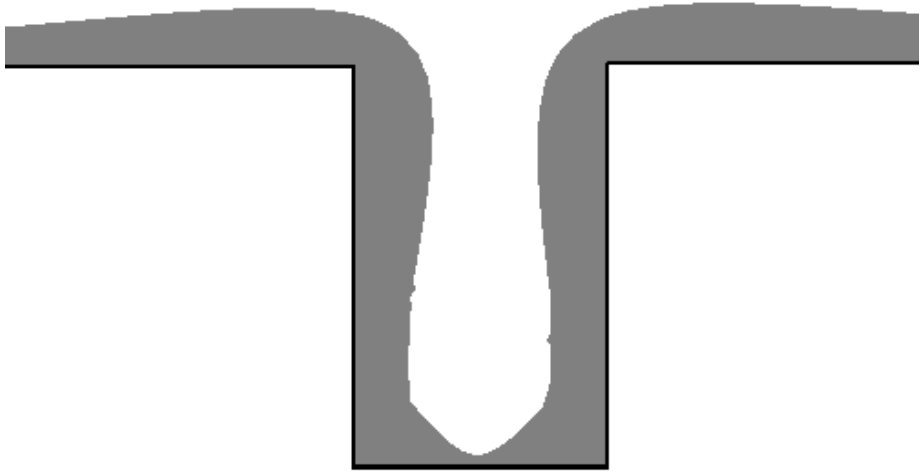
Via Fill in Small Trenches using Hot Aluminum Process

By Alice Wong

Goals for Project

- Good Via Fill in Small contact holes using hot aluminum process
- Be able to get good images of the contact holes using the Scanning Electron Microscope



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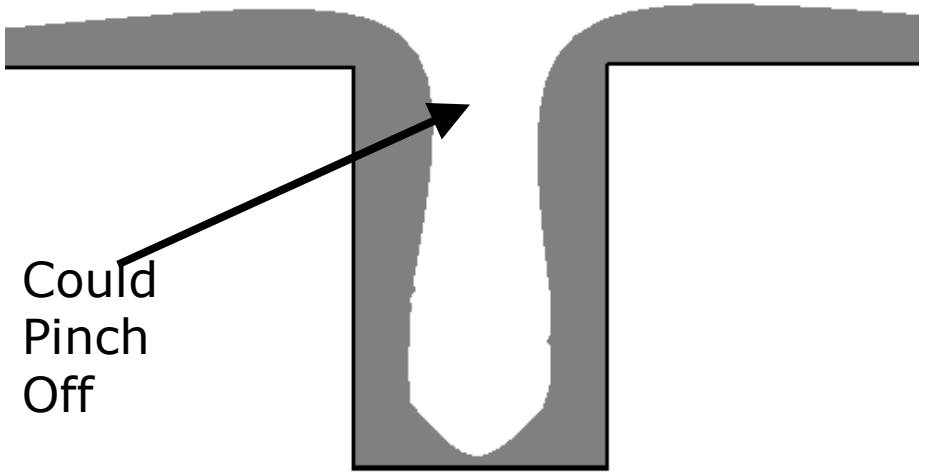

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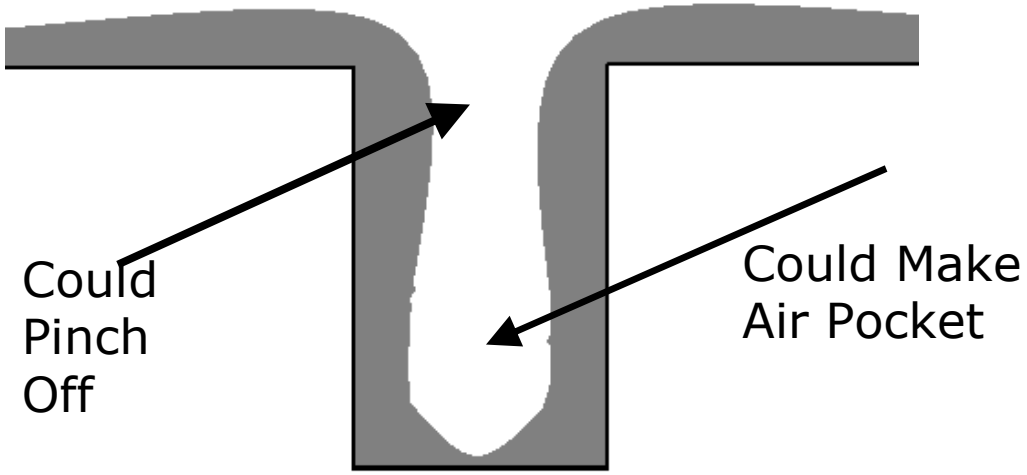


Equipment

- Furnaces
- Sinks
- Novellus
- Leo
- ASM Lithography
- SVG Coat 6
- SVG DEV 6
- Nanospec
- ASIQ
- Matrix
- UV Bake
- Microscopes
- Wafer Saw
- Centura-mxp

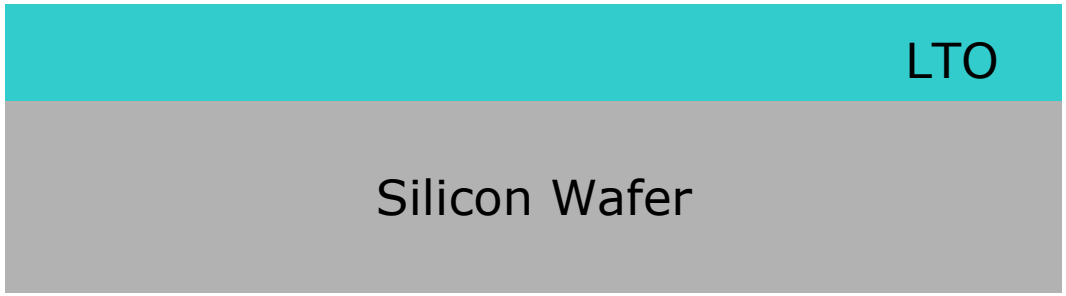
Procedure

- Start with 6” P type Prime wafers

Silicon Wafer

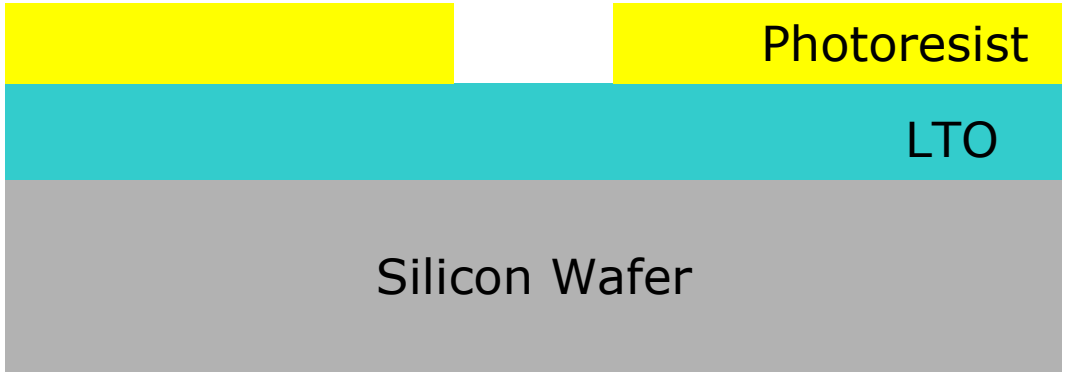
Procedure

- Grow ~2 um LTO
  - Sink 6
  - Tystar 11 (LTO)
  - Tystar 2 (Anneal)



