DEK Solar

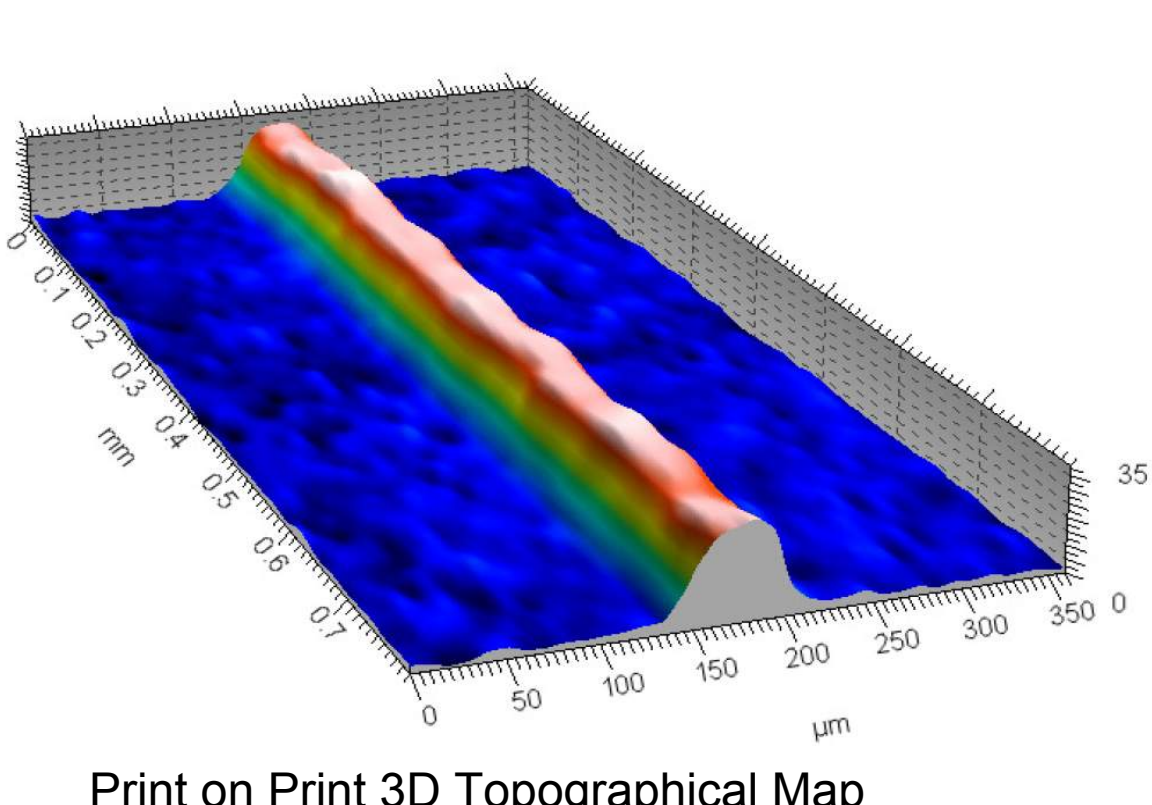
Development of a ‘Print On Print’ Process For High Aspect Ratio Frontside Conductors,

a 15 minute summary,

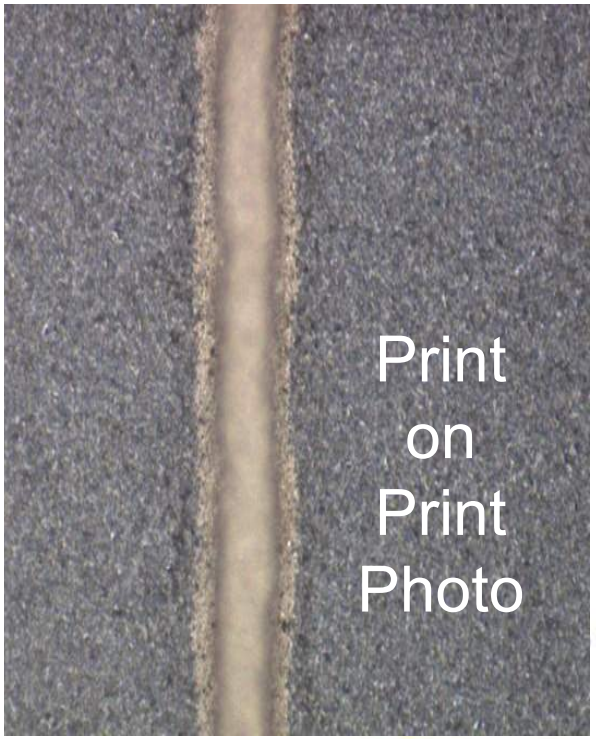
Tom Falcon & Alan Hobby 14/04/2010

PoP: 60µm on 60µm

- Pictures show a double printed conductor.
- Width 80µm, Height = 33µm.
- Note the uniformity of height and width.



