PROMERUS®

Subsidiary of Sumitomo Bakelite Co. Ltd.

Low Temperature Curable Polynorbornene as Redistribution Layer

Presented by: Brian Knapp, Ph.D.

Sumitomo Bakelite co-authors:

- Etsu Takeuchi
- Junya Kusunoki
- Seishi Ohashi

Promerus co-authors:

- Chris Apanius
- Ed Elce
- Hendra Ng

Outline

- General Characteristics of Avatrel® Photodefinable Polymers
  - Chemical Structure
  - Low Shrinkage
  - Wafer Stress
  - Planarity
  - General Imaging
  - Applications
- Redistribution Layer (RDL) Device Build
- Reliability Testing
- Summary

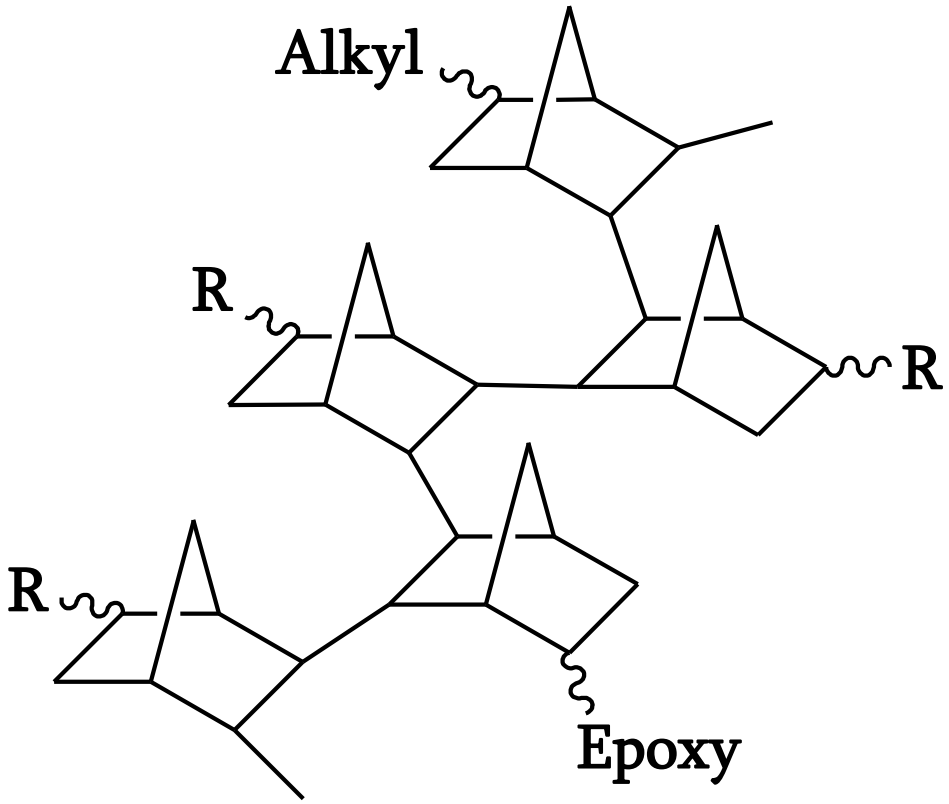
Synergies of Chemistry in Polycyclic Polyolefins

Polynorbornene

- High T_g From Backbone
- Alkyl – Tune Modulus/Stress
- Low Moisture Absorption
- Isotropic Properties
- Transparency
- Low Dielectric Constant