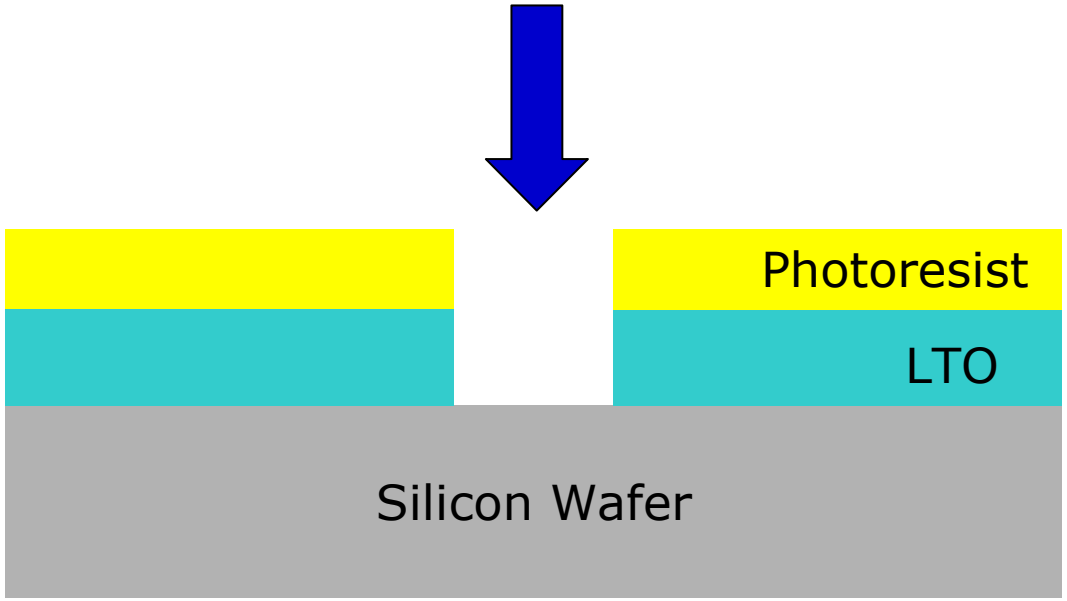
Procedure

- Photolithography
  - SVG Coat 6
  - ASML (CMOS 180 Contact Mask)
  - SVG DEV 6
  - UV Bake



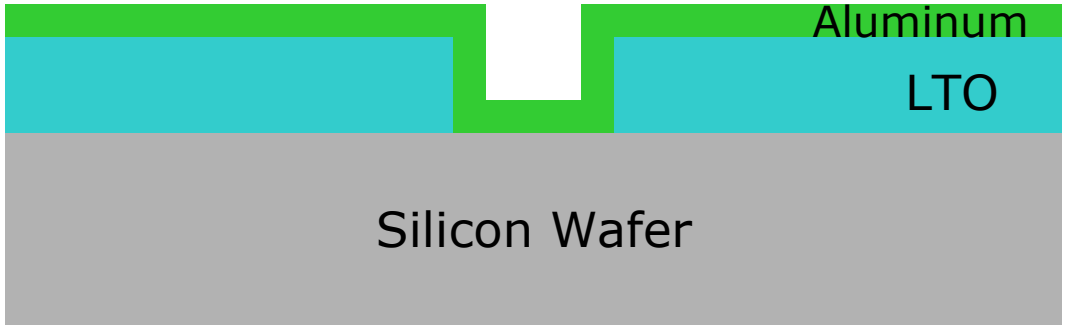
Procedure

- Etch
  - Centura- MXP



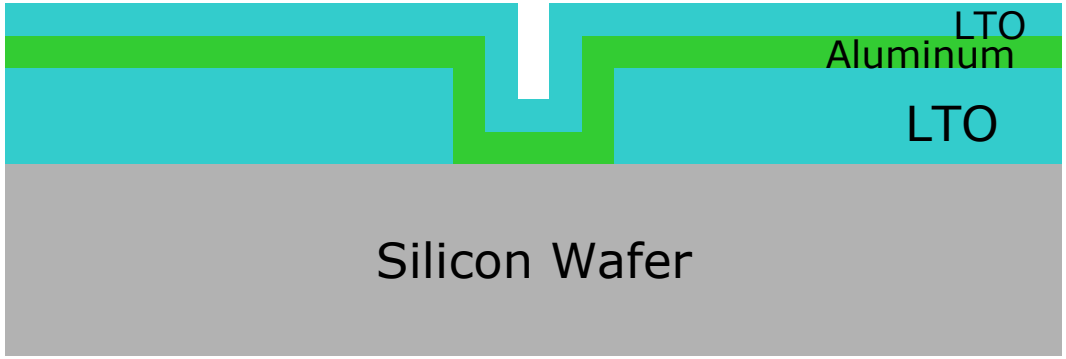
Procedure

- Aluminum Deposition
  - Novellus



Procedure

- Grow ~1 Micron of LTO
  - Sink 5
  - Tystar 12
- NO Anneal



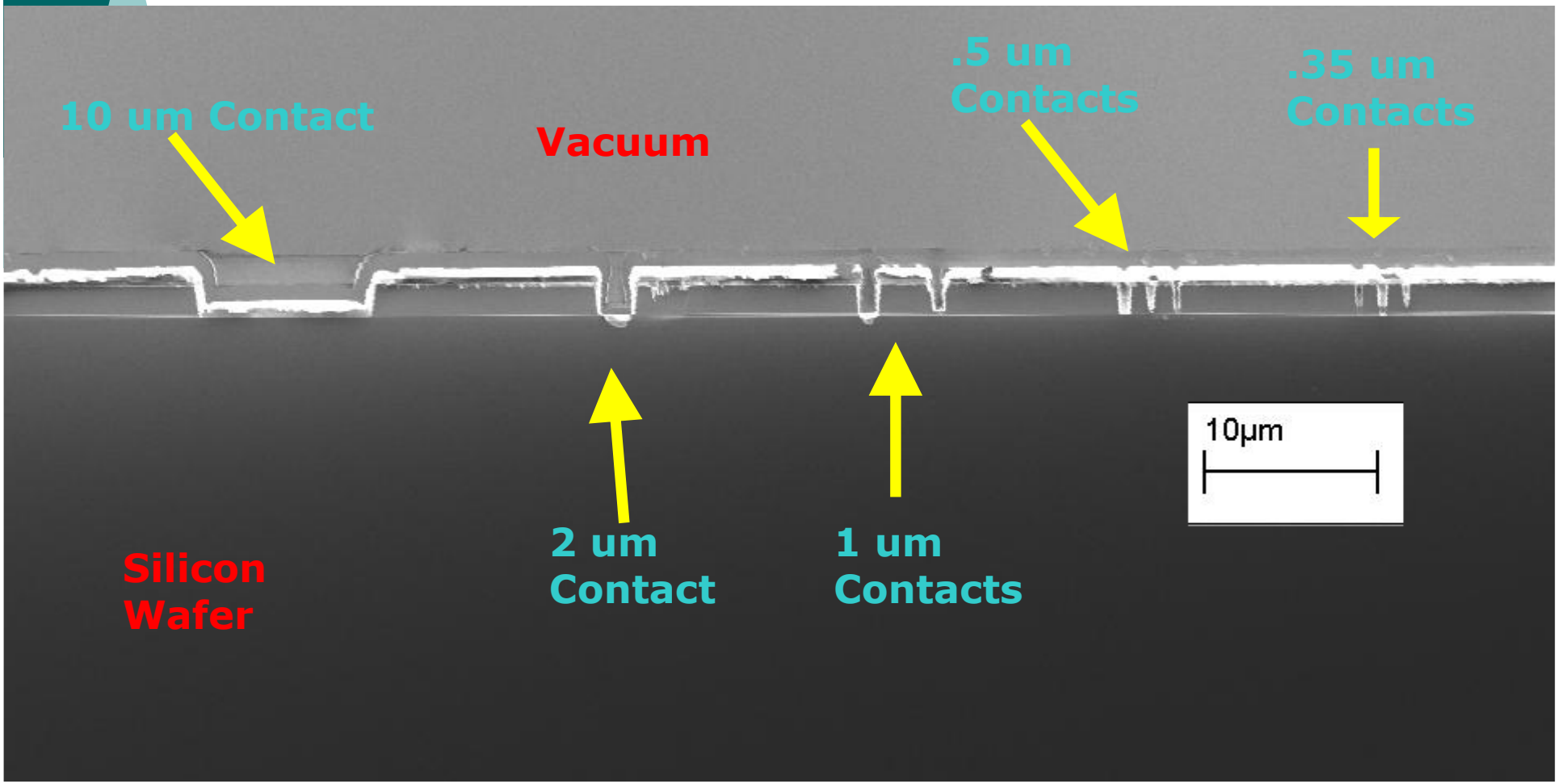
Hot Al Process

	Al Etch	Ti Glue Al	Al TSP	Al TSP
Heater Temp	400	50	500	500
Ar flow/ pres.	1.4 mT	40 sccm	4 mT	4 mT
Etch/ Dep Power (kW)	25%	15%	84%	9%
Dep/ Etch Time(s)	45	56	21	195
Back Side Argon on?	Yes	Yes	No	Yes