Print on Print 3D Topographical Map

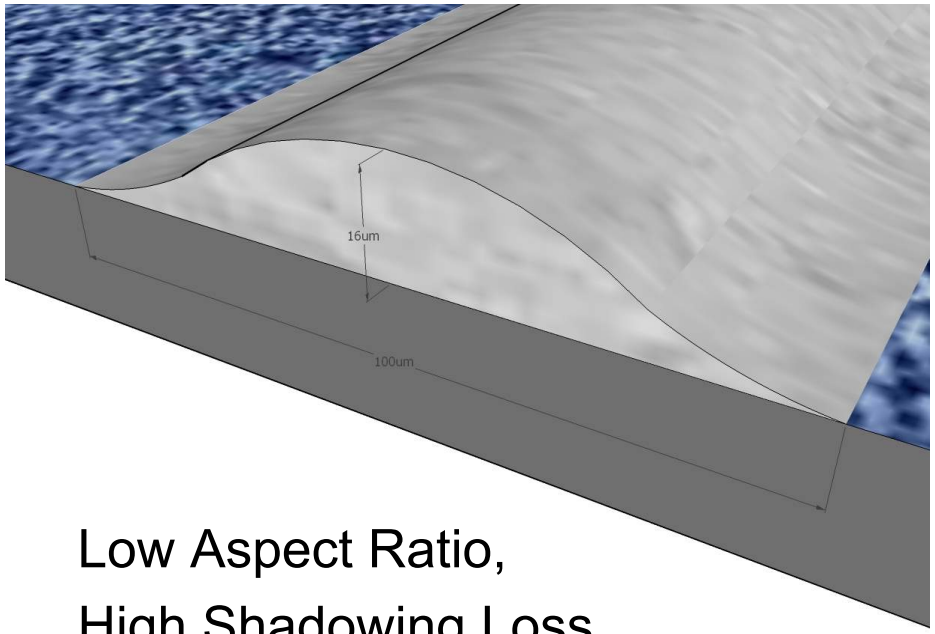


Agenda

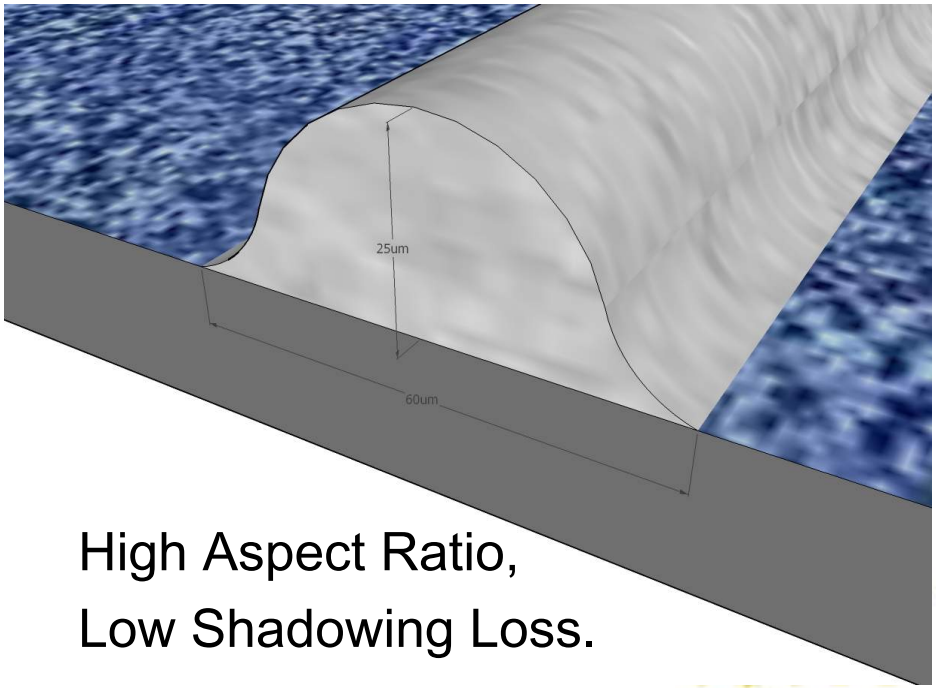
- Background.
- 1st Print.
  - Screen Type,
  - Process,
  - Paste.
- 2nd Print.
  - Additional Challenges of PoP,
  - Screen Type / Paste,
  - Equipment,
  - Process,
- Results.
- Conclusions.

Background

- Conductors typically shade 6 to 8% of silicon area.
- Narrower, taller conductors expose more silicon to light.
- Low, narrow conductors have high resistance.
- Tall, narrow, and uniform conductors are most effective.



Low Aspect Ratio,
High Shadowing Loss.



High Aspect Ratio,
Low Shadowing Loss.

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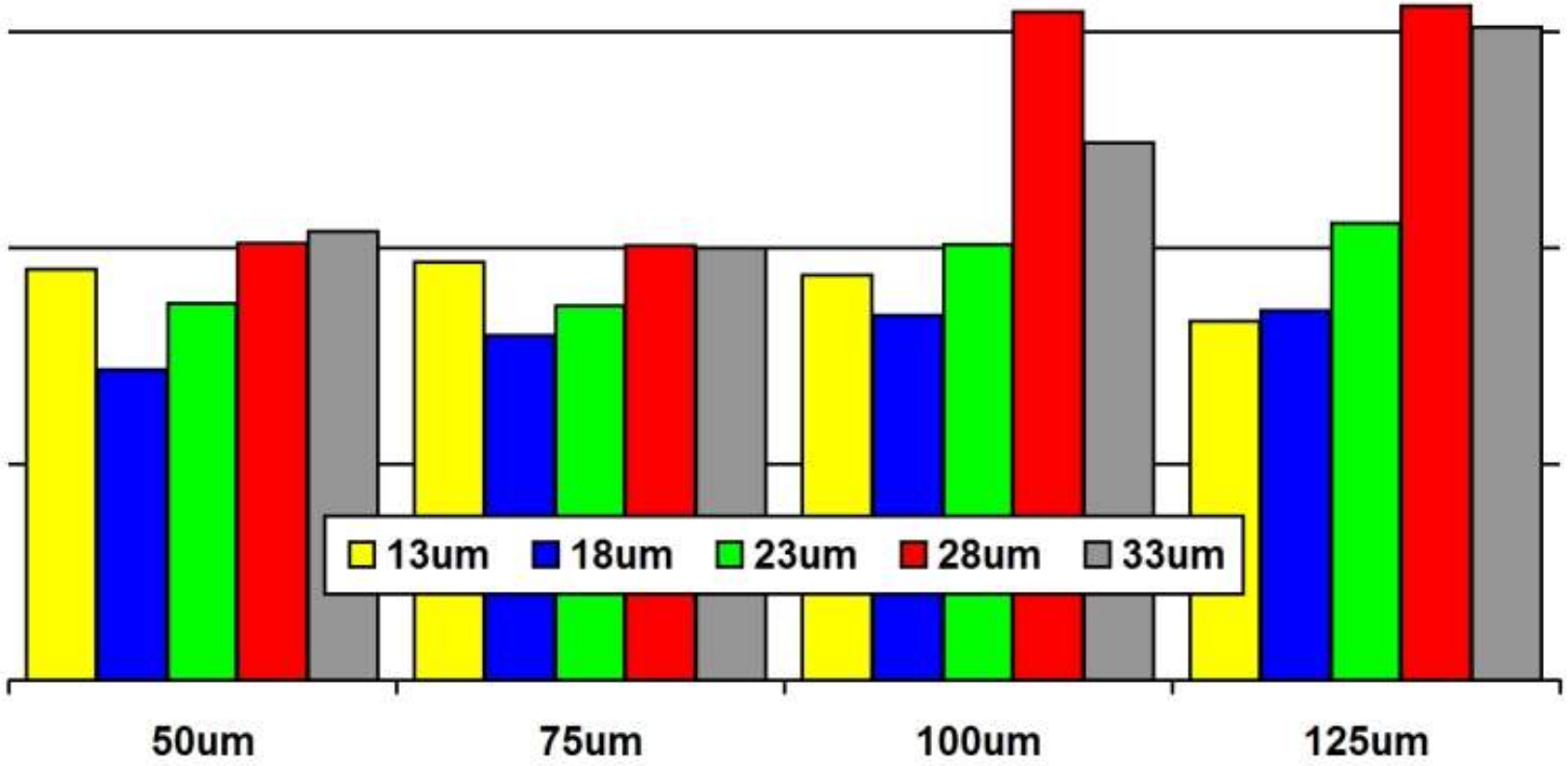
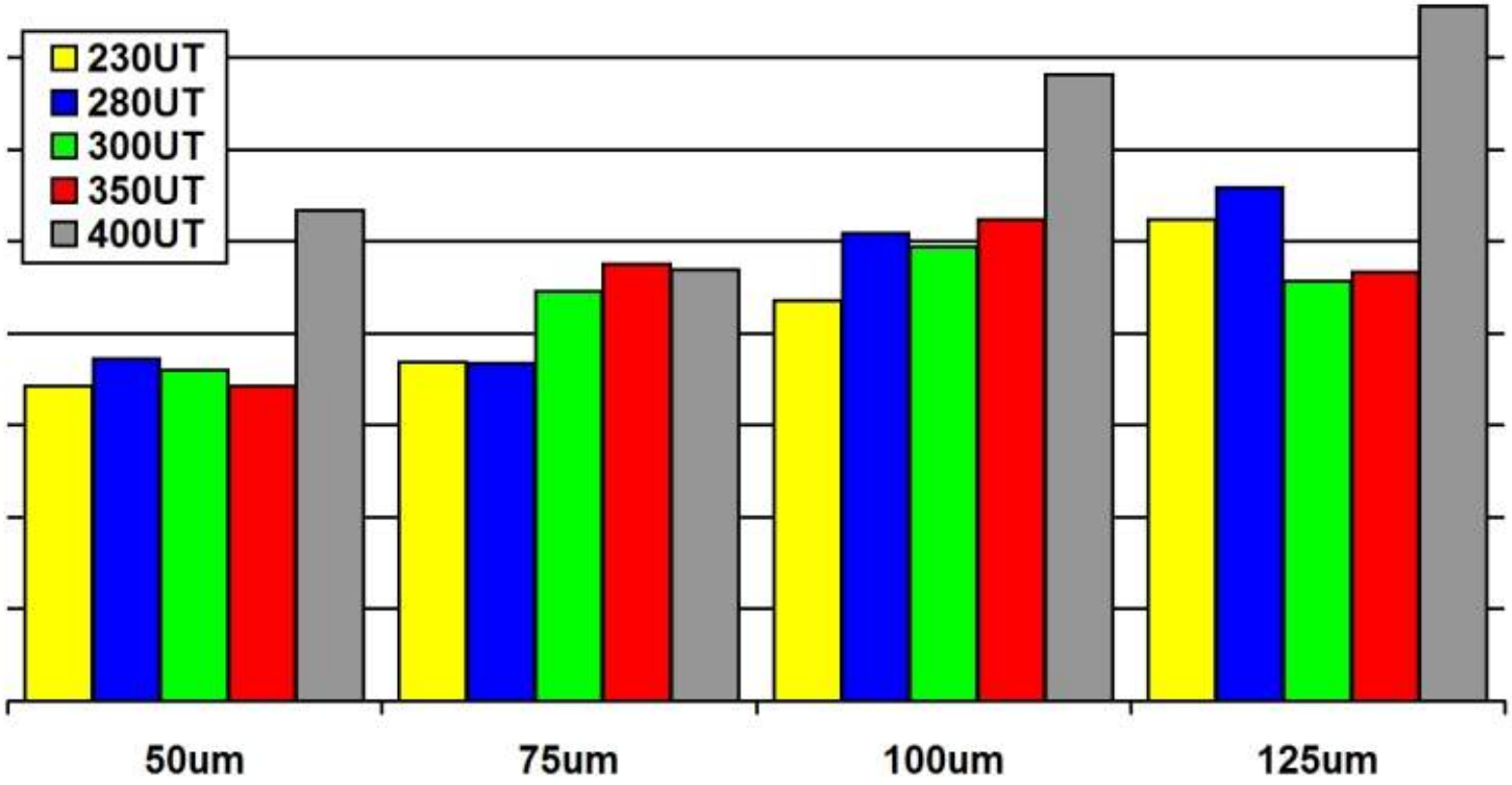
Emulsion Effect on A.R.

