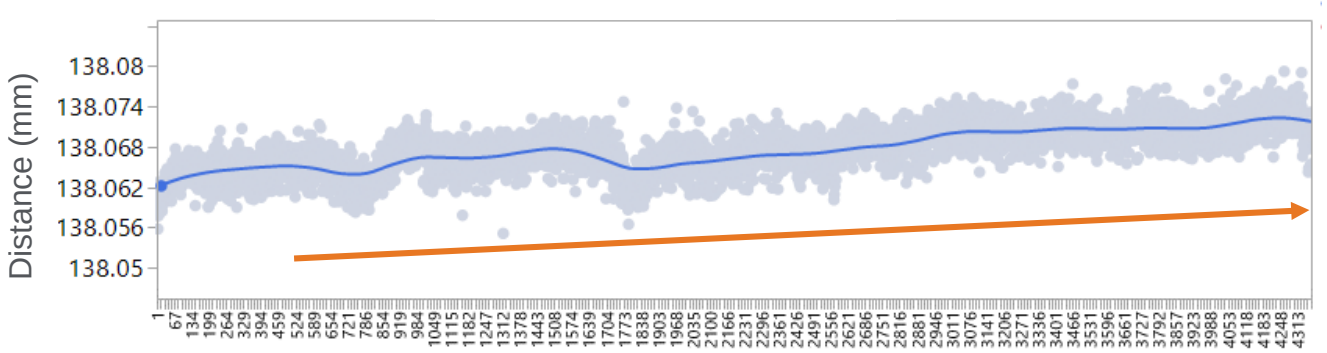




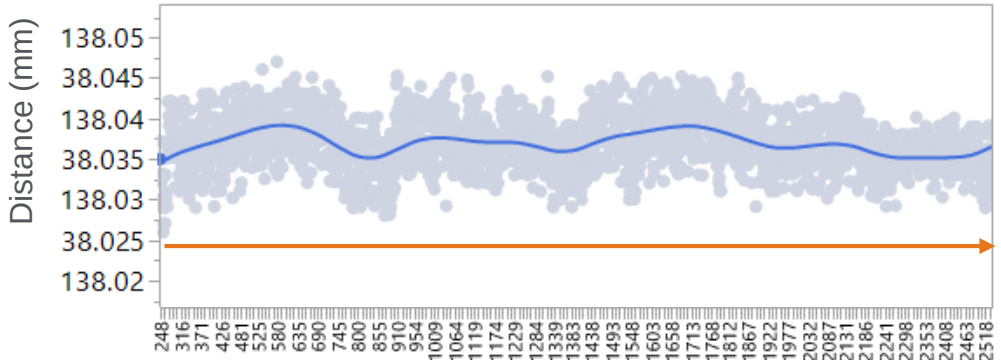
Fine Line Double Printing - Production Data

- Performed 3,000 wafers pilot run with Volo Flood
- Automatic printing direction management for improved printing control
- Improvement in screen pattern stability and Screen Lifetime due to Volo Flood