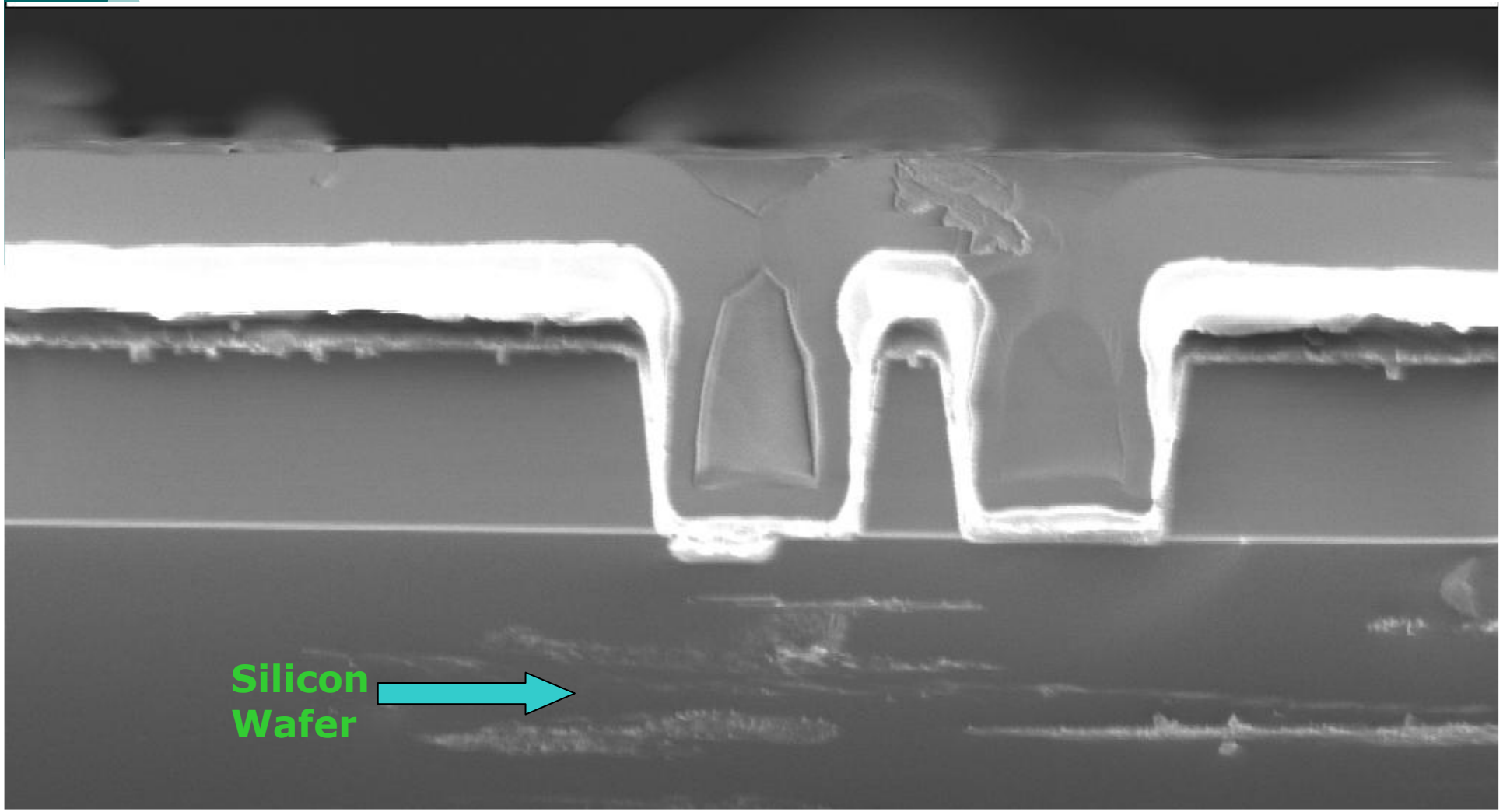
Cold Al Process

	Al Etch	Ti Glue Al	Al TSP
Heater Temp	400	300	350
Ar flow/ pres.	1.4 mT	5 sccm	2 mT
Etch/ Dep Power (kW)	25%	60%	75%
Dep/ Etch Time(s)	45	19	47
Back Side Argon on?	Yes	Yes	Yes

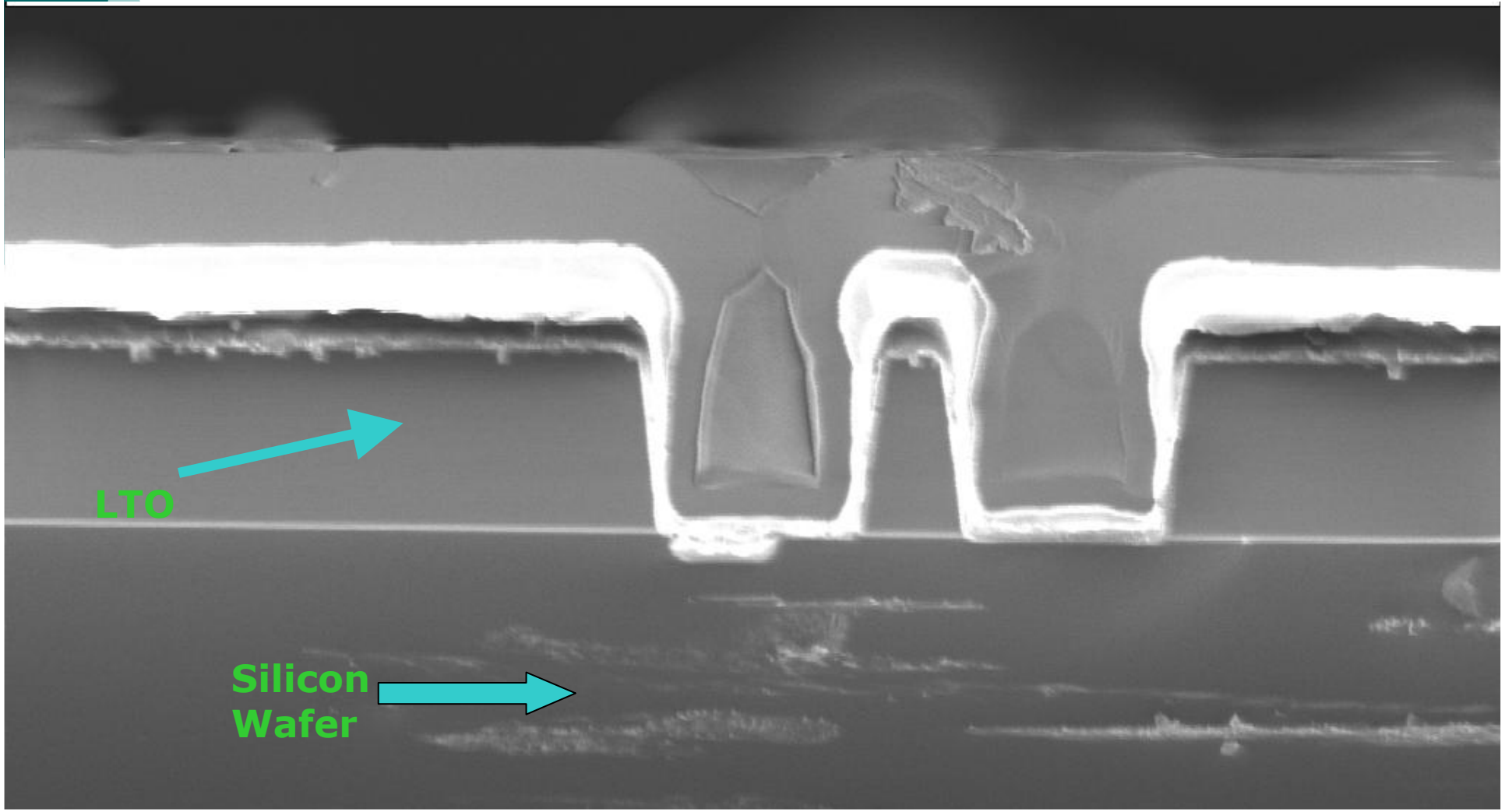
Results


10 um Contact
Vacuum
.5 um Contacts
.35 um Contacts
10µm
2 um Contact
1 um Contacts
Silicon Wafer