Chart shows relative aspect ratios achieved by various emulsion thicknesses for 50µm to 125µm line widths.



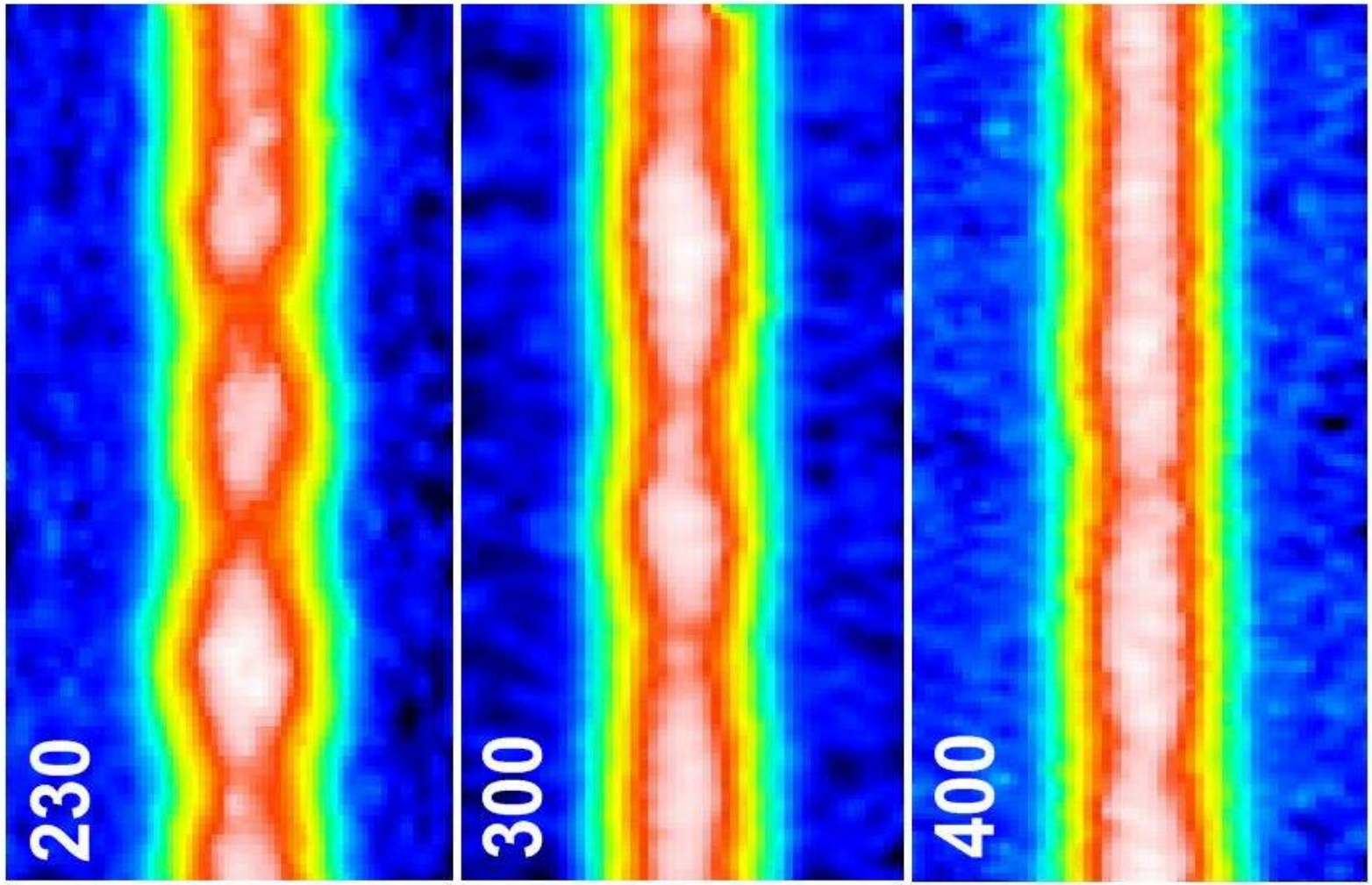
Mesh Effect on Aspect Ratio

Chart shows relative aspect ratios achieved
by various mesh types for 50µm to 125µm line widths.



Mesh Effect on Uniformity

Height contour maps show better uniformity on finer meshes.