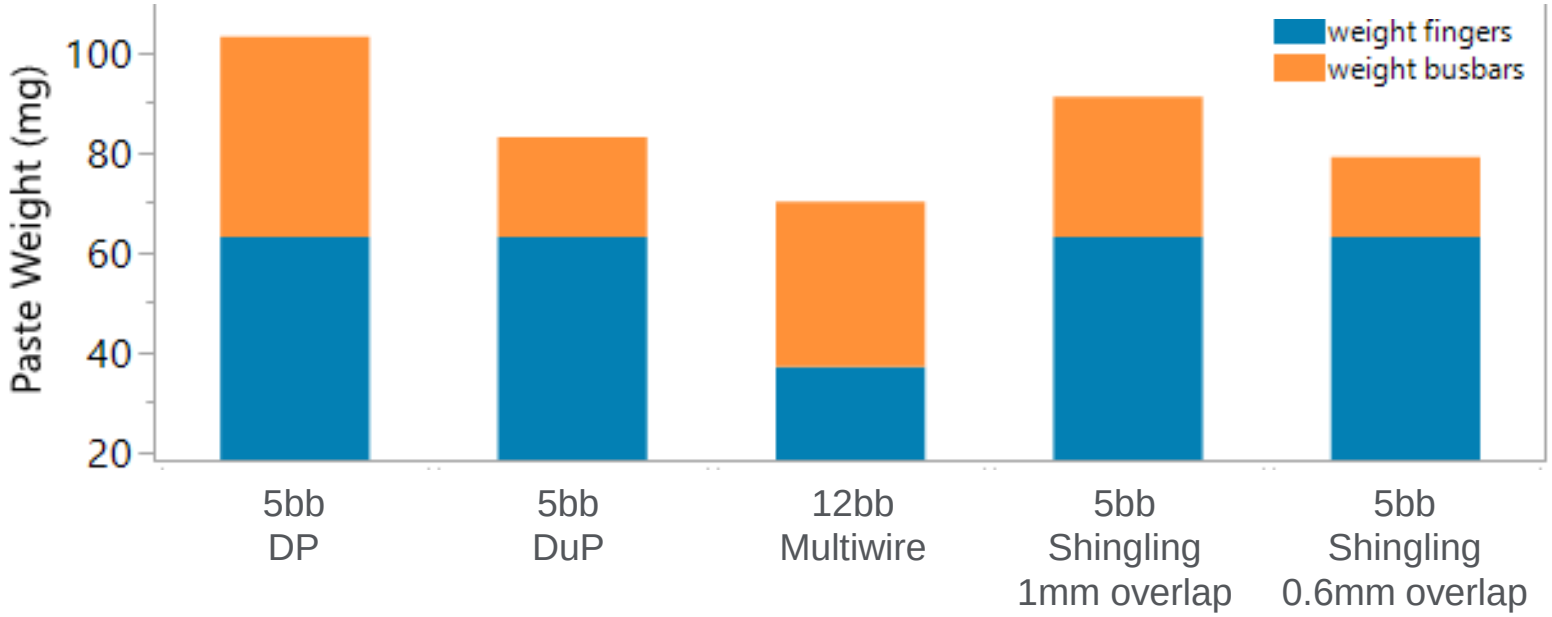
Print and Flood
New screen: 4,000wafers
>8um deformation



Volo Flood
New screen: 2,600wafers
No detectable deformation

Developments towards Ag Paste Saving

- Shingling
  - Overlap reduction, thin busbars
- Front Process
- Heterojunction nano-Paste