Results



Results



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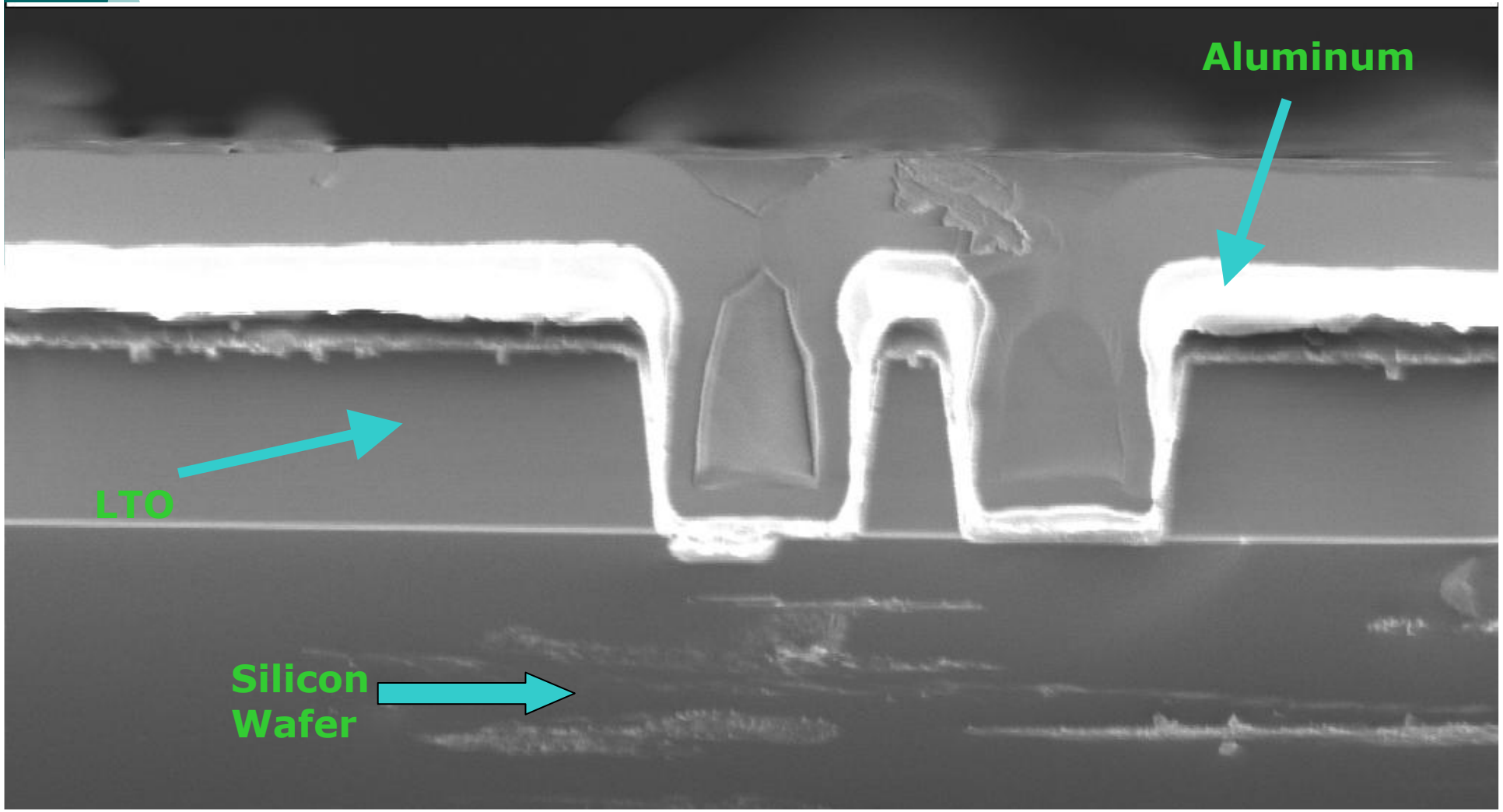

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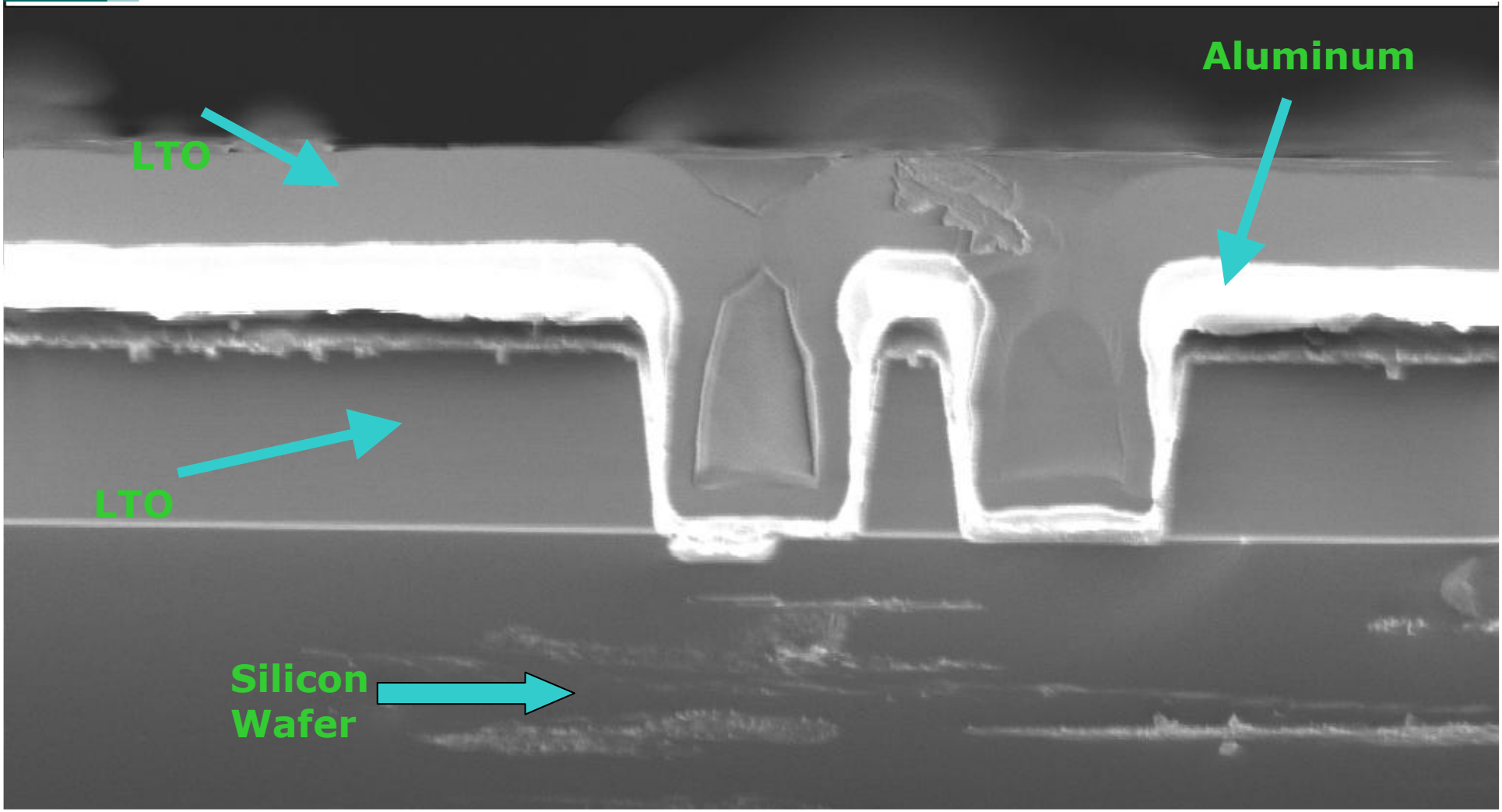