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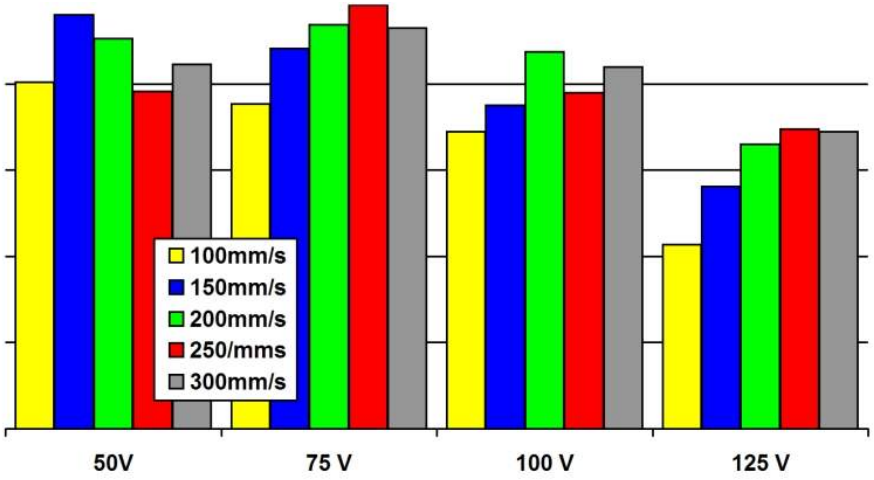
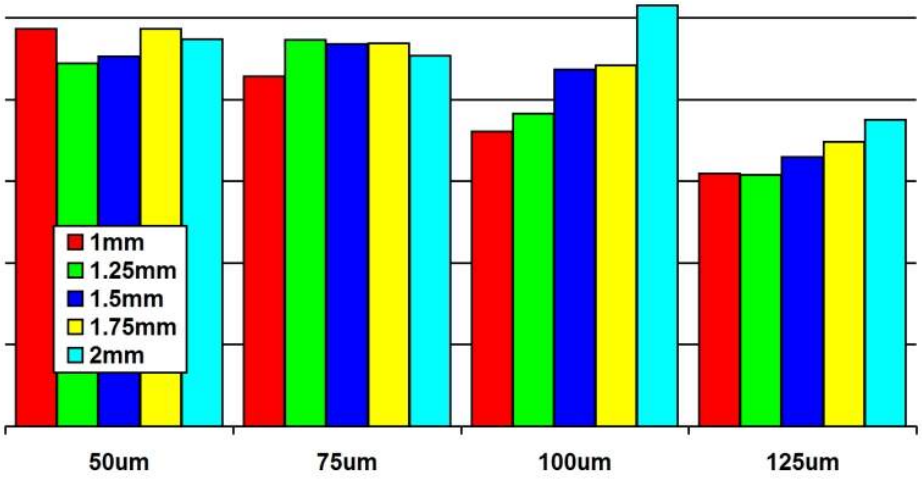
Print Parameter Effect on A.R.

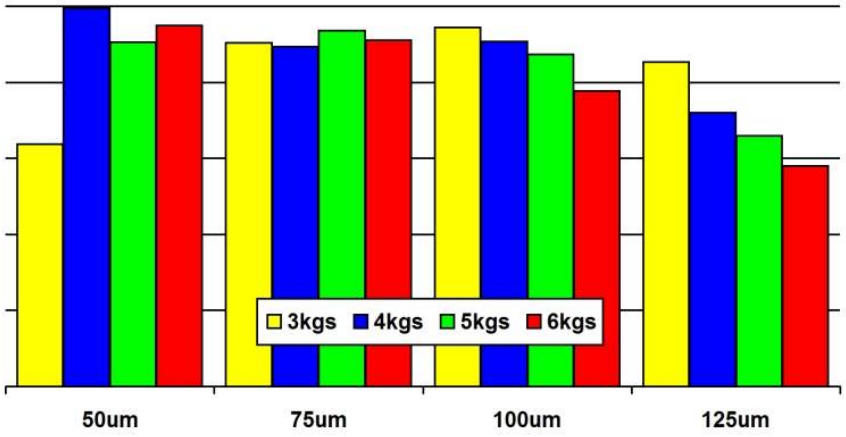
Print Speed



Print Gap



Print Pressure



Process parameters don't make a big difference.

Should be used for fine tuning only.

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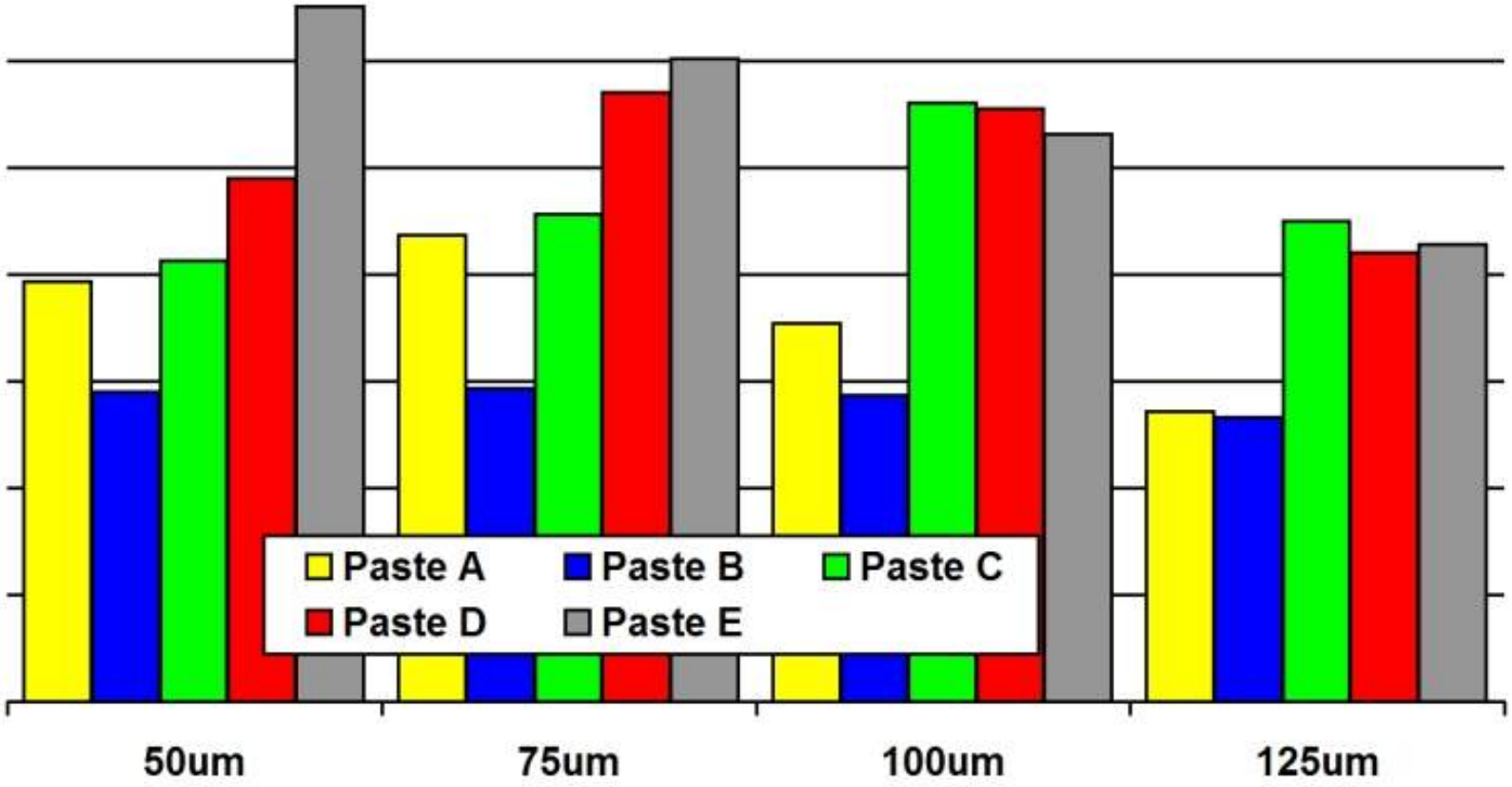
Paste Effect on A.R.