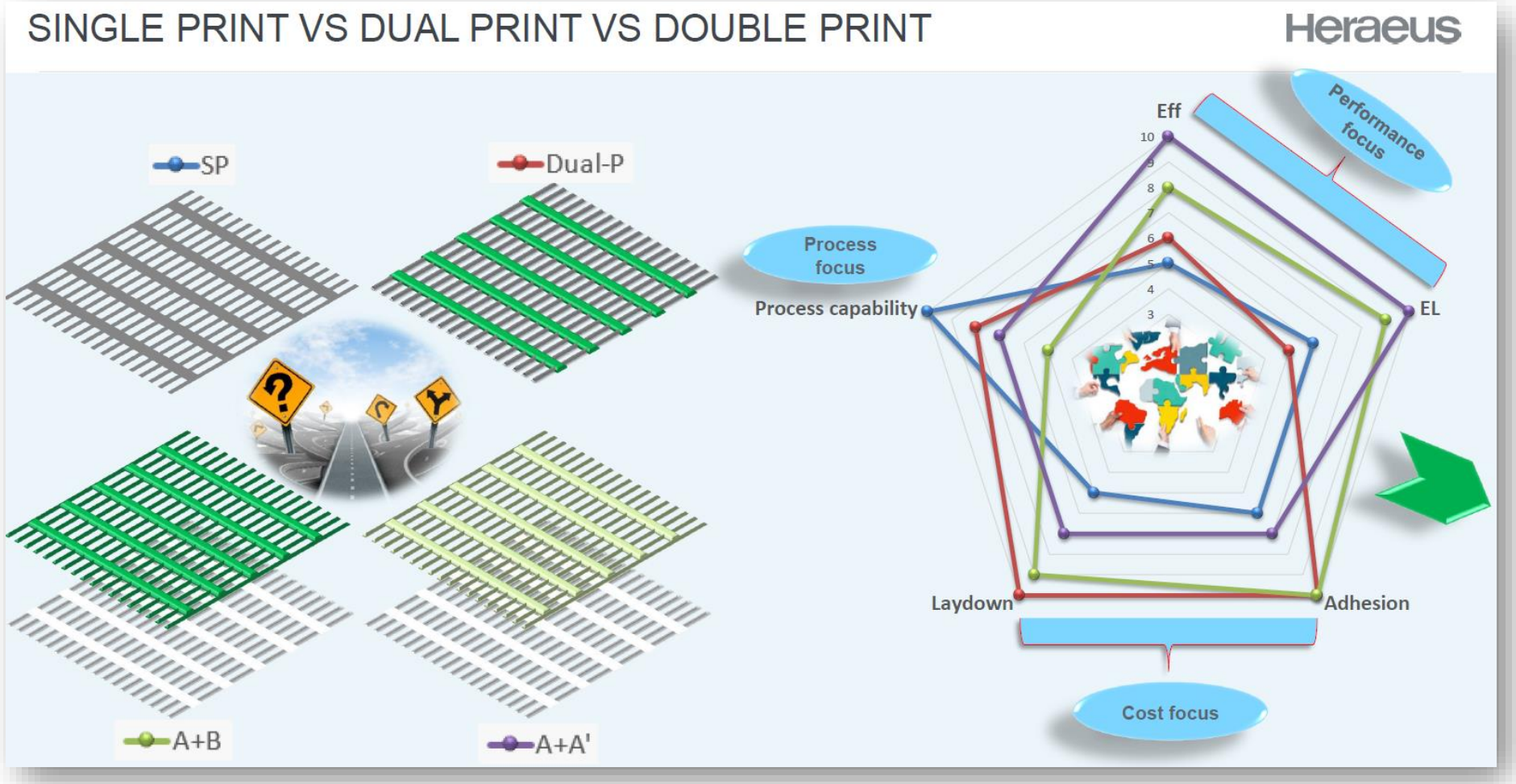


simulation condition	finger height (mm)	busbar width (mm)	busbar height (mm)
5bb DP	0.017	**0.85**	0.01
5bb DuP	0.017	**0.85**	**0.005**
12bb MW	**0.01**	**0.3**	0.01
5bb SHG 1mm	0.017	**0.6**	0.01
5bb SHG 0.6mm	0.017	**0.35**	0.01

100 fingers, 40um finger width for all conditions

Developments towards Ag Paste Saving

- Shingling
  - Overlap reduction, thin busbars
- Front Process
  - Double and Dual Printing
- Heterojunction nano-Paste



[Enabling higher efficiency through metallization improvements and breakthroughs | Dr. Weiming Zhang | Heraeus Photovoltaics, PVCelltech, Penang, Mar2019]

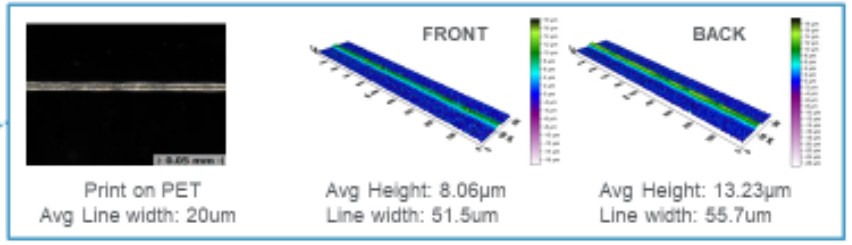
Developments towards Ag Paste Saving

- Shingling
  - Overlap reduction, thin busbars
- Front Process
  - Double and Dual Printing
- Heterojunction nano-Paste
  - Increased conductivity

New HJT paste

- Main advantages
  - Medium Viscosity → Increase the Printing Speed
  - High Conductivity → Paste Cost Saving
  - Low Particle Size → Increase CE, Fine Line Printing
- Technical Achievement at R&D level