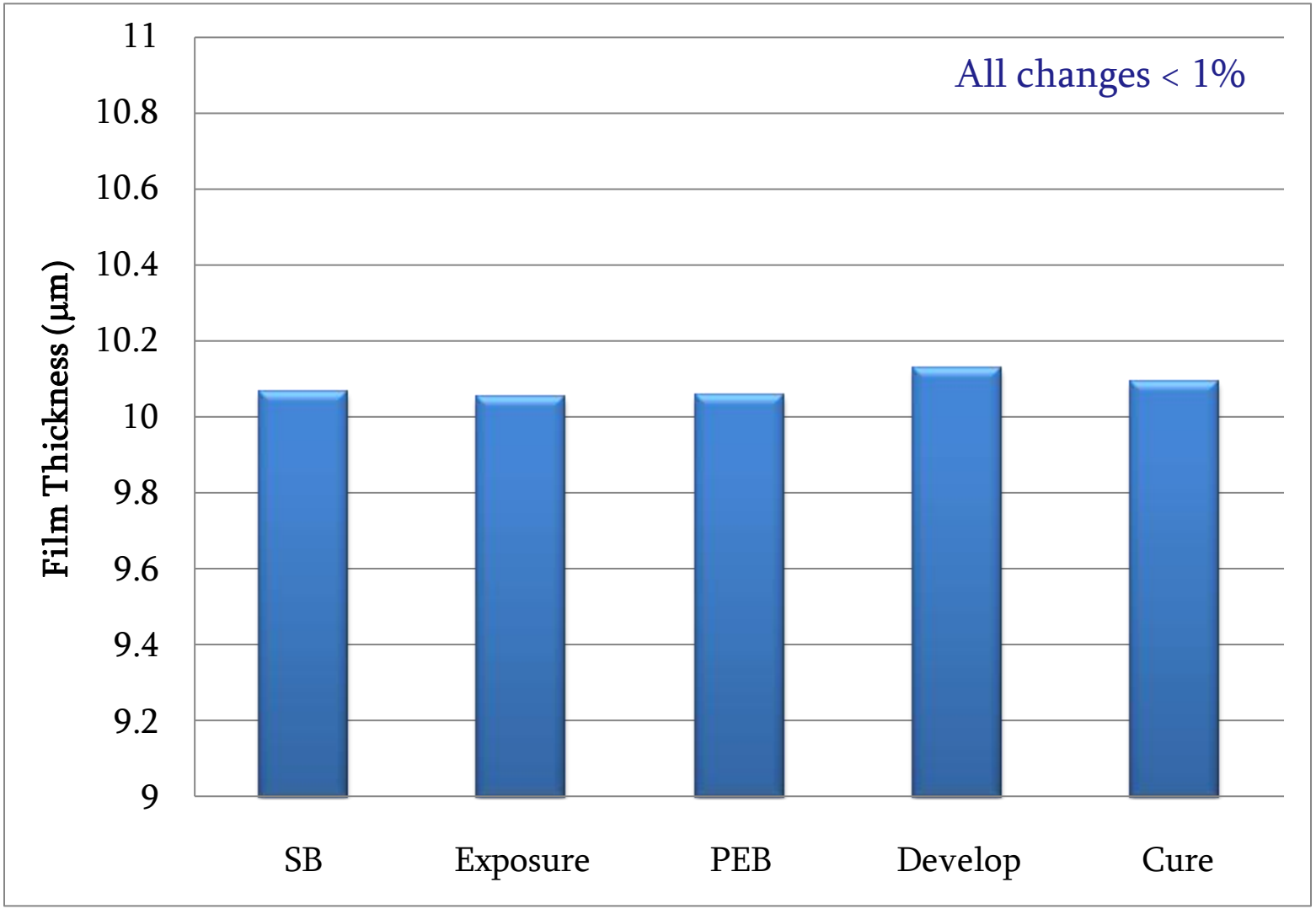
Epoxy

- Accepted Chemistry
- Low Temperature Cure
- Adhesion
- Photosensitive

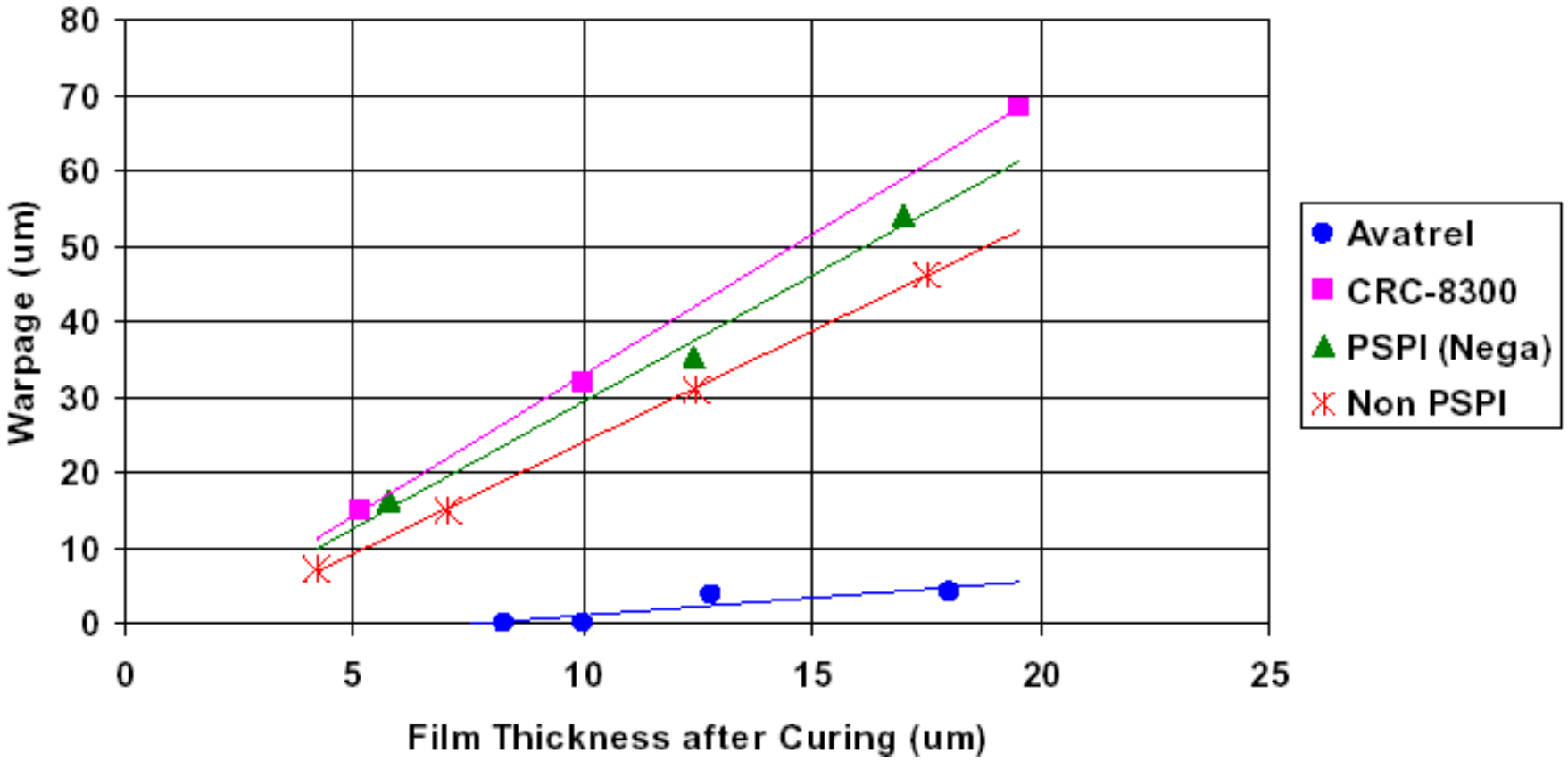


Low Film Thickness Shrinkage through Wafer Processing

- 1400 rpm, Cyclopentanone develop, 180°C/2h cure



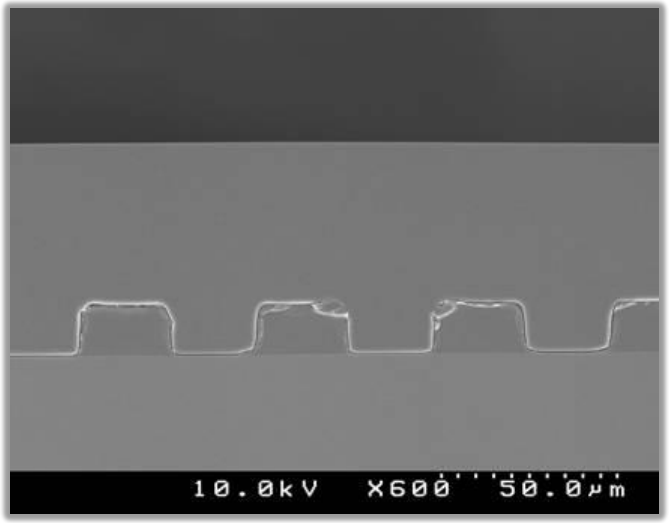
Low Wafer Warpage with Simple Coatings

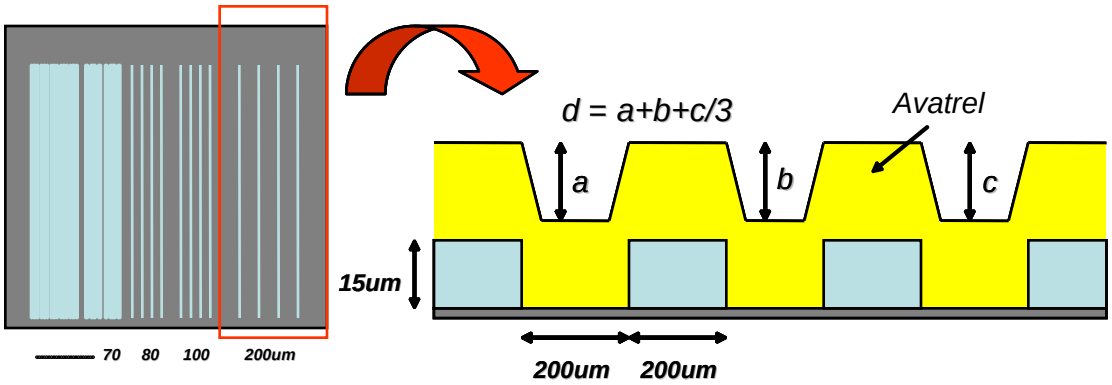


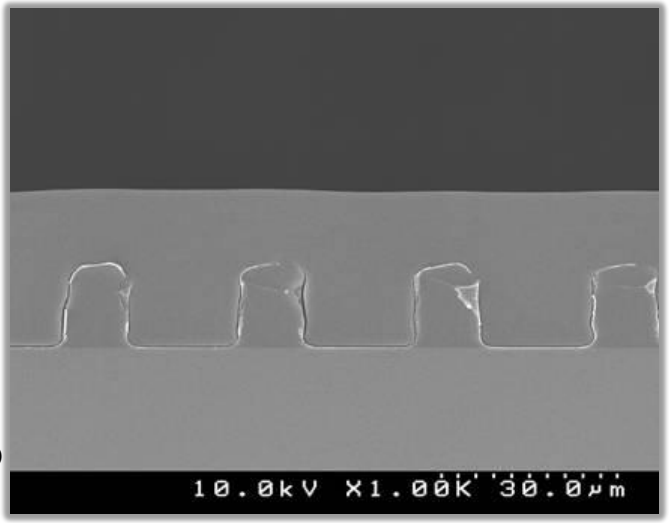
- Wafer: 200 mm Si Wafer
- Thickness: 625 µm
- Measuring span: 100 mm

Planarization of Avatrel over Topology

- Avatrel has good planarization with dense feature patterns
  - Planarization is very good for 60 µm thick films on 7 & 15 µm topology, 100% DOP
  - Planarization is 85 to 96% DOP for 30 µm thick films on 7 µm topology
  - Planarization is 75 to 82% DOP for 30 µm thick films on 15 µm topology



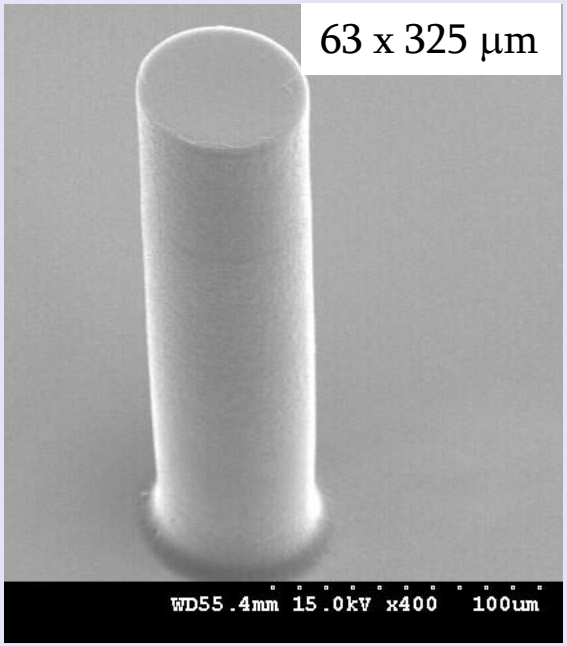


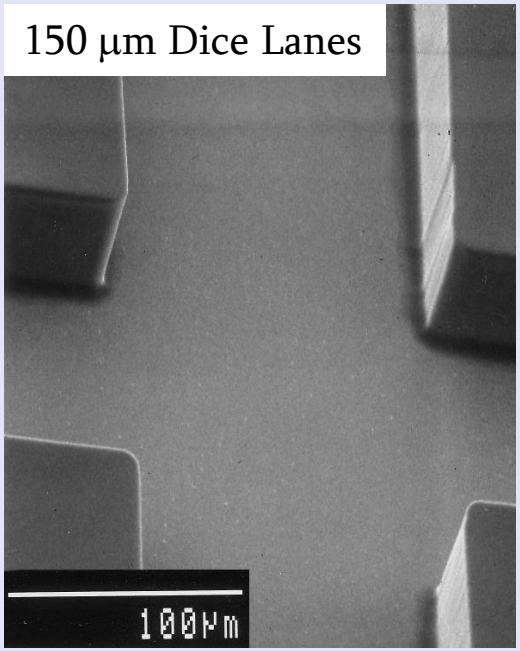


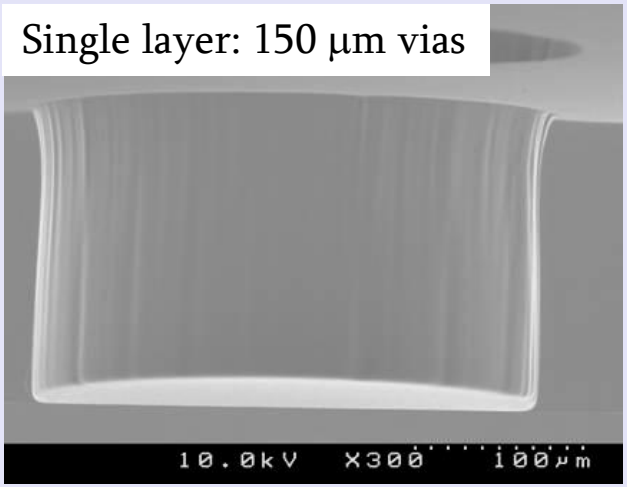
% DOP (degree of planarization) = (1–d/step height) x 100%