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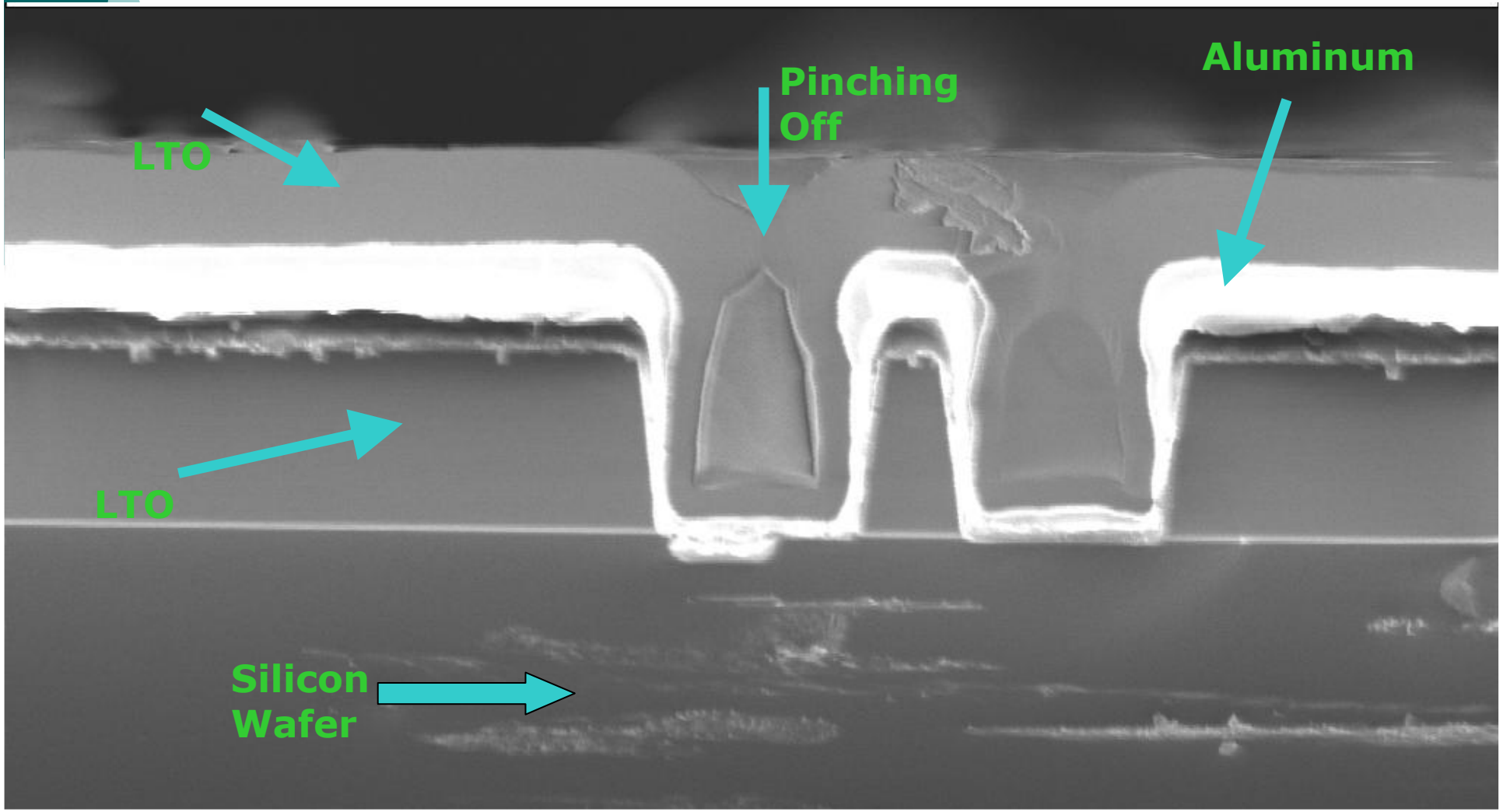

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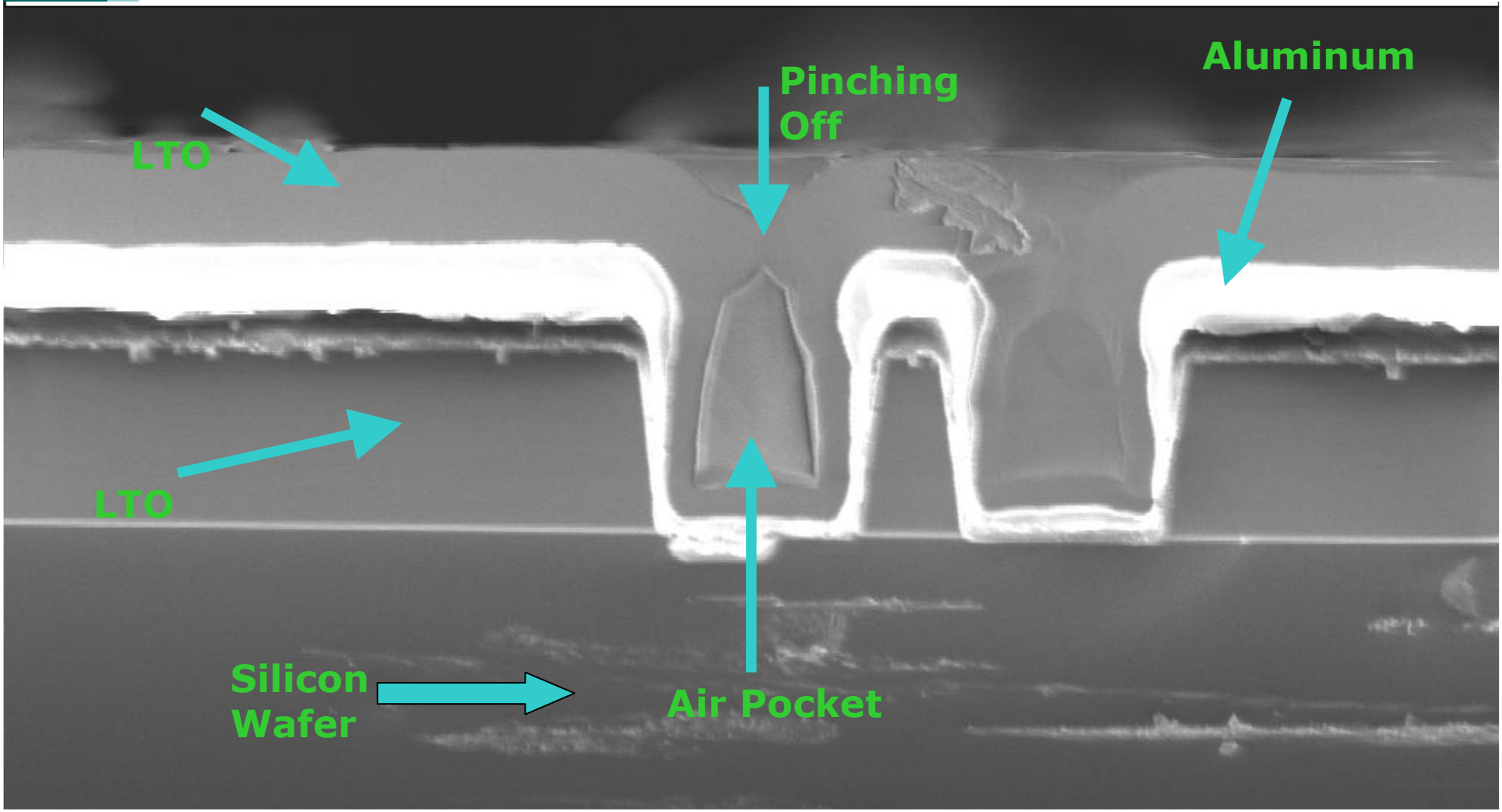
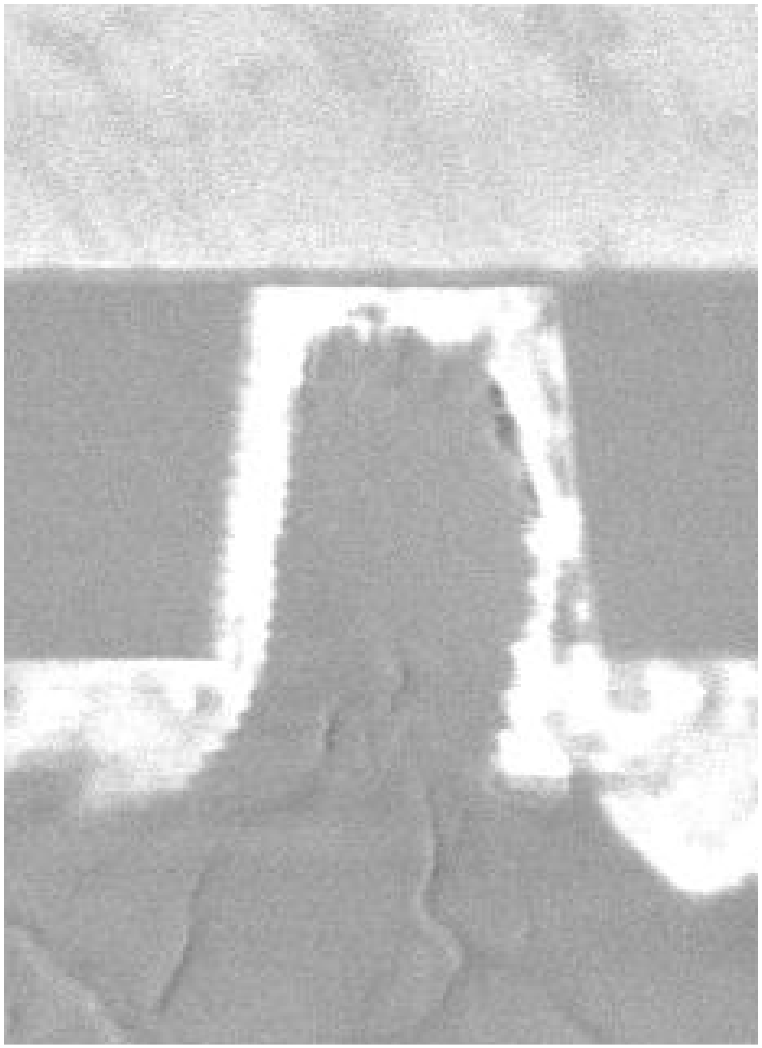