Chart shows relative aspect ratios achieved
by various paste types for 50µm to 125µm line widths.



Paste type makes a huge difference !

First Print Conclusions:

- Paste choice has the greatest effect.
- Finer meshes give better Aspect Ratio and uniformity.
- Thicker emulsions give better AR but less uniformity.
- Moderate emulsion gives better platform for 2nd print.
- Process parameters have only a slight effect.

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PoP Challenges

- **Screen stretch & shrink - ideally less than 0.005%**
  - Poor alignment gives wide lines and low aspect ratios.
  - Chrome glass phototools and accurate mesh tensioning required.
  - Temp. stability required for all stages of screen manufacture and use.
- **Alignment to wafer edges OK, topside features better.**
  - Printing alignment marks with the 1st print helps the 2nd print.
- **Two paste types, base for contact & top for conductivity.**
  - This adds complexity to the process but brings added benefits.
- **Two screen designs.**
  - 1st screen often has fingers and busbars, 2nd has fingers only.
  - 2nd screen often benefits from a narrower aperture (eg 50 over 60µm).

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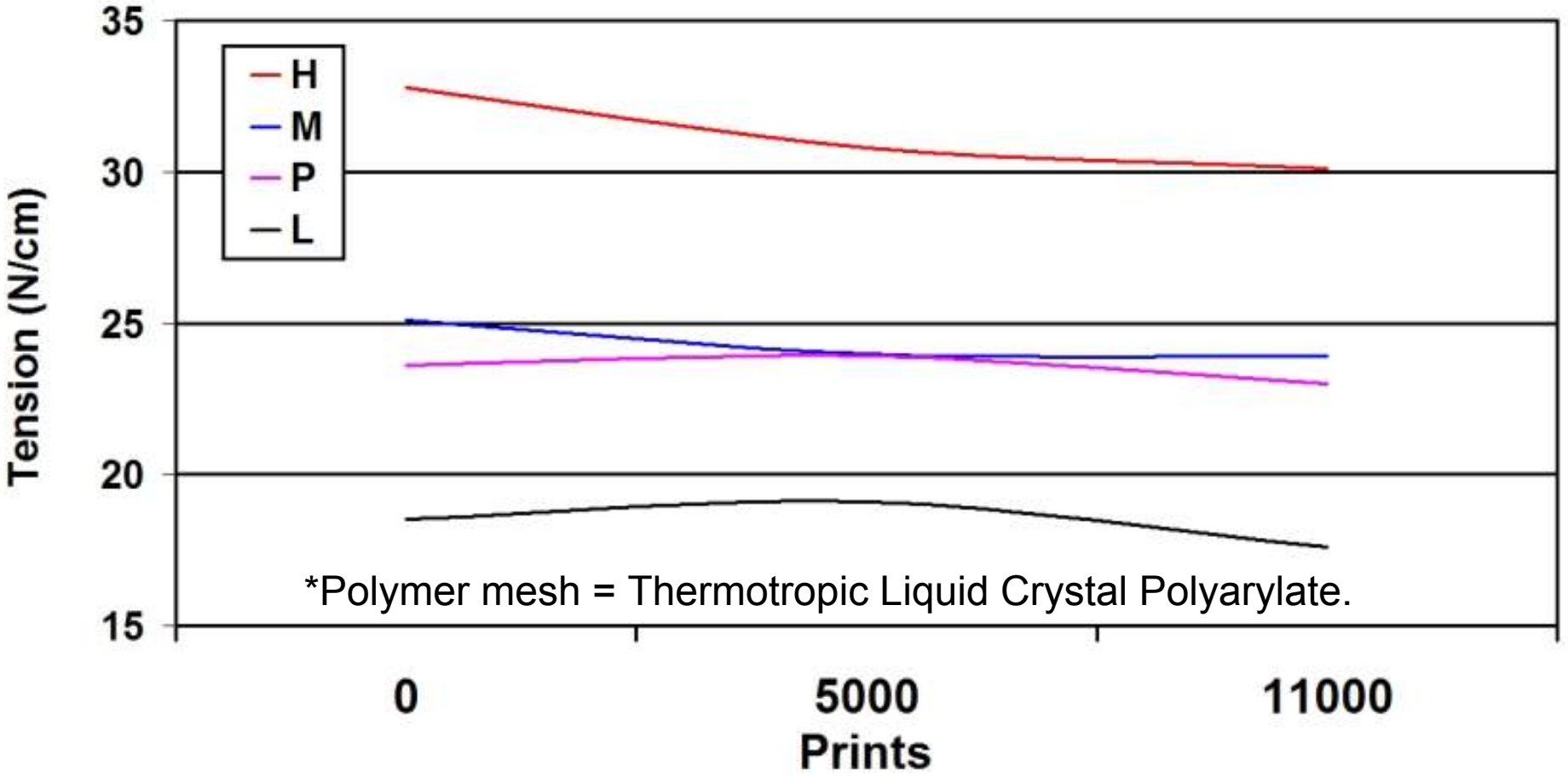
Screen Tension Losses:

H = High Tension
M = Med. Tension
L = Low Tension
P = Polymer Screen*

Relaxing screens cause mis-alignment

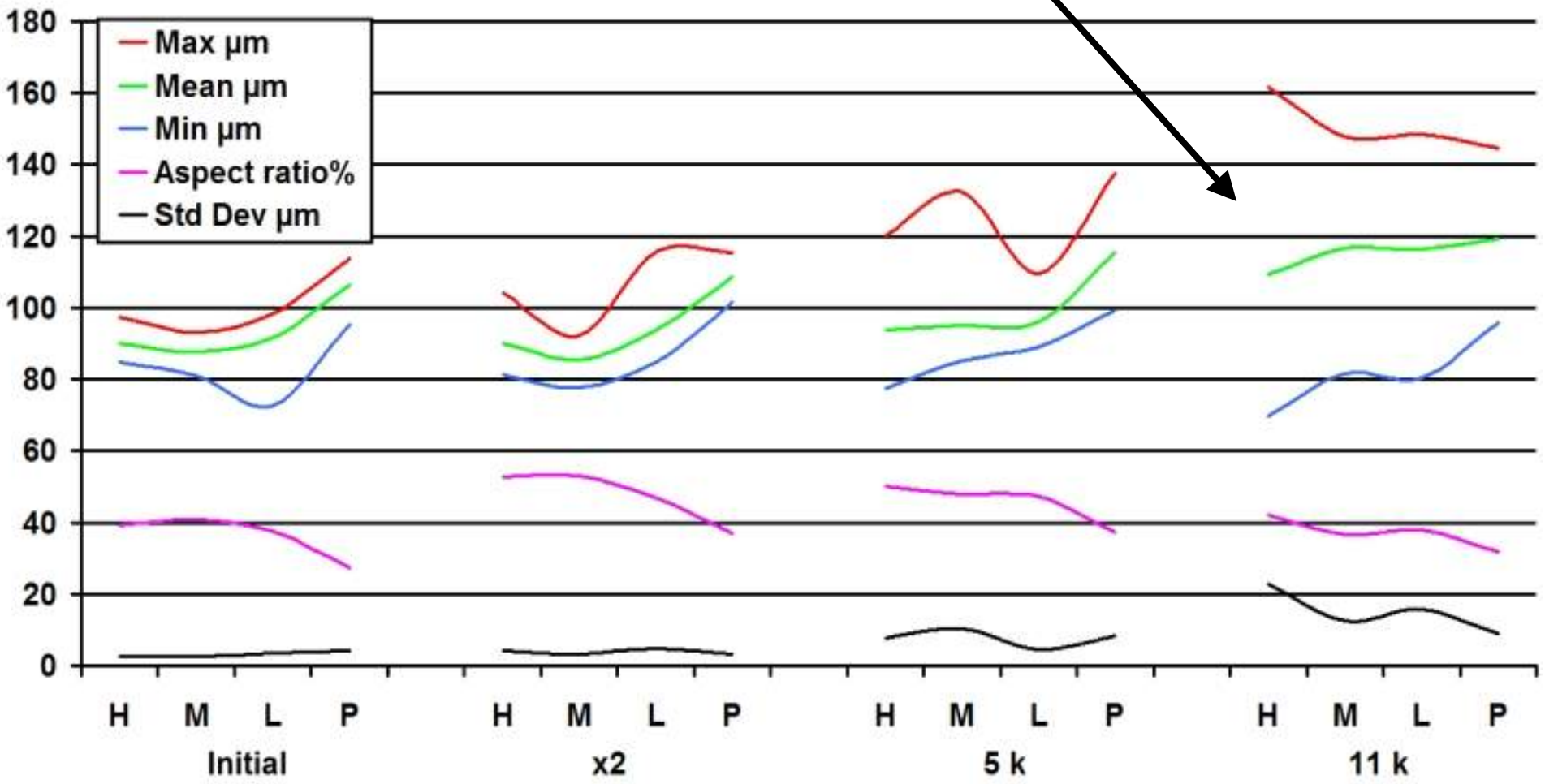


*Polymer mesh = Thermotropic Liquid Crystal Polyarylate.

Print on Print line width over screen's lifetime…

H = High Tension
M = Med. Tension
L = Low Tension
P = Polymer Screen

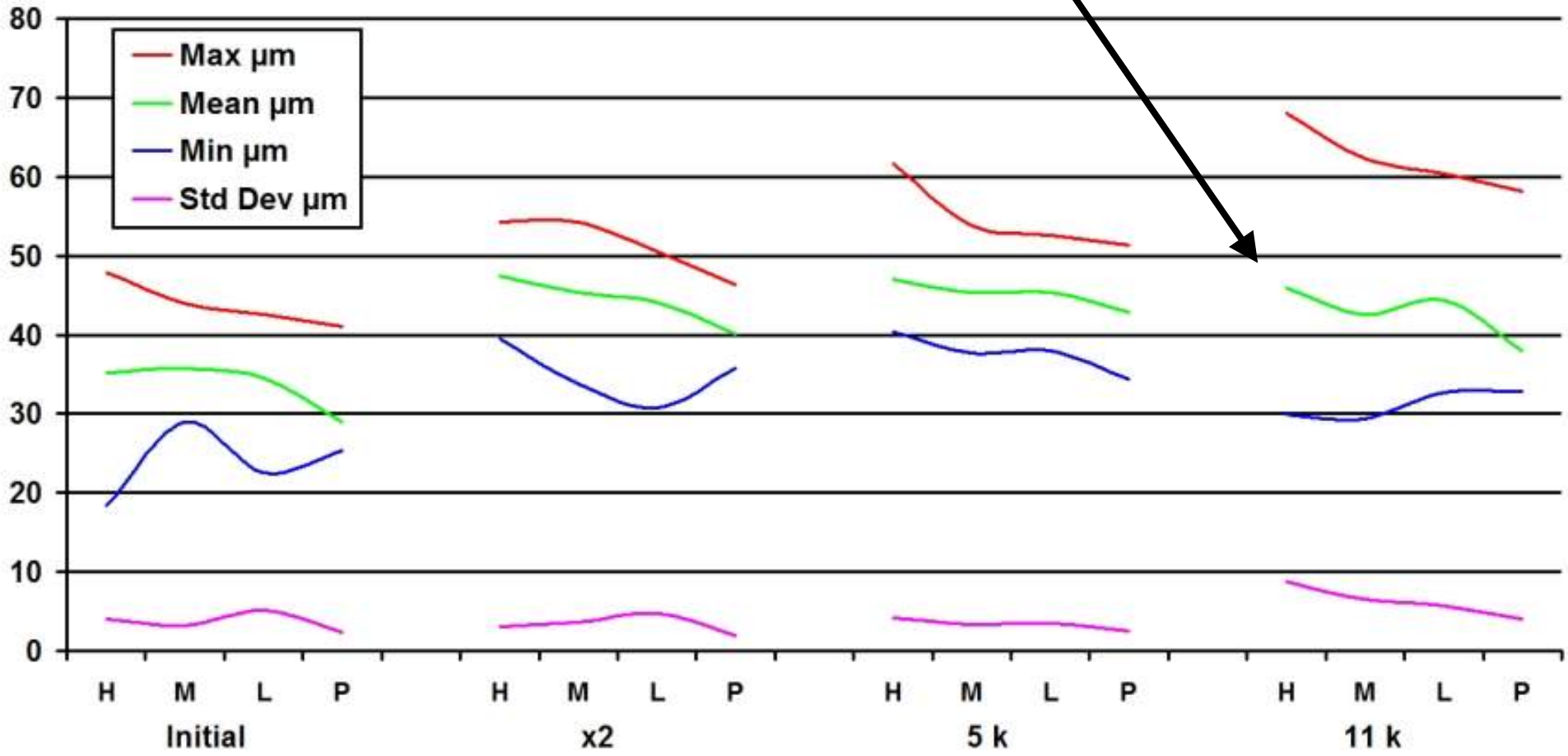
Width range increases dramatically over 10k prints