General Imaging Capability of Avatrel® Polycyclic Polyolefins

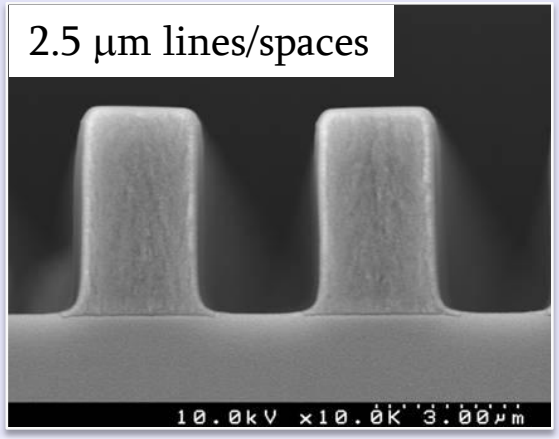
Solvent Developable

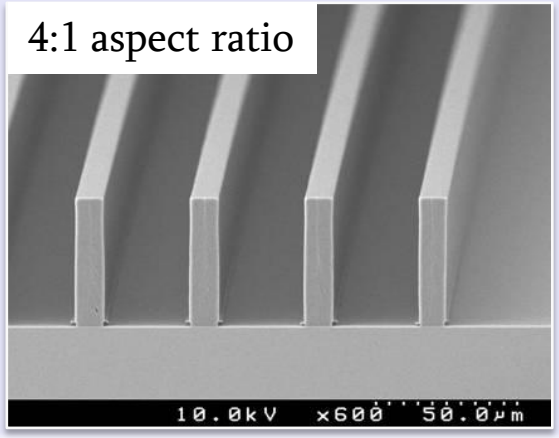


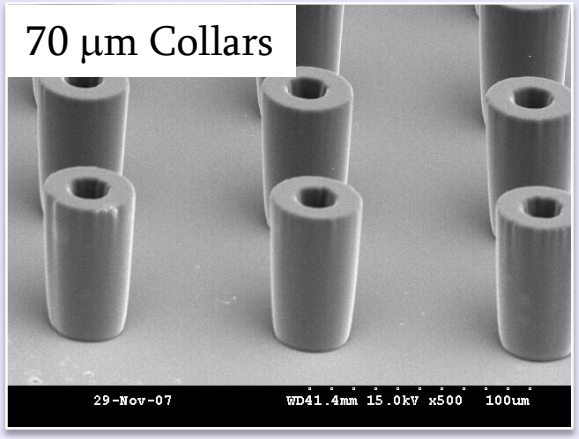




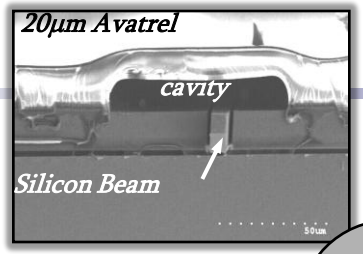
Aqueous Developable

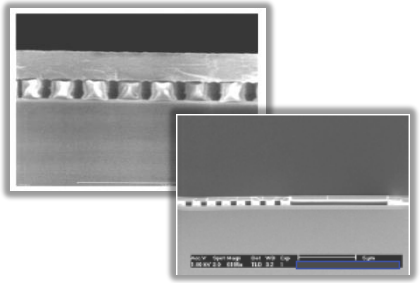


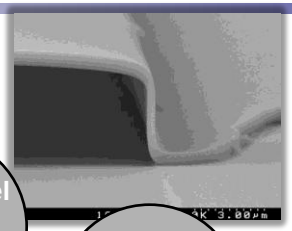


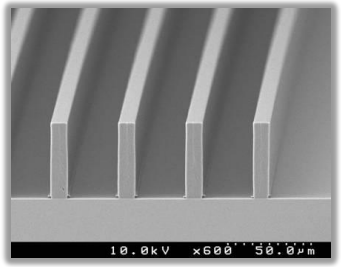


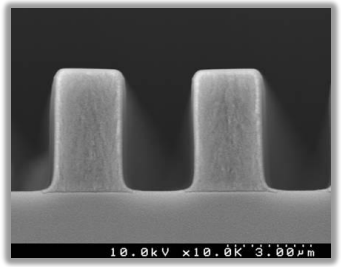
Avatrel®/Unity® Applications

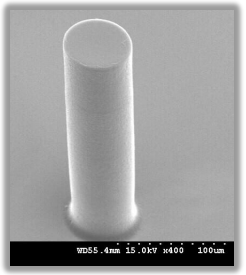


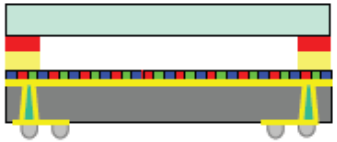


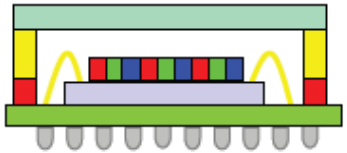


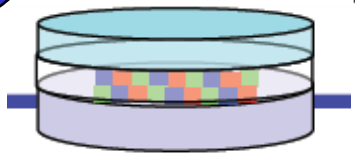












Wafer Level MEMS Packaging

Photo-definable Unity

Temporary Wafer Adhesive

High Temperature Unity

Wafer Level Packaging

Avatrel/ Unity

Aqueous Developable

300 µm Layers

CIS Dam Applications

Backside Interconnect Layer

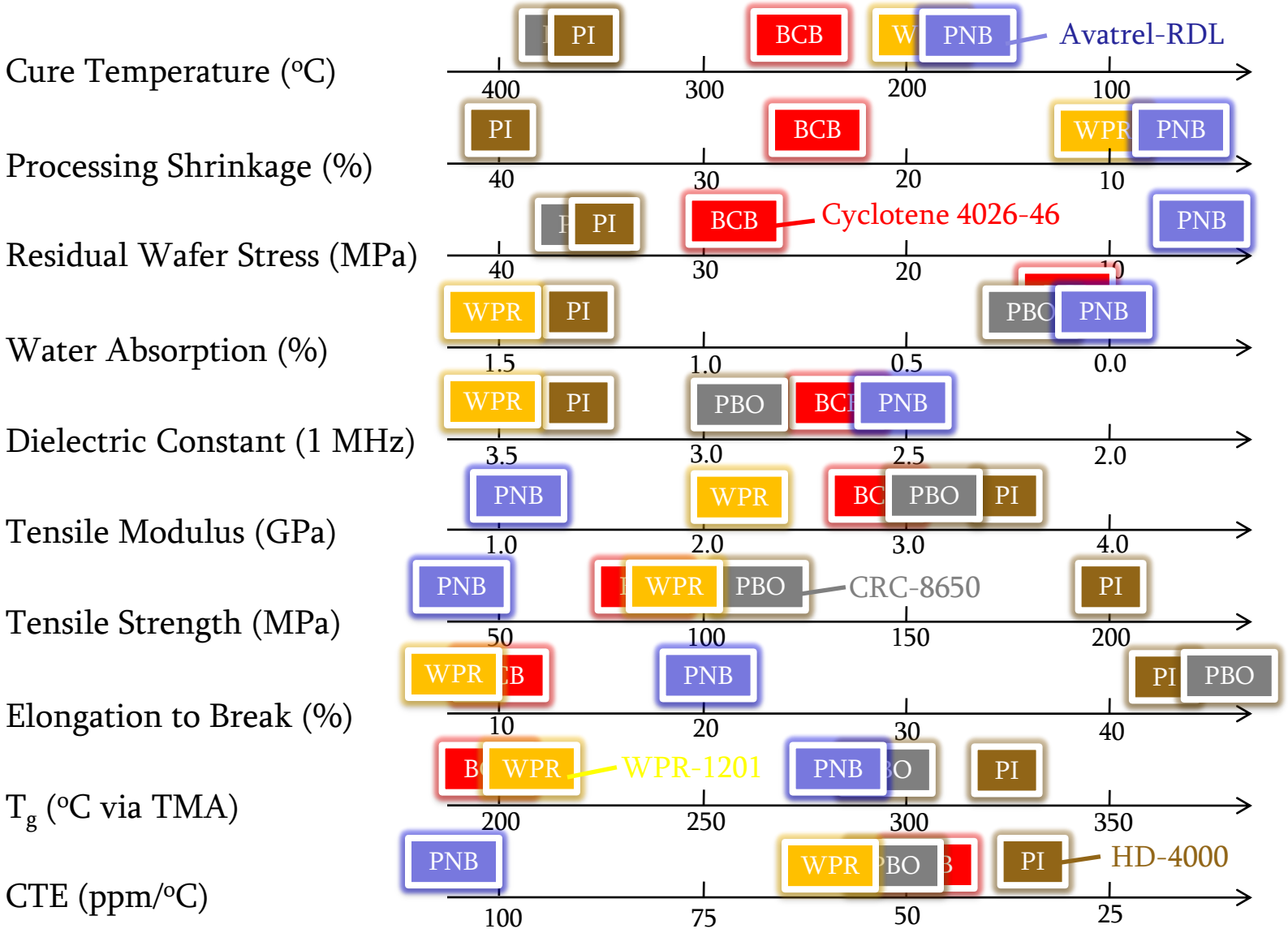
Transparent Adhesive

Motivation for Redistribution Materials

- A material which aids in the relocation of bond pads
- Desirability stems from small package size, high-speed electrical access, and ability to accommodate standard pad layouts
- RDL WL-CSP is often used in miniaturized consumer electronic products
  - Cell phones consume 80-90% of all WL-CSP packages
- Redistribution is the most popular WL-CSP
  - >90% of the 6.1 Bn WL-CSP packages shipped in 2007 used RDLs
- As processors move to multi-core designs, clock redistribution may be required