2 um contacts

Cold Al process

Hot Al Process



2 um contacts

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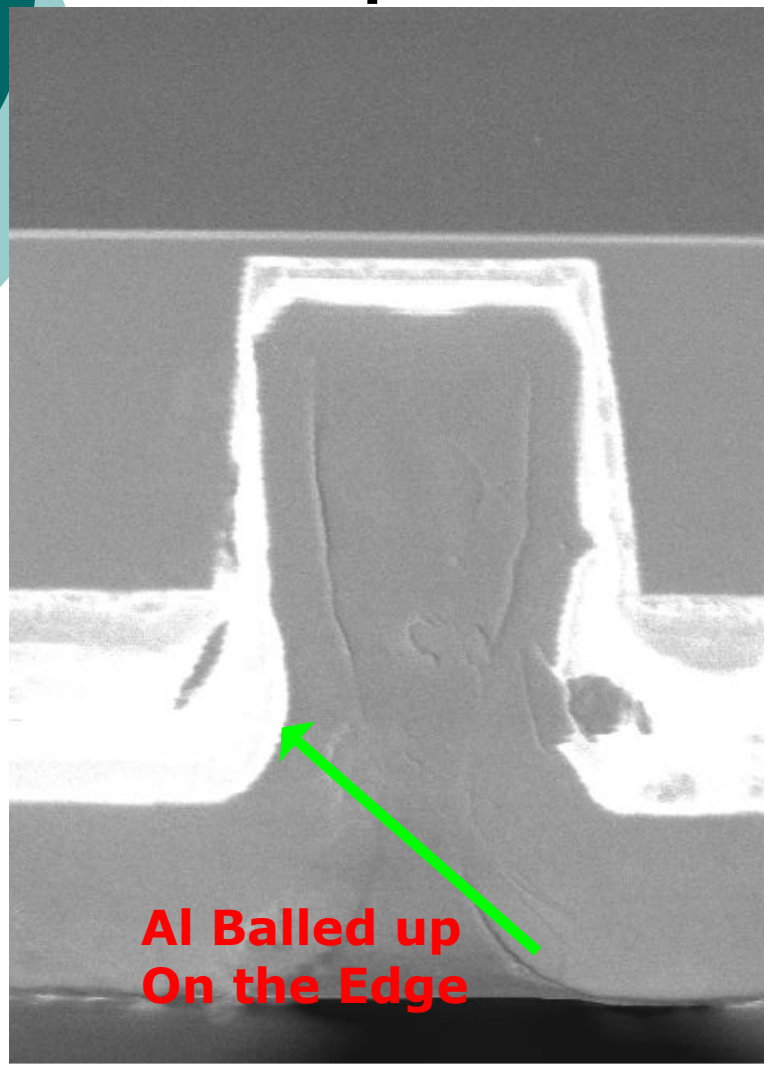

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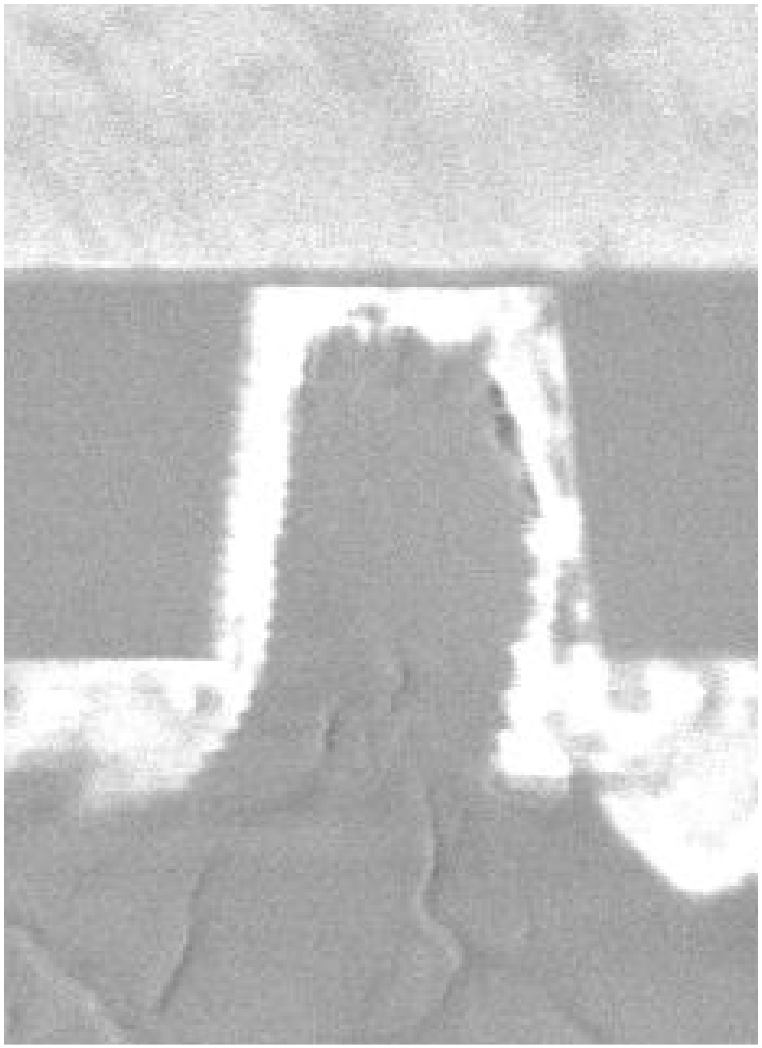

2 um contacts

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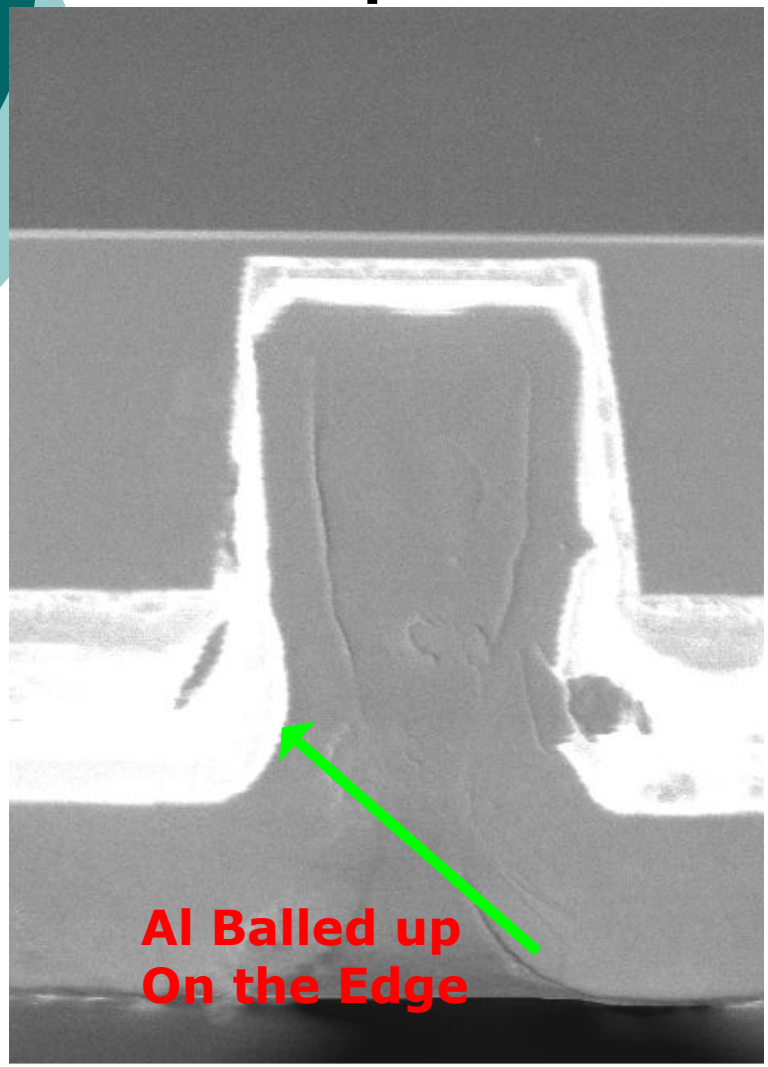