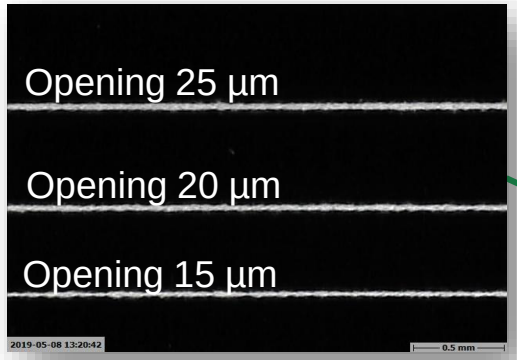
Printing Speed	Up to 500 mm/sec
Conductivity	Up to 50% Ag bulk
Fine Line Printing	Proven down to 20 µm Avg. Linewidth 50-55 um
CE (%)	~ Same range as baseline
Paste Laydown	Almost 45% reduction*
Adhesion/Solder	Yes / Tests ongoing
Contact Resistance	~ Same range as baseline

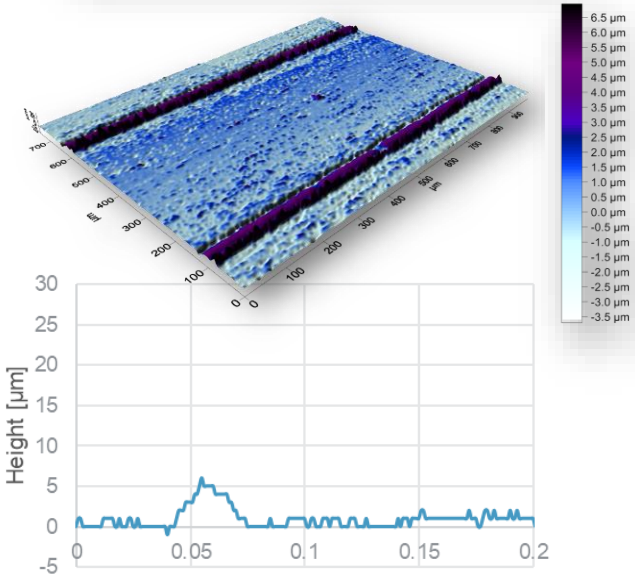


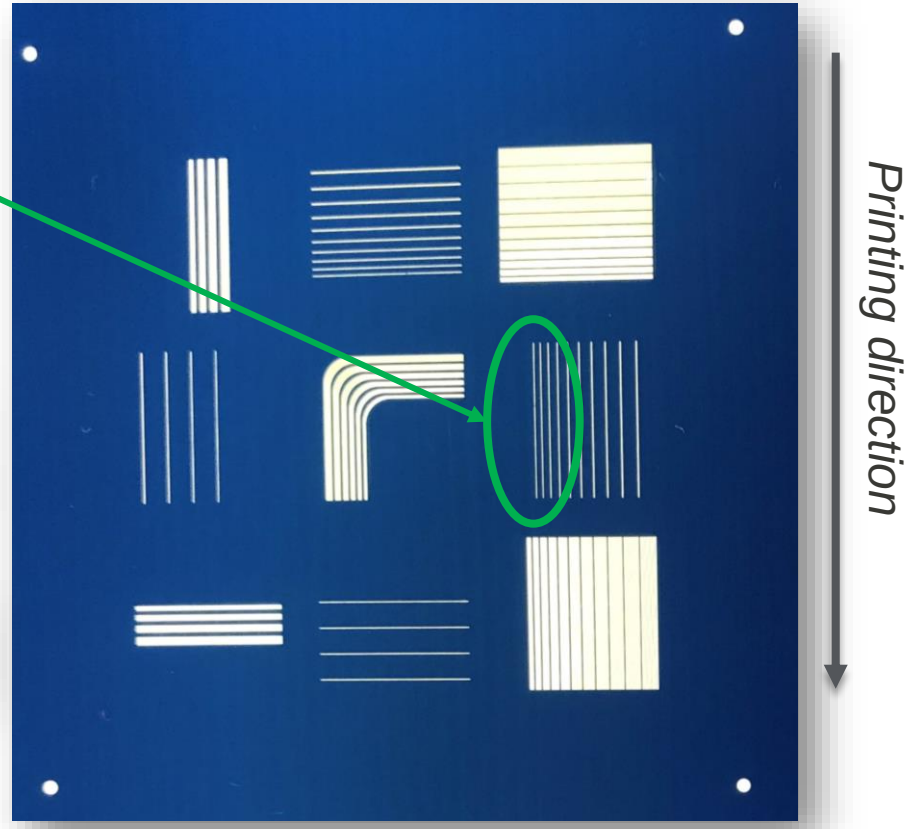
Process Parameters	
Drying Time	2-3 minutes
Drying Temperature	130°C
Curing Time	20 minutes
Curing Temperature	200°C