Marketing data courtesy of: PRISMARK PARTNERS LLC

Property Comparison of Redistribution Materials



*Source: Manufacturer websites

2008 Symposium on Polymers

Process Flow for RDL Device Build

Metal-1

1a) Passivated Copper Wafers

1b) Coat with Resist

1c) Photo/Etch

Polymer-1

2) Pattern Layer-1 of Avatrel-RDL

Metal-2

3a) Copper Seed Layer Deposition

3b) Coat with Plating Resist

3c) Copper Electroplating

3d) Resist Strip and Seed Layer Etch

Polymer-2

4) Pattern Layer-2 of Avatrel-RDL

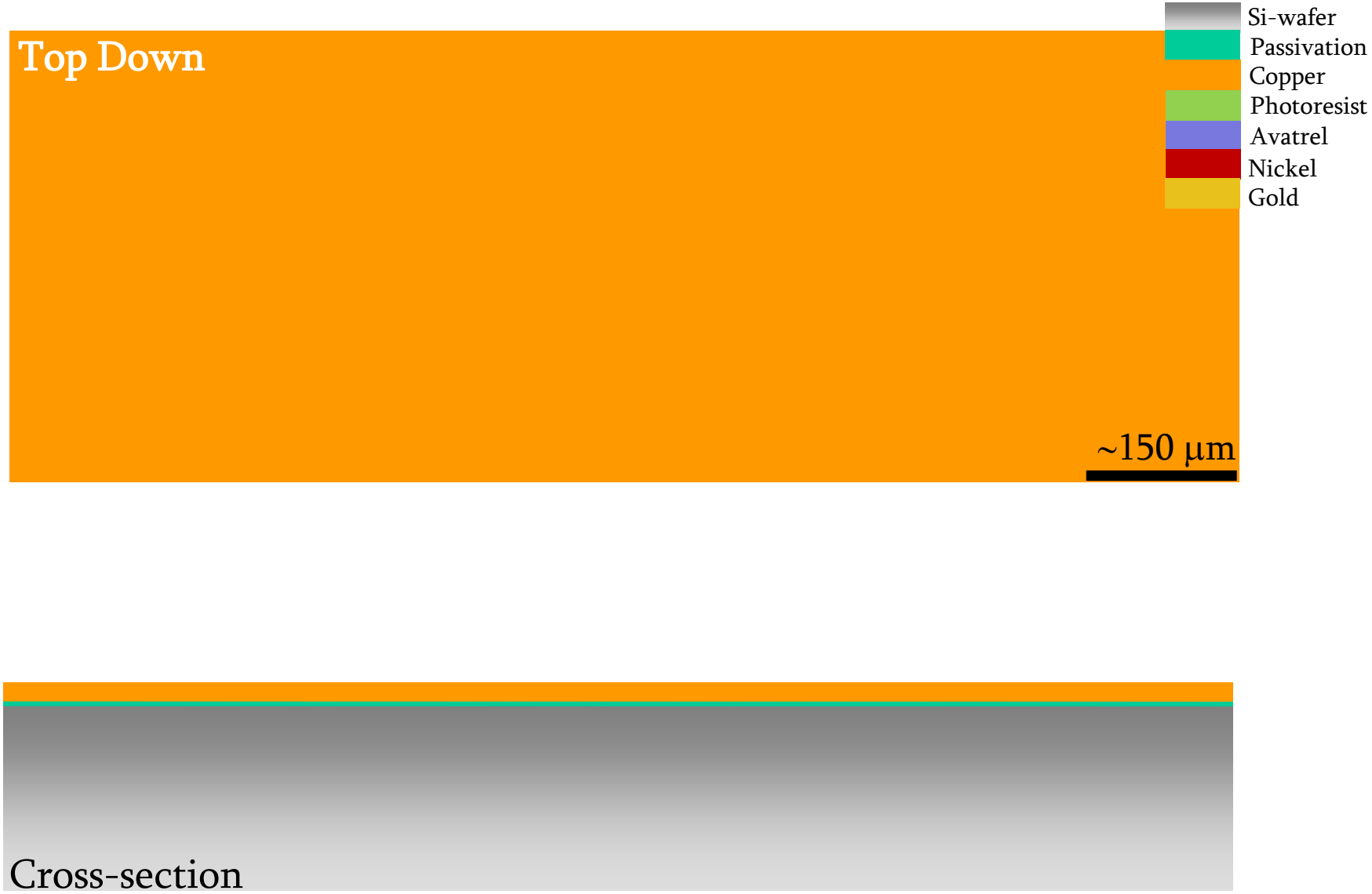
Metal-3

5a) Deposition of Nickel/Gold

5b) Photo/Etch

Step 1a: Copper Wafers over Passivation Layer

- Copper (5000Å) on SiOx or Si_3N_4

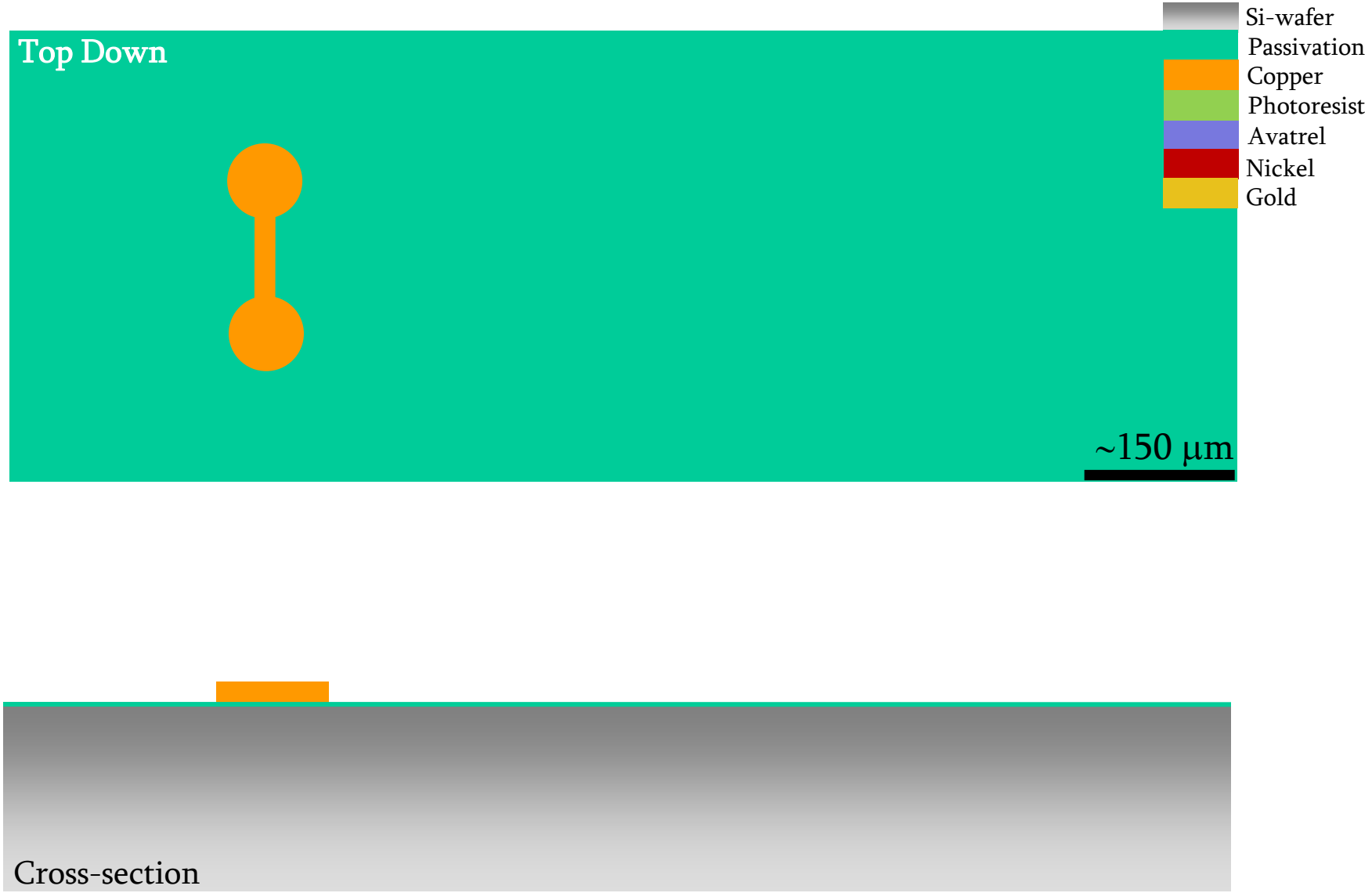


Step 1b: Copper Wafer Coated with Resist

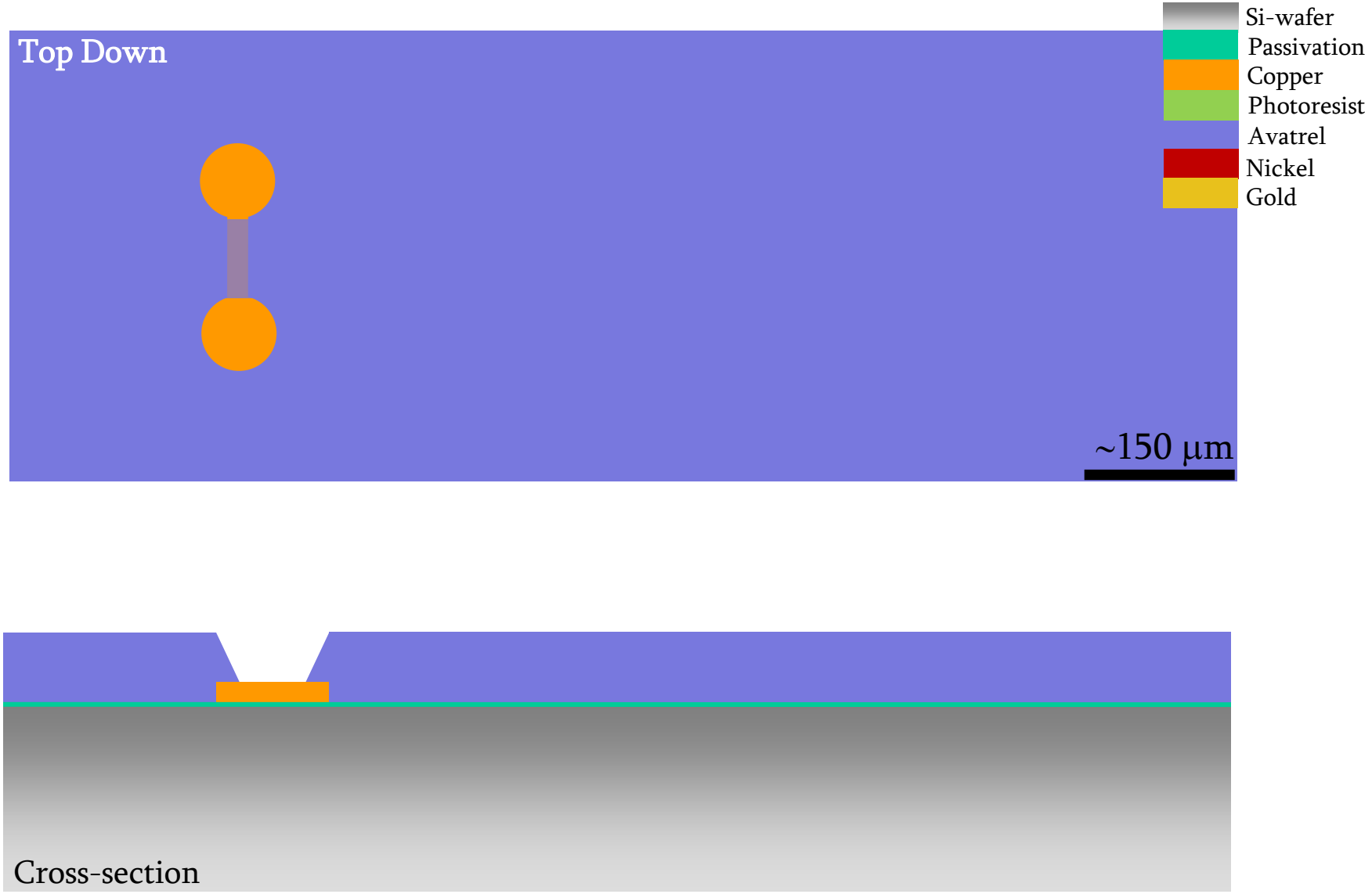
- Shipley 1813 PT Resist

Step 1c: Metal-1 Patterned with Photo and Cu-Etch

- Transene APS-100 Etchant



Step 2: 1st Layer of Avatrel Processed



Standard Process for the Imaging of Avatrel® Redistribution Material

Wafer Process Conditions

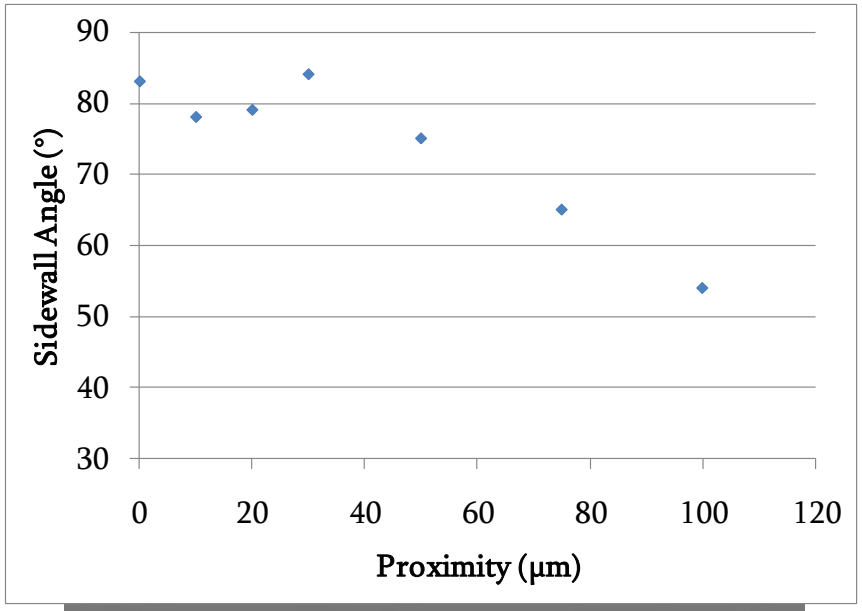
- Dehydration Hydration Bake: 130°C/2 min
- Plasma Pretreatment: 50/50 Ar/O_2, 300 W, 30 sec
- Spin-coat
- Prebake: 120°C/5 min
- Exposure: 300-800 mJ/cm^2
- Post-Exposure Bake: 90°C/4 min
- Develop: Cyclopentanone, 20 sec
- Cure: 180°C/2h