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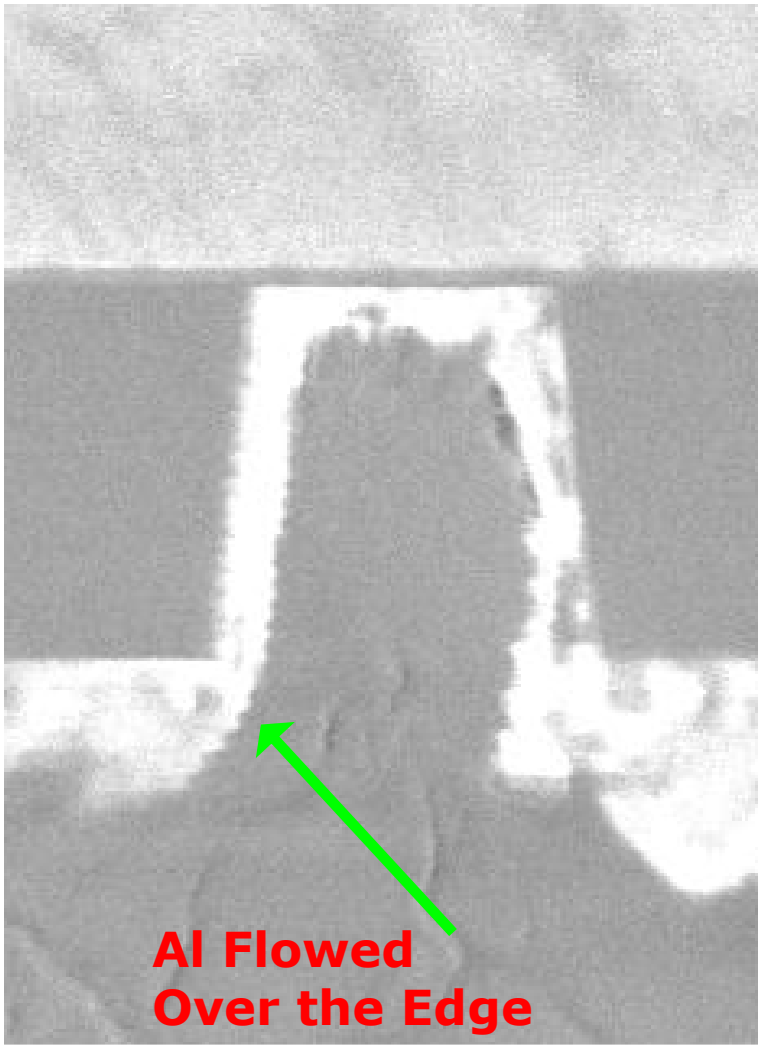


Results

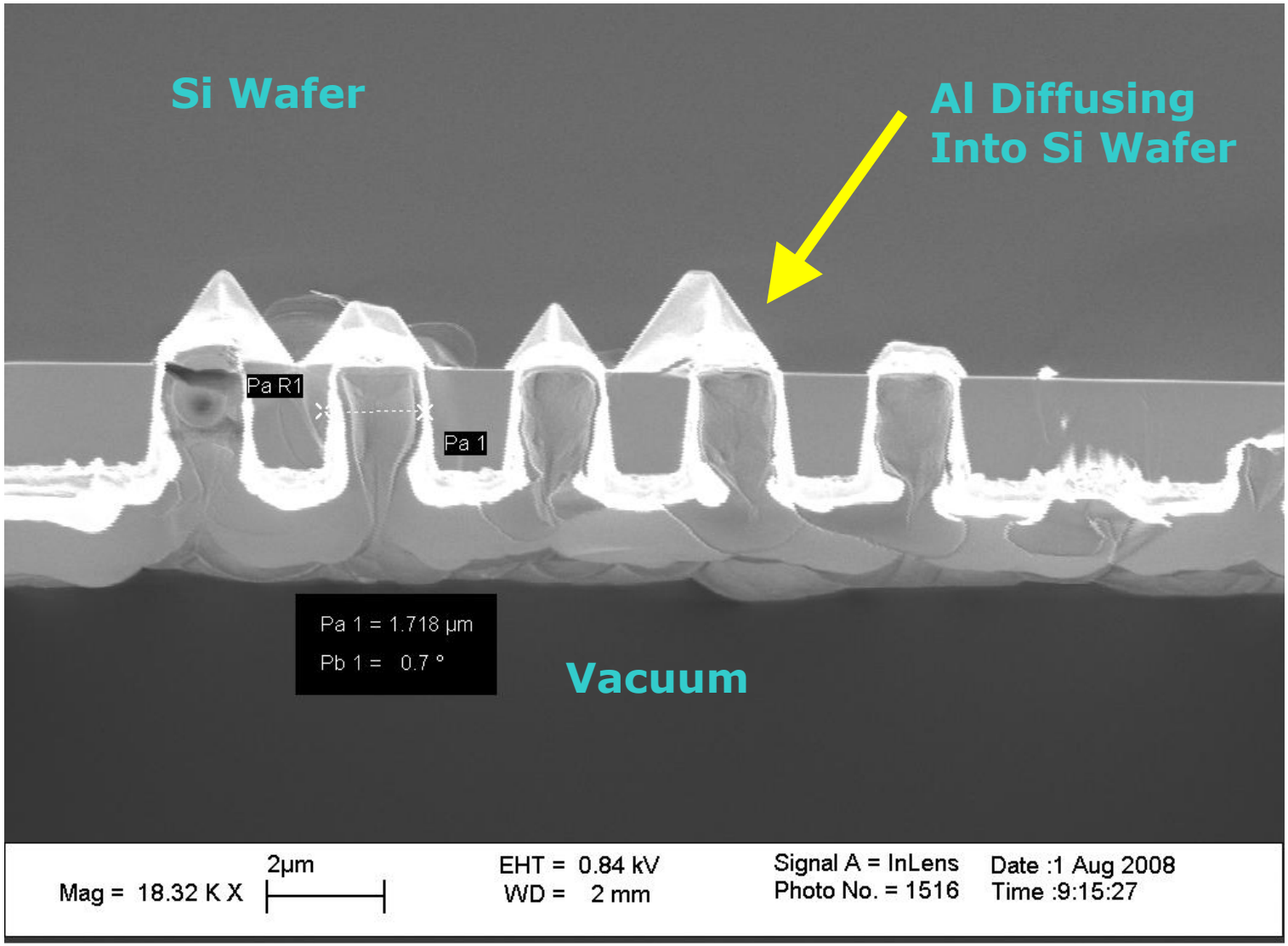
$$C_s = (T_{thin} / T_{thick}) \times 100$$

Depth →

Contact Size →

	.66 um	.57 um	1.19 um	1.04 um	1.62 um	1.63 um
10 um	93%	68%	80%	49%	78%	72%
2 um	56%	49%	13%	30%	18%	34%
1 um	22%	32%	7%	13%	16%	13%
.5 um	31%	18%	6%	7%	5%	9%
.35 um	x	3%	2%	5%	2%	3%

Spiking


Si Wafer
Al Diffusing
Into Si Wafer
Pa R1
Pa 1
Pa 1 = 1.718 µm
Pb 1 = 0.7 °
Vacuum
2µm
Mag = 18.32 K X
EHT = 0.84 kV
WD = 2 mm
Signal A = InLens
Photo No. = 1516
Date :1 Aug 2008
Time :9:15:27

Al Alloy Planarization Methods

-Standard Two Step Process
-Reflow

Enhanced Mobility

<u>Contact or Via</u>

≥0.6 um

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-Standard Two Step Process
-Reflow

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Al Alloy Planarization Methods