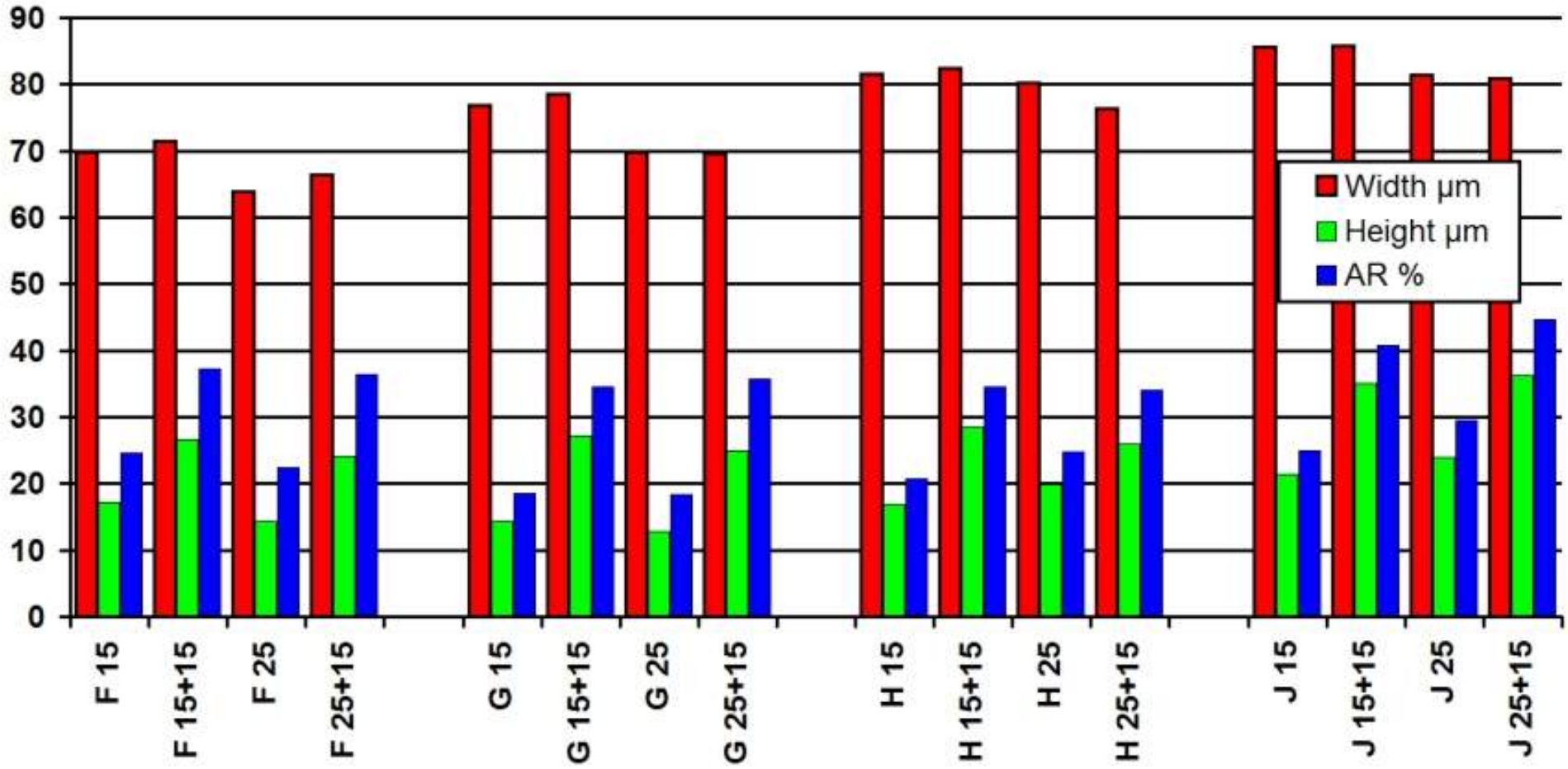
Print on Print line height over screen's lifetime…

Height range increases dramatically over 10k prints

H = High Tension
M = Med. Tension
L = Low Tension
P = Polymer Screen



Paste & Emulsion Effect.



Paste F Paste G Paste H Paste J

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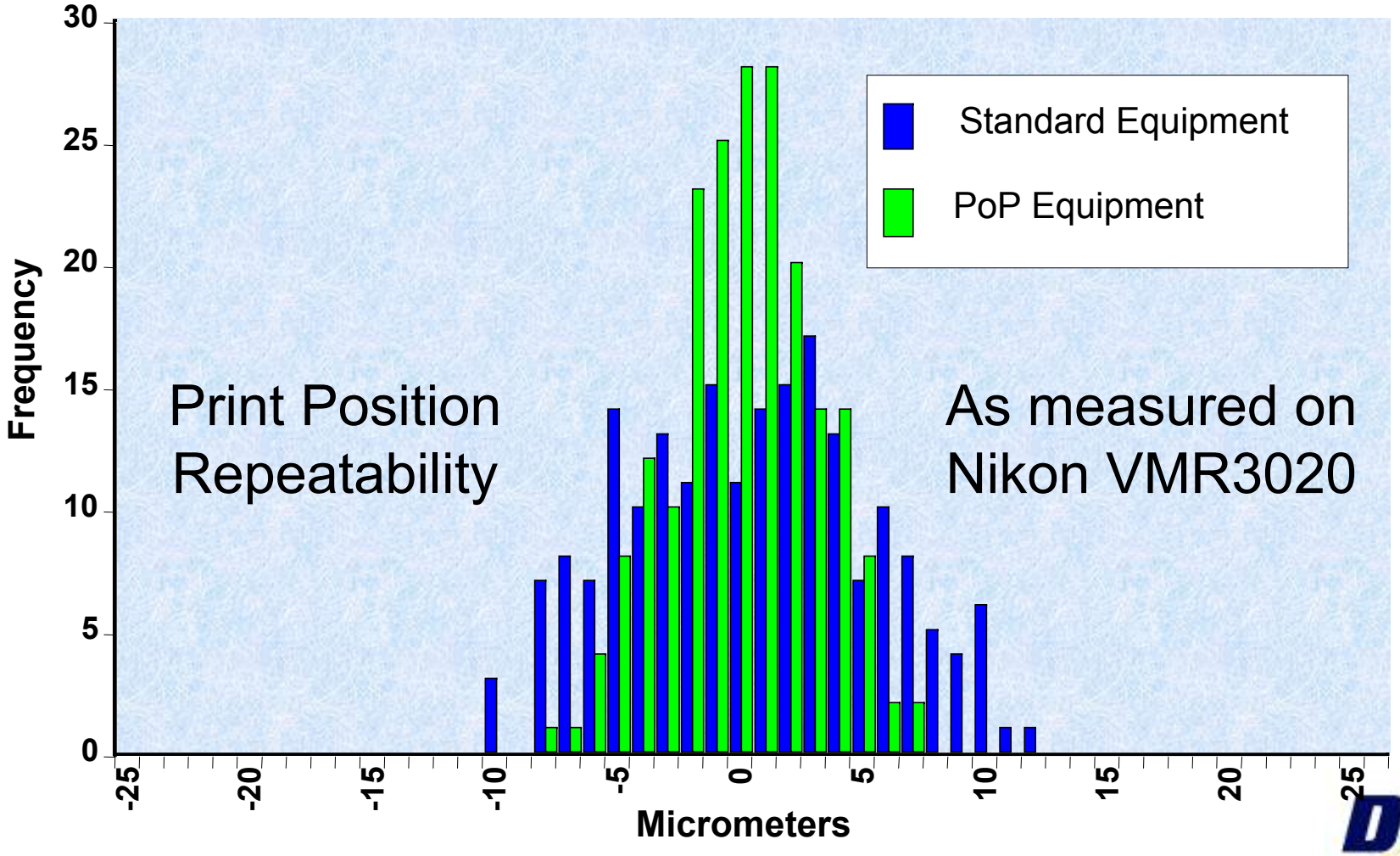
Equipment:

Alignment accuracy is the most important factor.