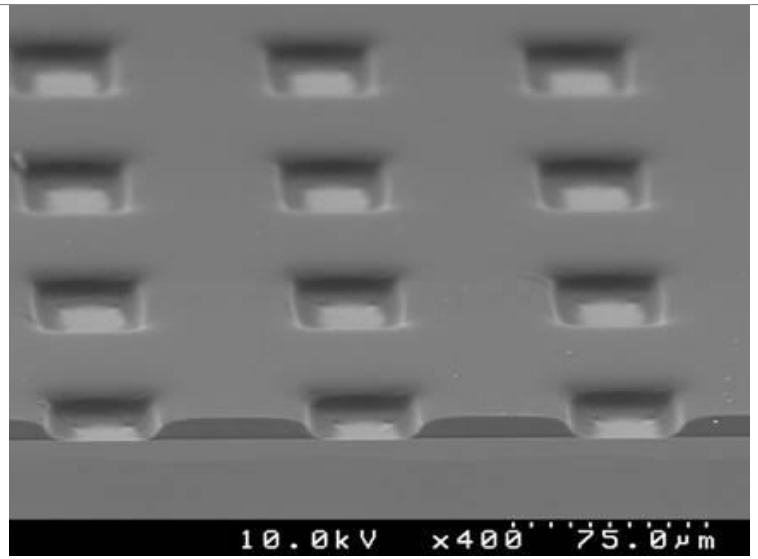
Inducing Sidewall Slope

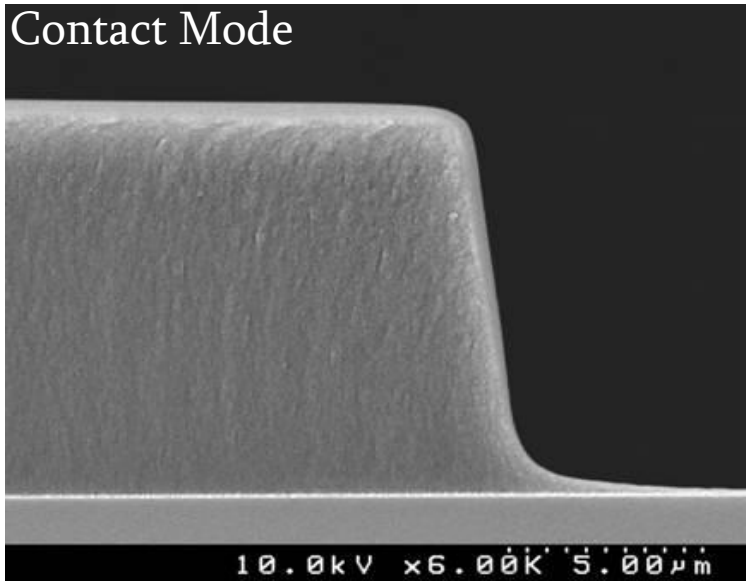
- Proximity
- DOF
- Polymer
- Formulation

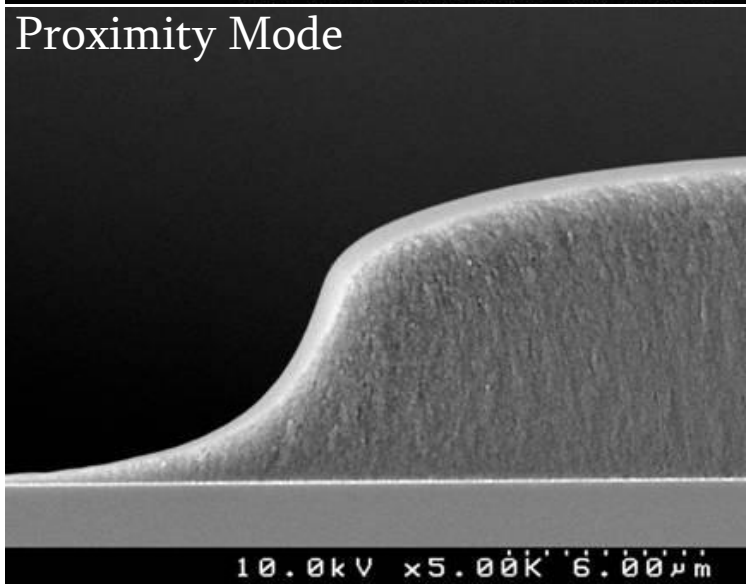
Step 2 Details: Sidewall Imaging in Proximity Mode on Aligner