-Standard Two Step Process
-Reflow

Enhanced Mobility

-Low Pressure Two Step Process

Directional Sputter Neutrals

Contact or Via

≥0.6 um

Contact or Via

≥0.35 um

Conclusion

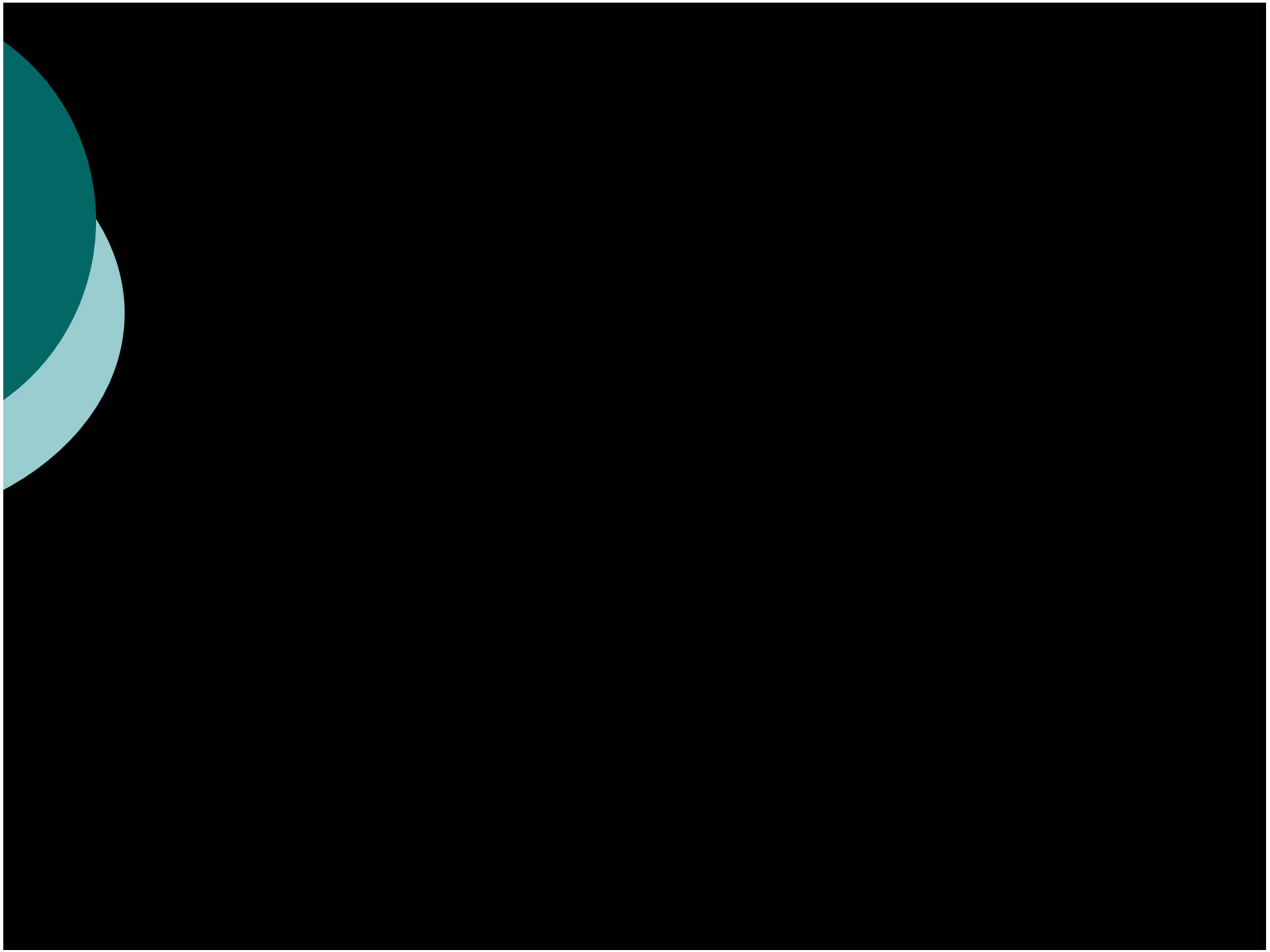
- Get better step coverage using the Hot Al Process
- Hot Al process is designed for contacts down to .6 um
- Still unable to get complete contact fill
- Future Directions
  - Improve the cross sectioning
    - Use focus ion beam (FIB)
  - Effect of Ti on this process
  - Include Collimation

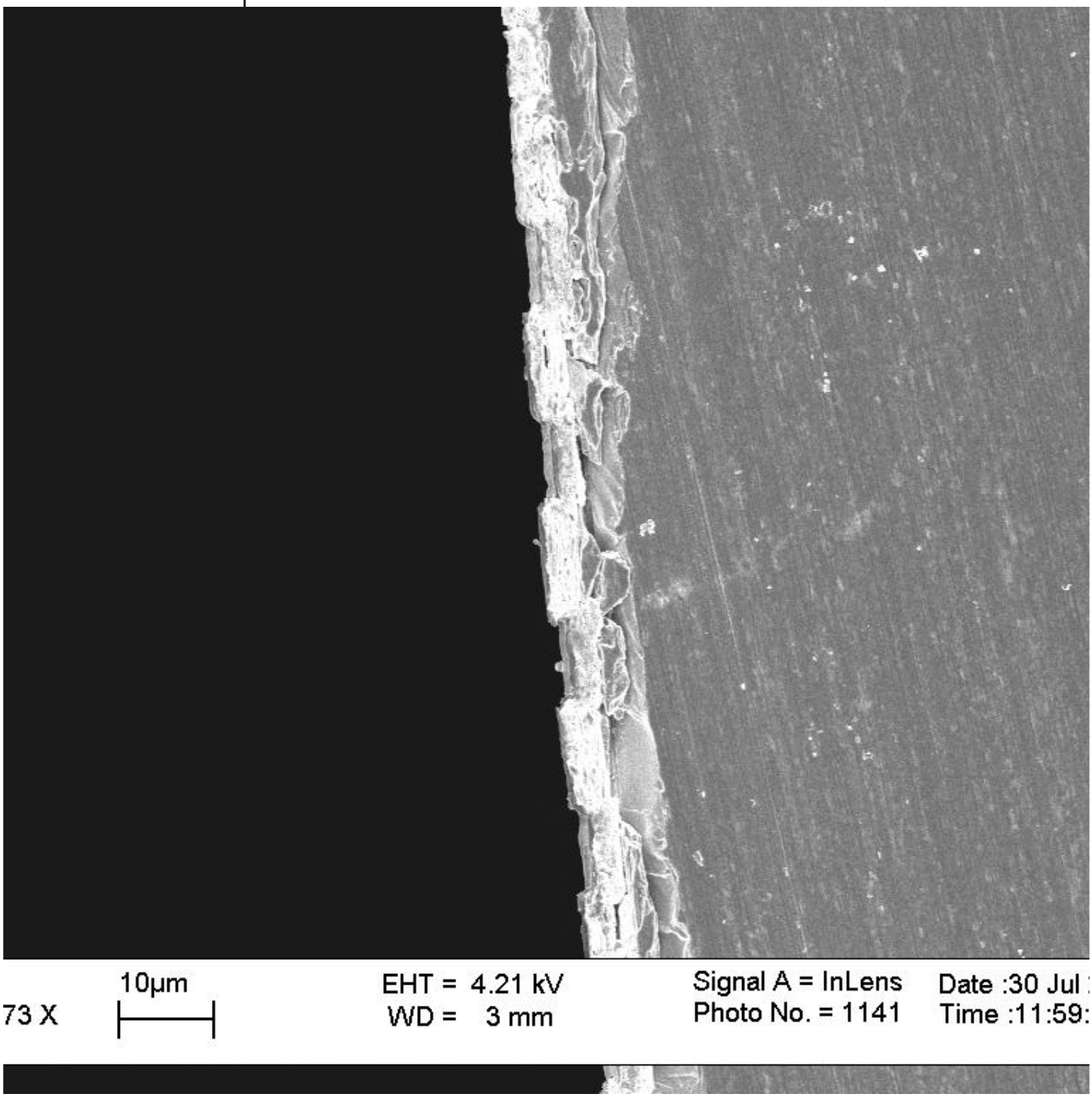
What I learned

- Learned about different types of equipment
- Learned about lab safety procedures
- Became familiar with Microlab jargon
- Became familiar with Lab Maintenance procedures
- Became familiar with the Wand

Acknowledgements

- Thank you Kim Chan, Sia Parsa, Laszlo Petho, Attila Szabo, Jimmy Chang, Joe Donnelly and Rosemary Spivey
- Thanks to **Katalin Voros** for giving me such a wonderful opportunity
- Thanks to **Daniel Queen** for being my mentor, explaining things when I didn't understand them, and for helping me get acquainted with the lab
- Thanks to Marilyn Kushner for taking us to Semi Con
- Thanks to Chris and Eric for helping me run my process
- Thanks to the Lab Assistants for letting me follow you around




73 X
10µm
EHT = 4.21 kV
WD = 3 mm
Signal A = InLens
Photo No. = 1141
Date :30 Jul
Time :11:59:

Novellus Hot Aluminum Process

- Using two layer aluminum films deposited at different temperatures will improve step coverage. To do this, the Al Two Step Process (TSP) is used
- 1. Deposit 500 A Ti under layer (used as glue layer) cold just before Al. The Ti cold layer not only works as a glue, but also enhances capillary action that draws Al into trench.

Novellus Hot Aluminum Process

2. Deposit a 400 nm cold Aluminum layer at high deposition rate (> 190 A/sec) on a cold wafer. No back side Argon during deposition, this will keep the wafer temperature low.
3. Deposit a hot layer at a slow rate with Back Side Argon on. With the BSA on, the wafer temperature ramps up quickly to a high temperature. The low deposition rate allows time for the surface migration of Al atoms to fill in the trench.