Agenda

- Background.
- 1st Print - Properly.
  - Screen Type,
  - Process,
  - Paste.
- 2nd Print - on Top.
  - Additional Challenges of PoP,
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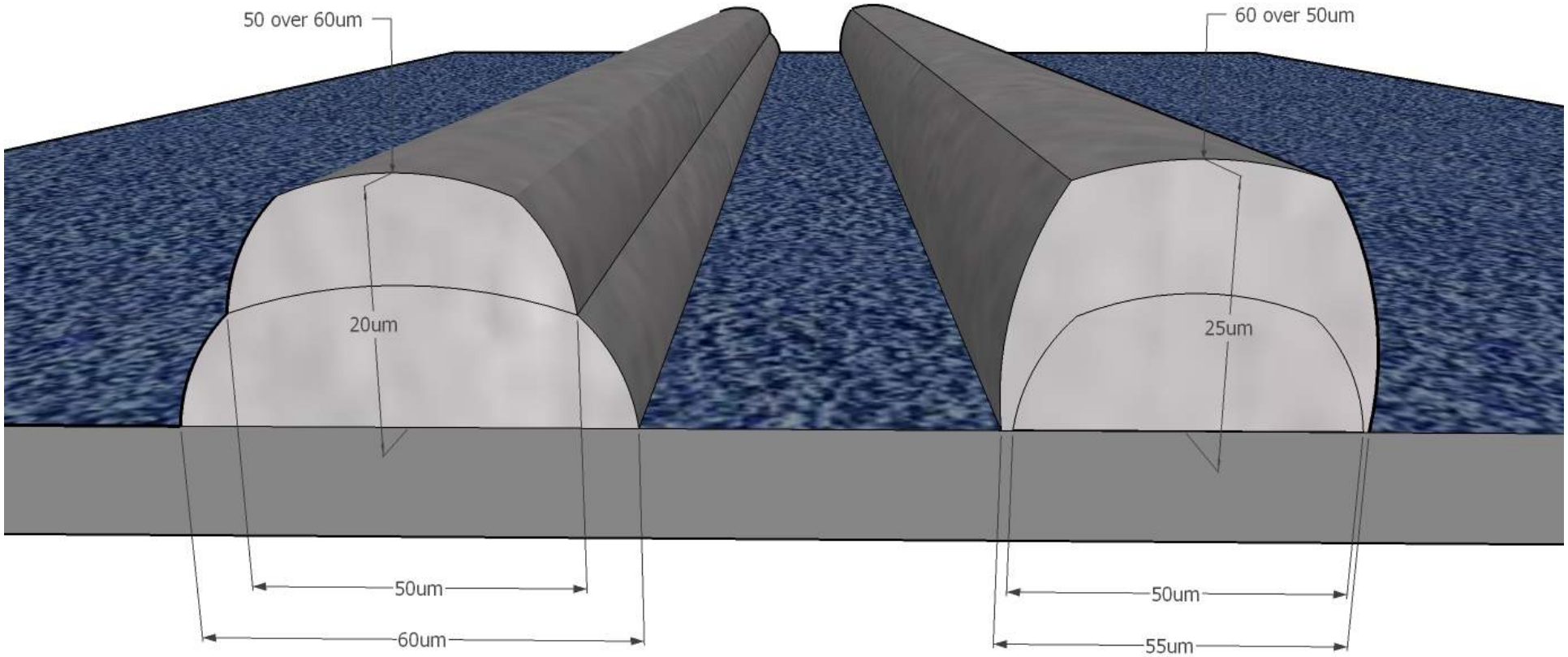
Print on Print

Wider base print with narrow 2nd print, or…

Narrow base print with wider 2nd print.



Process Parameters.

- As per 1st Print, process parameters are not the most important factor and should only be used for fine tuning.
- Having said that, the following generally apply to the 2nd print.

1. Lower squeegee pressures can help minimise line spread.
2. Lower squeegee pressures can also minimise drag on the screen and its associated misalignment.

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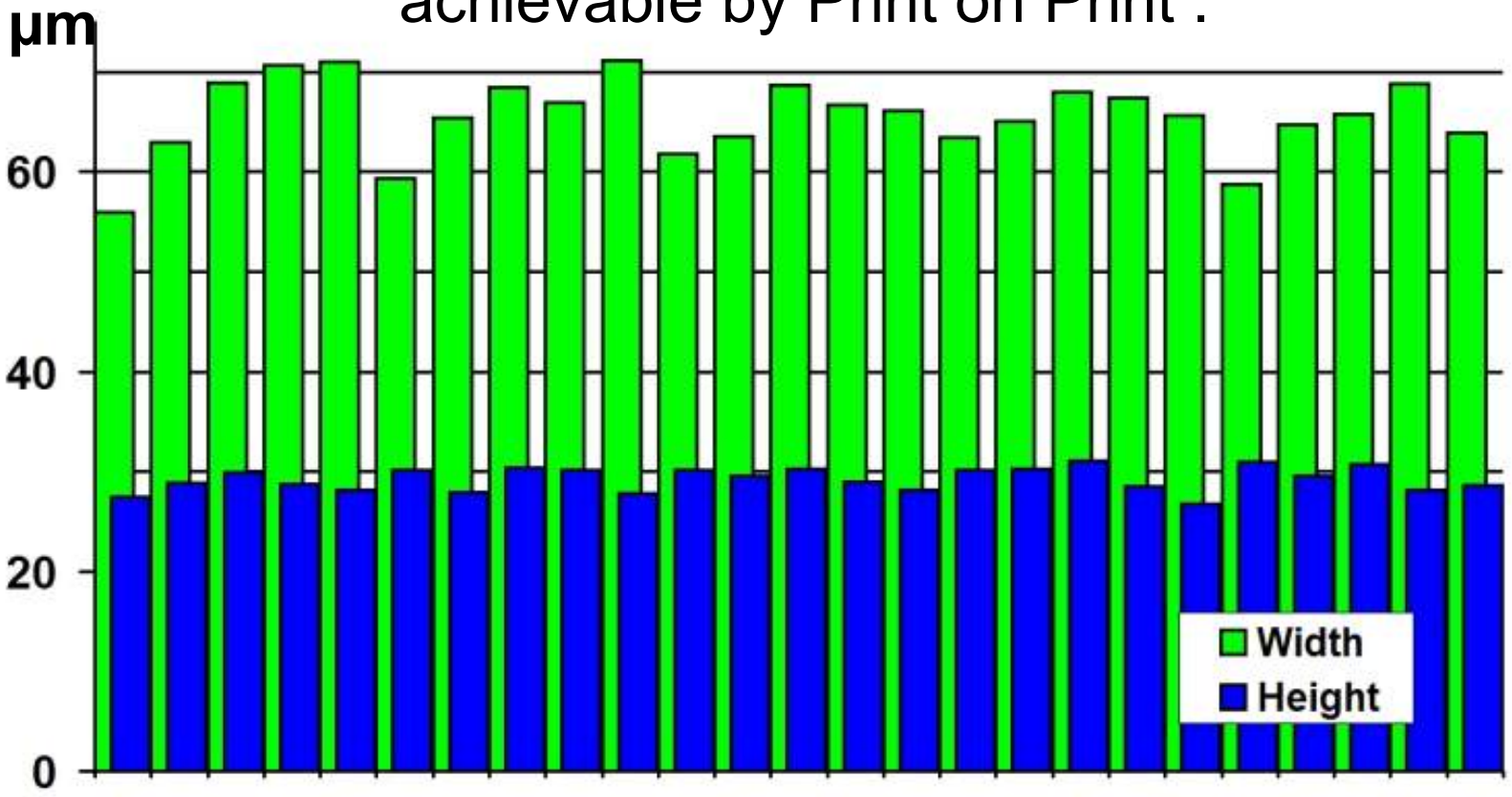
PoP: 60µm on 60µm

Chart shows line heights / widths (dried)
achievable by Print on Print .



Mean Width: 65µm, Mean Height: 29µm. A.R. 0.45
Single Print: 17um. A.R. 0.26

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PoP Conclusions

- Paste choice is critical to maximise performance.
- Quality screens required for 1st to 2nd alignment.
- Finer meshes / moderate emulsion give best prints.
- Screen life is around 7.5k wafers.
- ~40% increases in conductor aspect ratio possible and sustainable in high volume over single print.

Questions?

Thanks for your attention,

for further information, please contact:

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