- 300 mJ/cm^2 on Copper

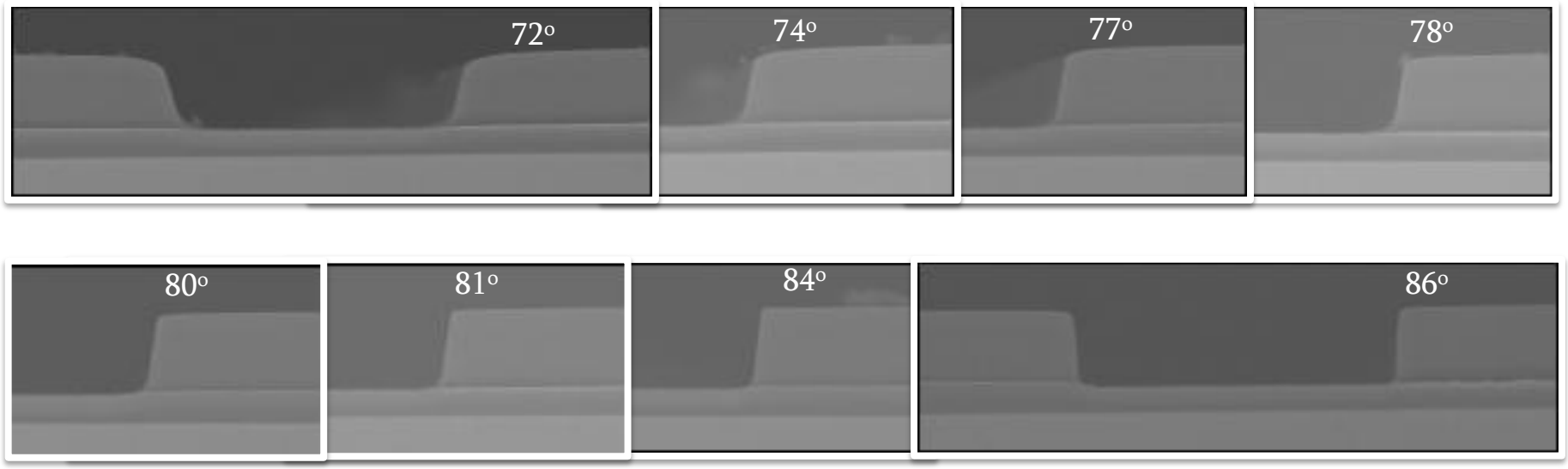


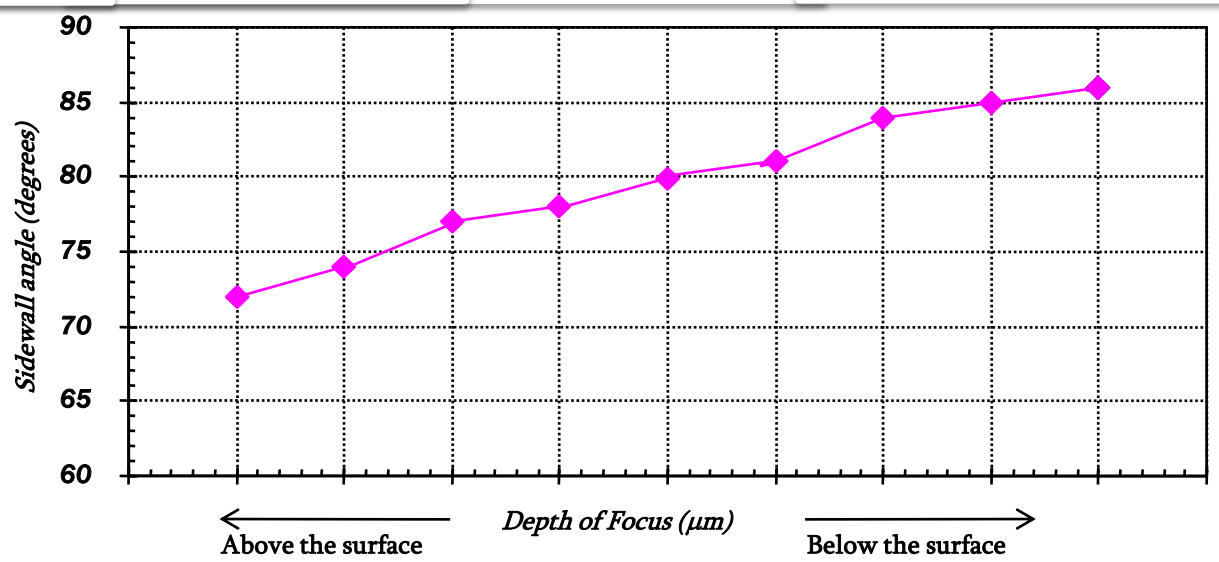




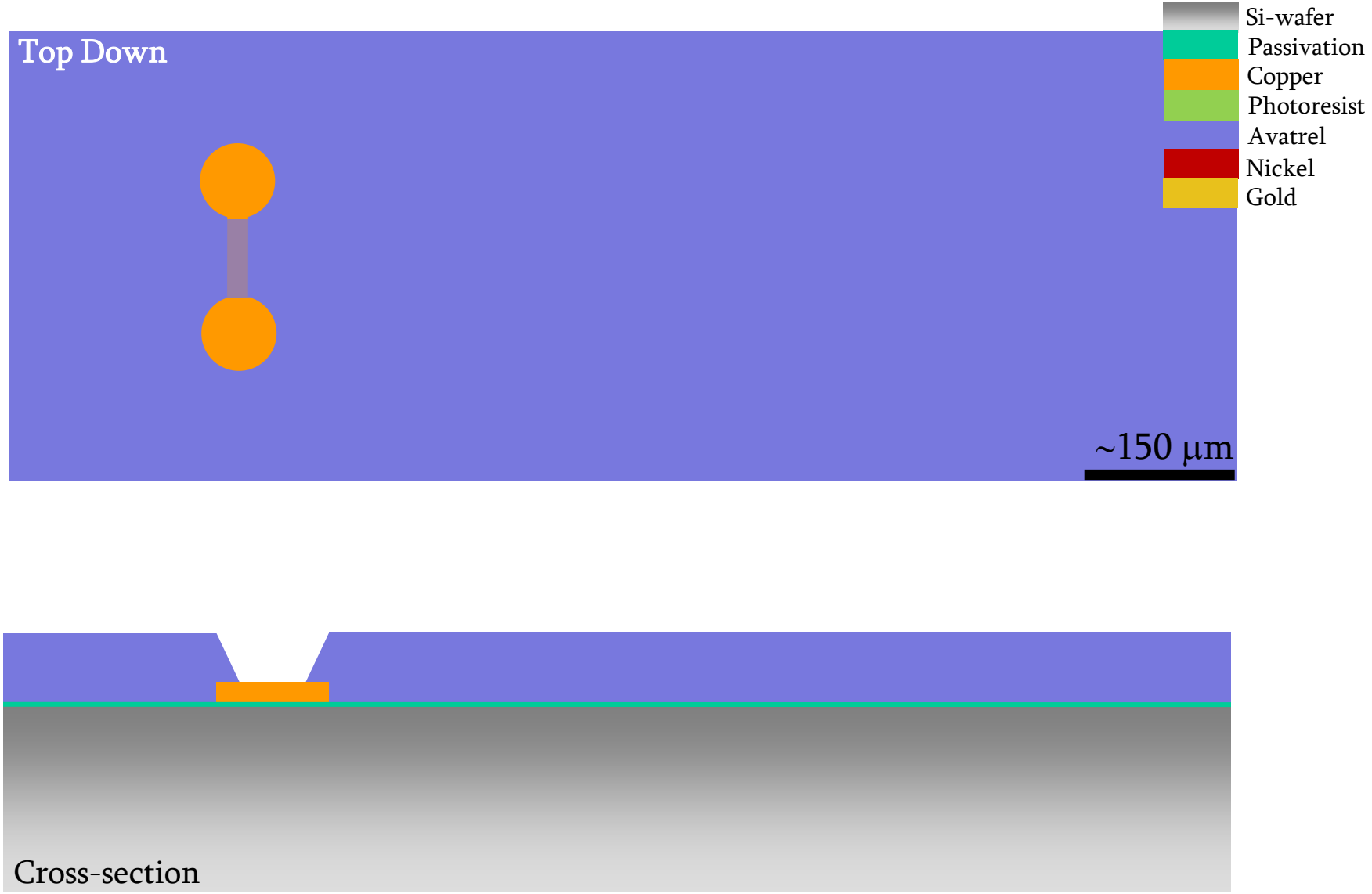


Step 2 Details: Tunable Sidewall using Depth of Focus on Stepper



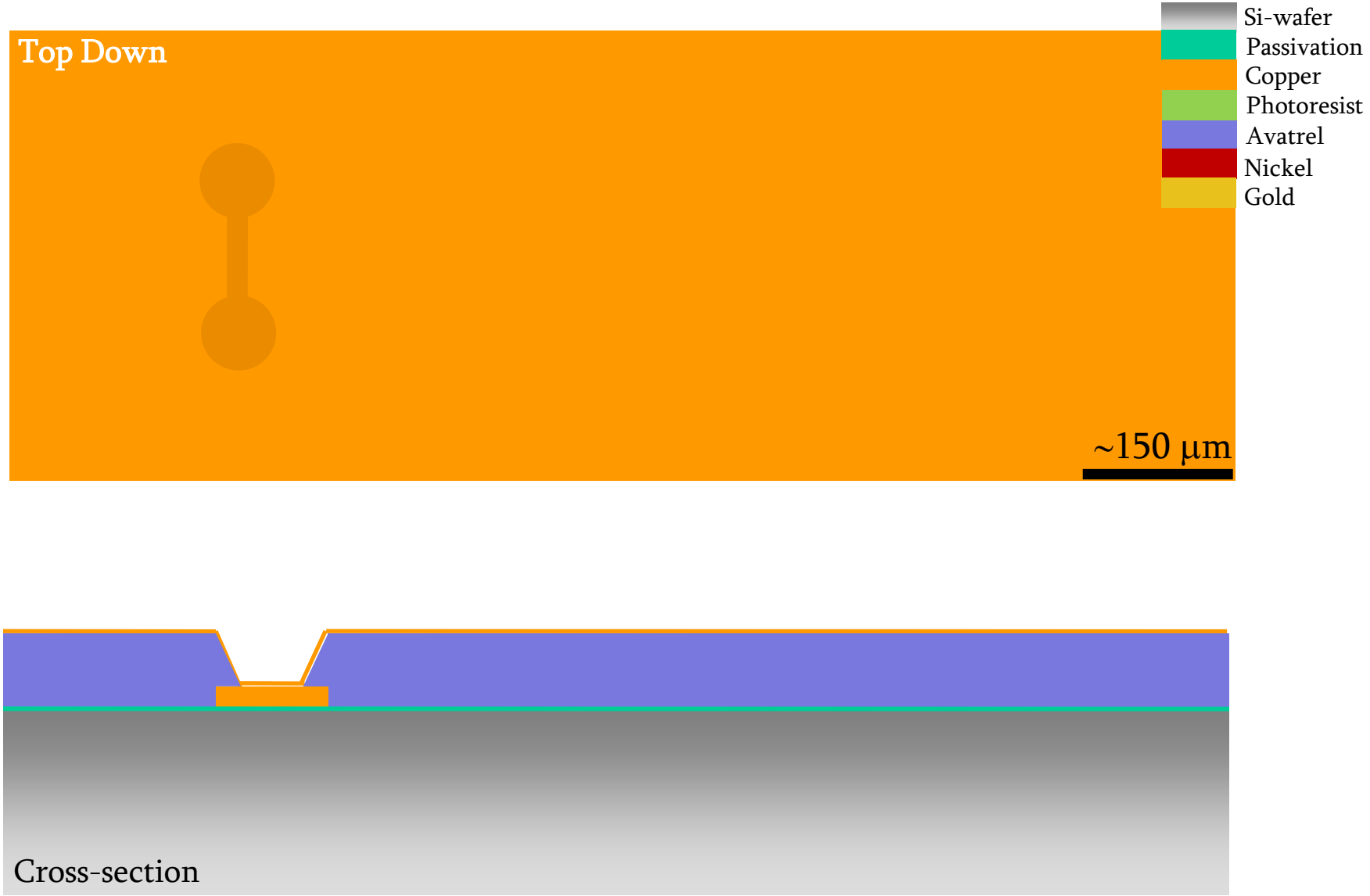


Step 2: 1st Layer of Avatrel Processed



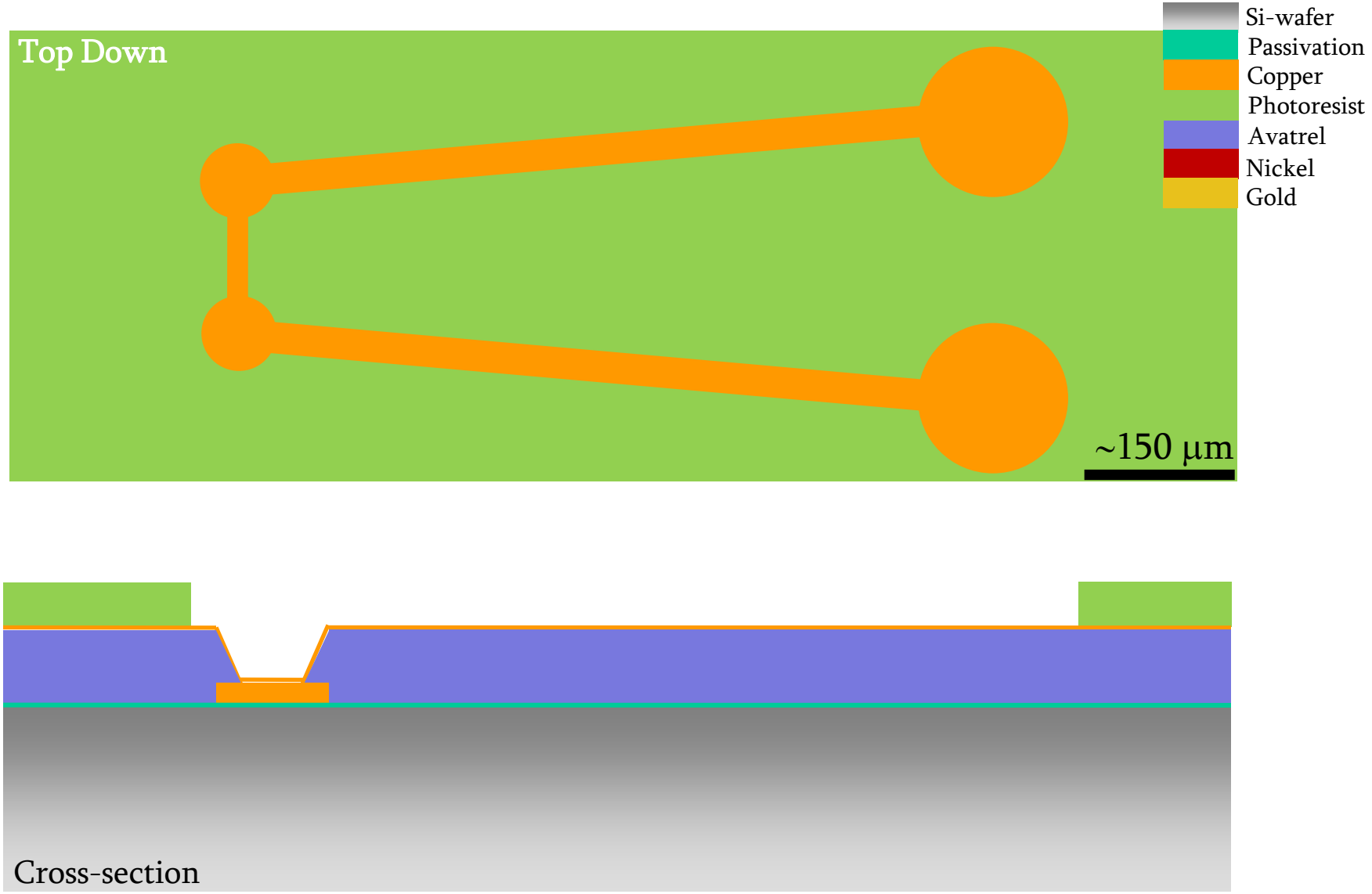
Step 3a: Deposited Conductive Seed Layer for Electroplating