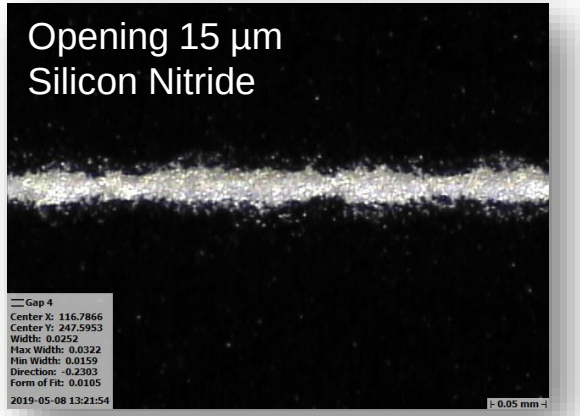
Fine Printing Process Development

- Fingers printing at 25um x 5um – influence of substrate

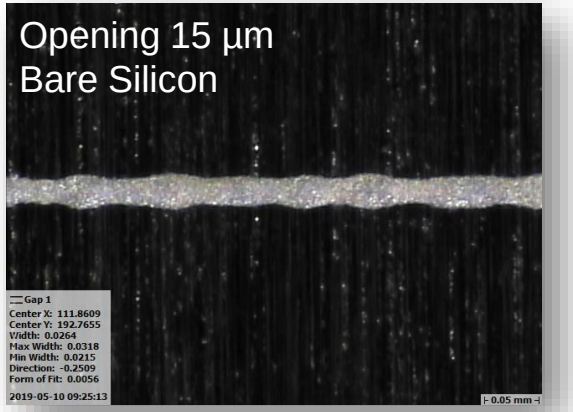








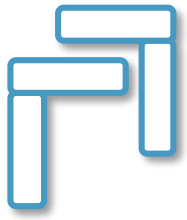
Measured line width: 25 µm

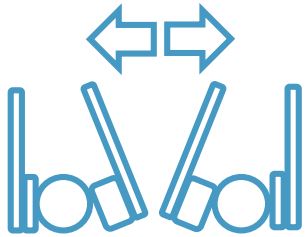


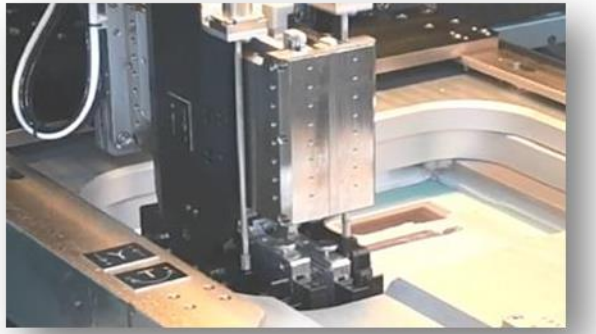
Measured line width: 26 µm

Conclusions

- Tempo™ Presto shuttle architecture allowing fastest handling at 0.32sec
- Volo Flood printing process enabling 7,500 wph at 350mm/s printing and flooding speed
- BCS continuous improvements:
  - Tool precision ±8um
  - Process development for paste saving







Thanks for your attention!

APPLIED MATERIALS®

make possible