- Sputtered Copper, 1000Å

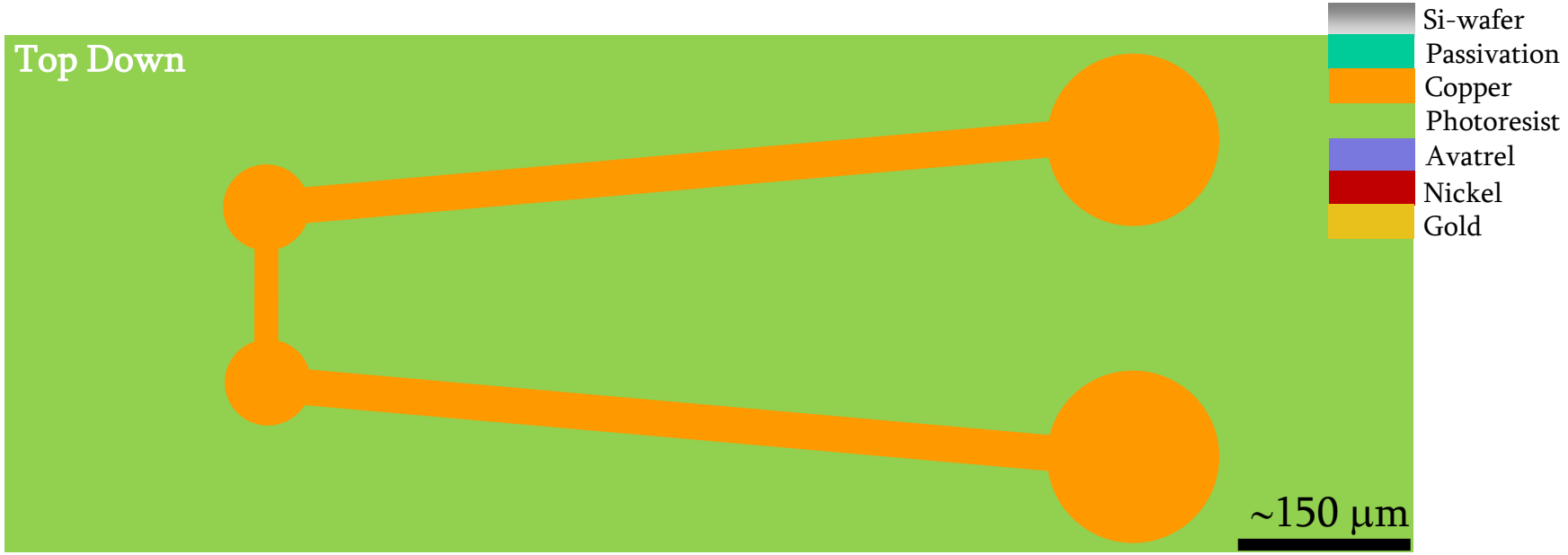


Step 3b: Patterned Metal-2 with Plating Resist

- AZ 9260: Thick Film, Positive-Tone

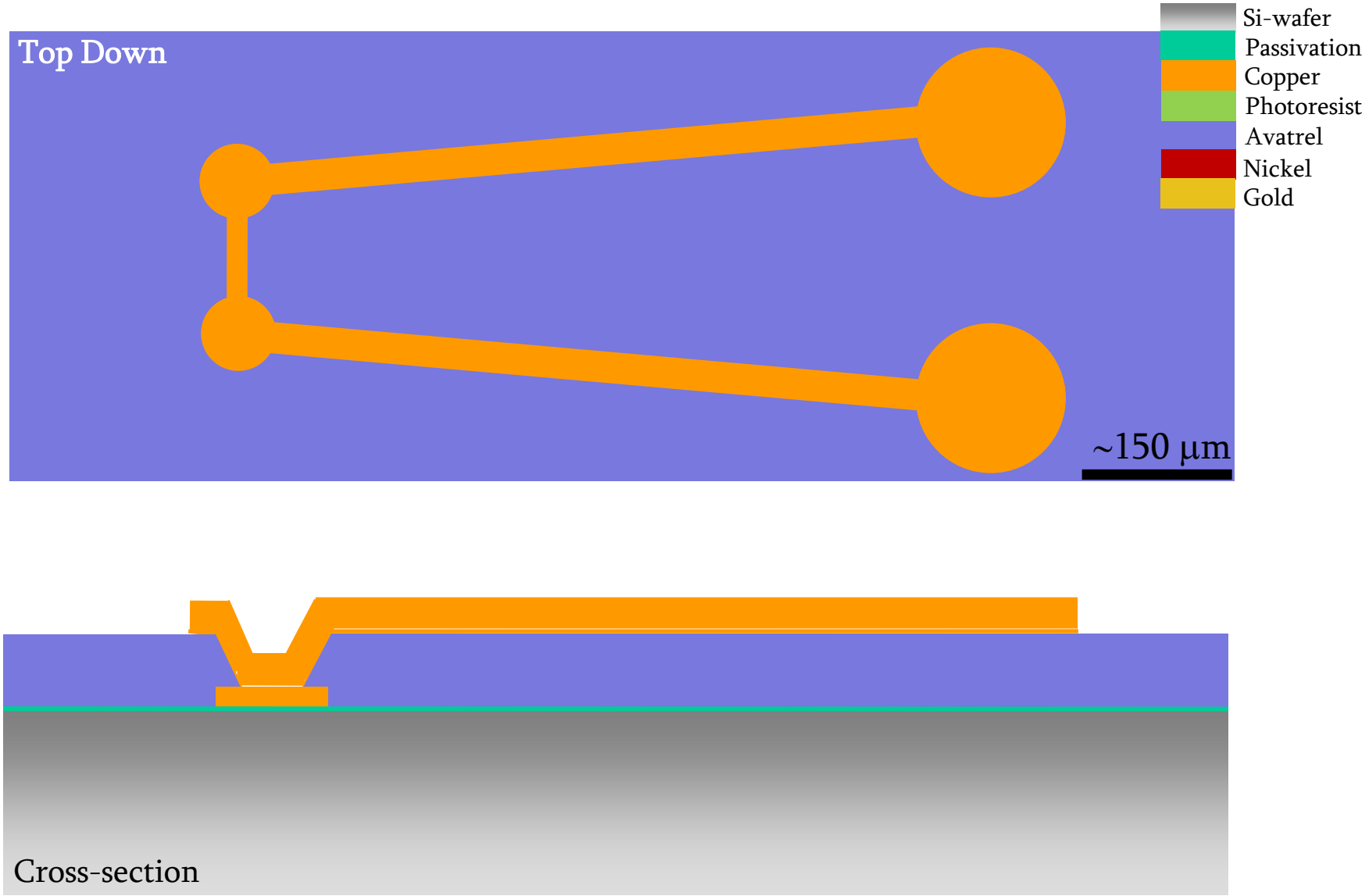


Step 3c: Subjected to Copper Electroplating (3-7 µm)

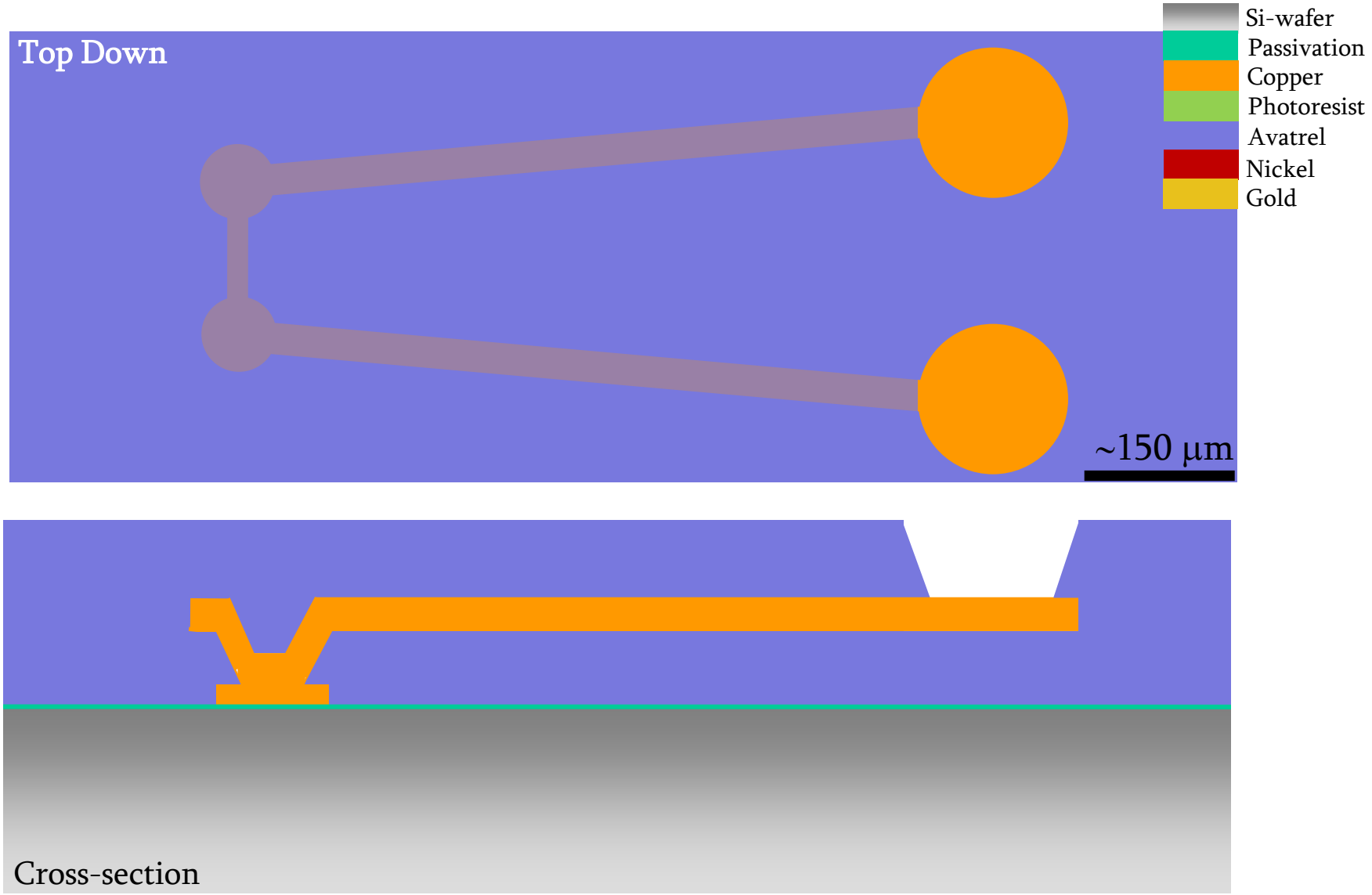


Step 3d: Stripped Resist and Etched Seed Layer

- Acetone/IPA, Transene APS-100 Copper Etchant

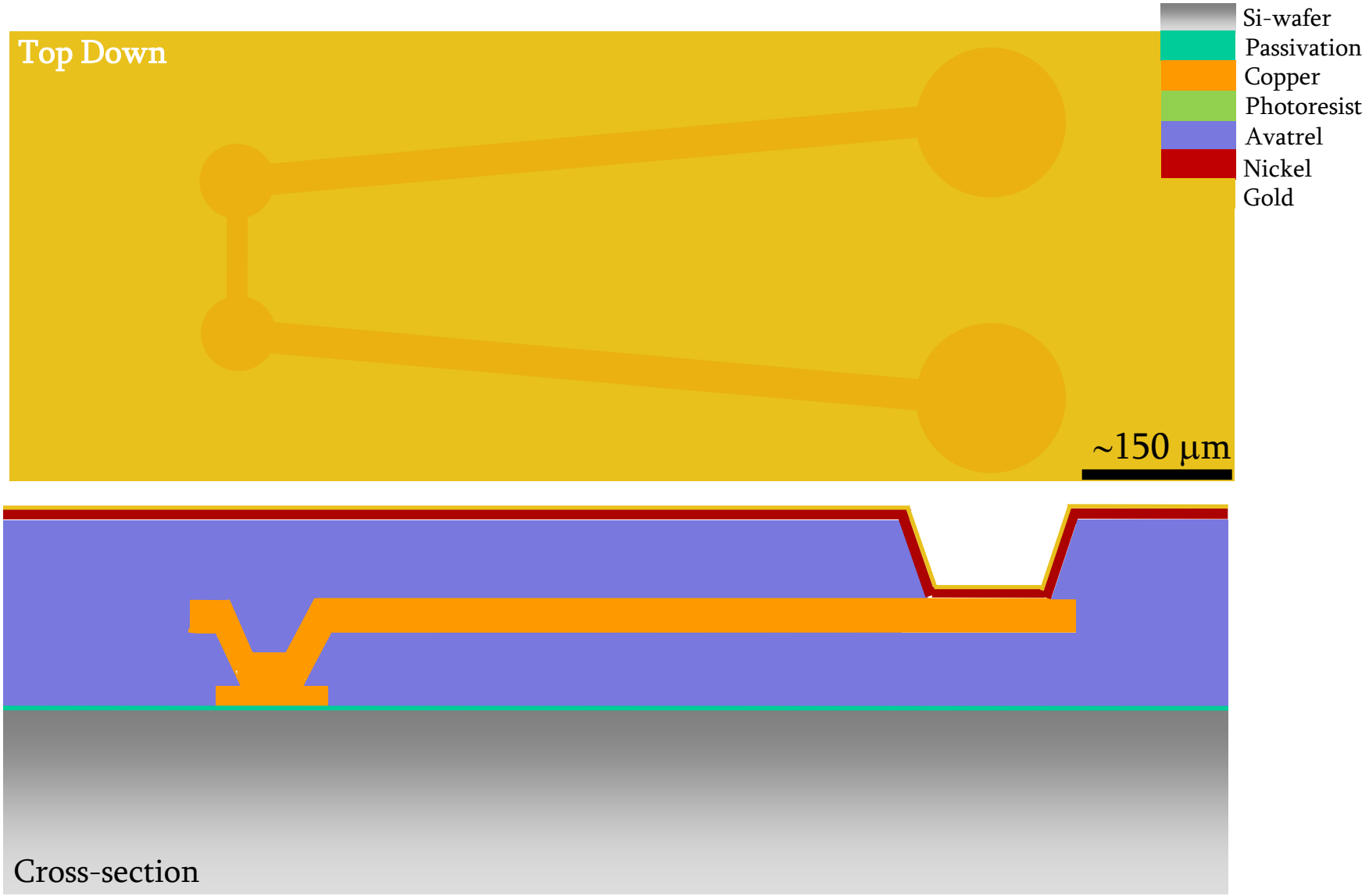


Step 4: 2nd Layer of Avatrel Processed



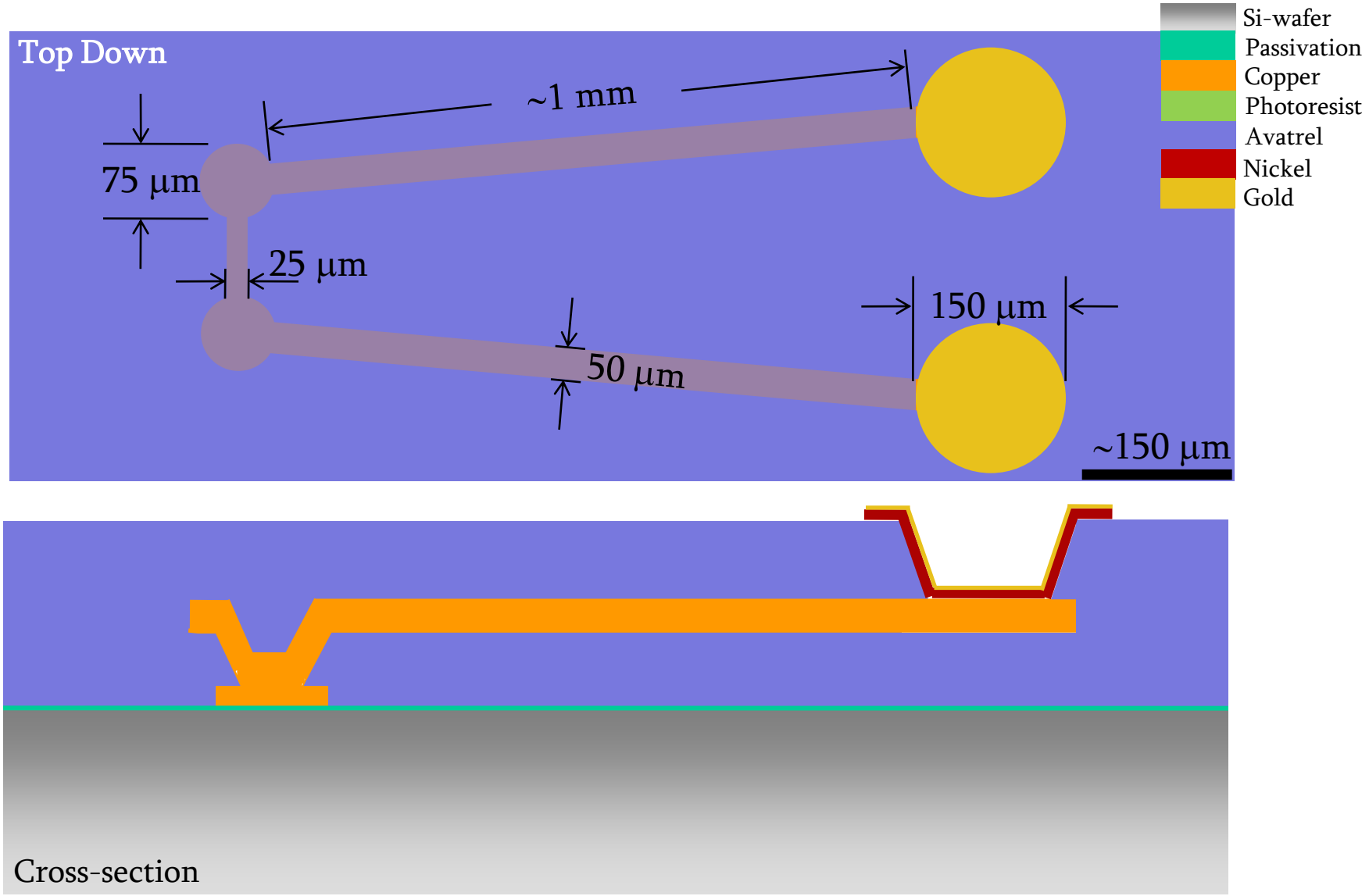
Step 5a: Deposited Metal-3 for UBM

- Sputtered 3000Å Nickel, 500Å Au

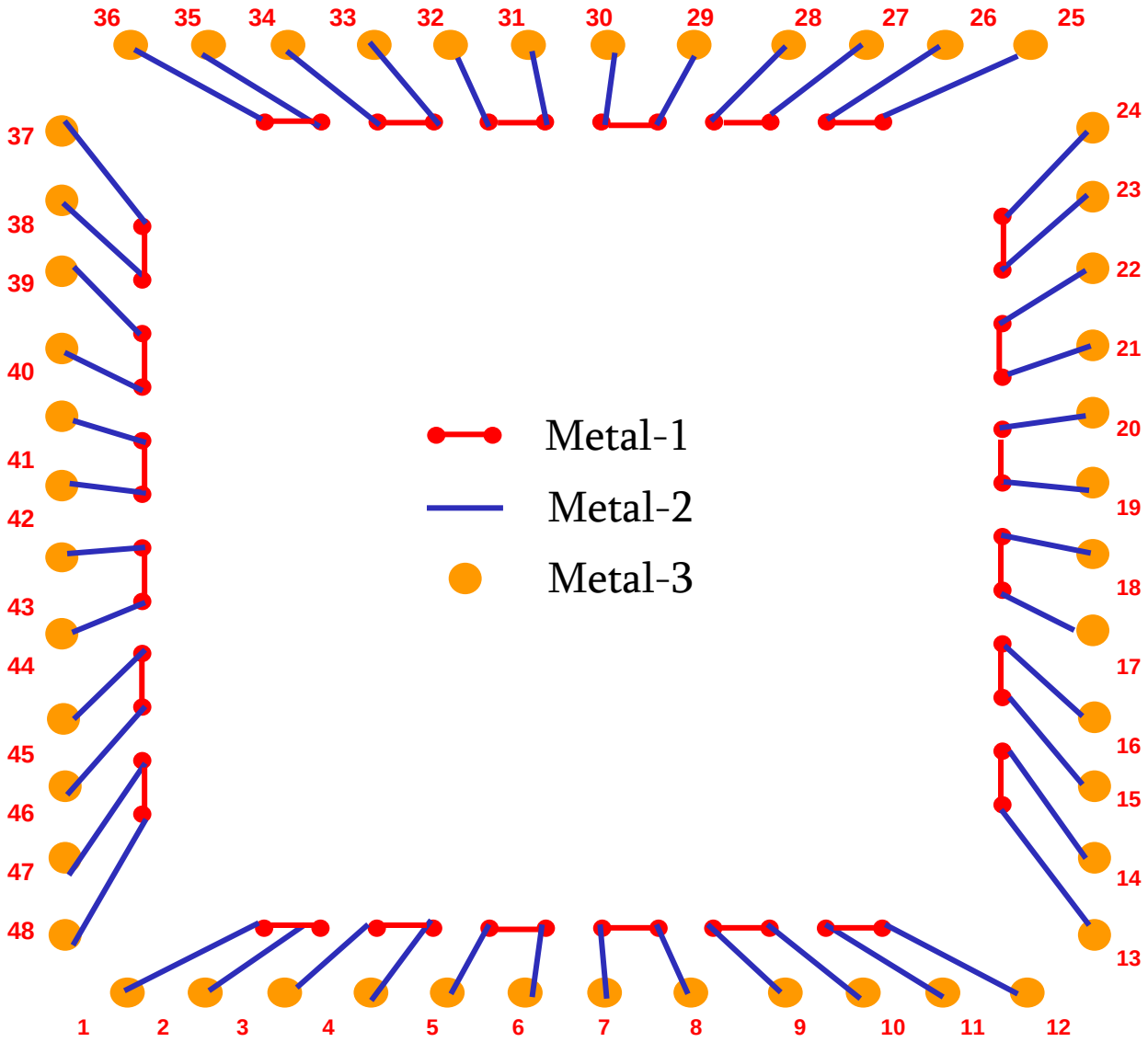


Step 5b: Metal-3 Patterned with Photo/Etch

- AZ 9260 Resist, Transene Gold Etch TFA & Nickel Etch TFG

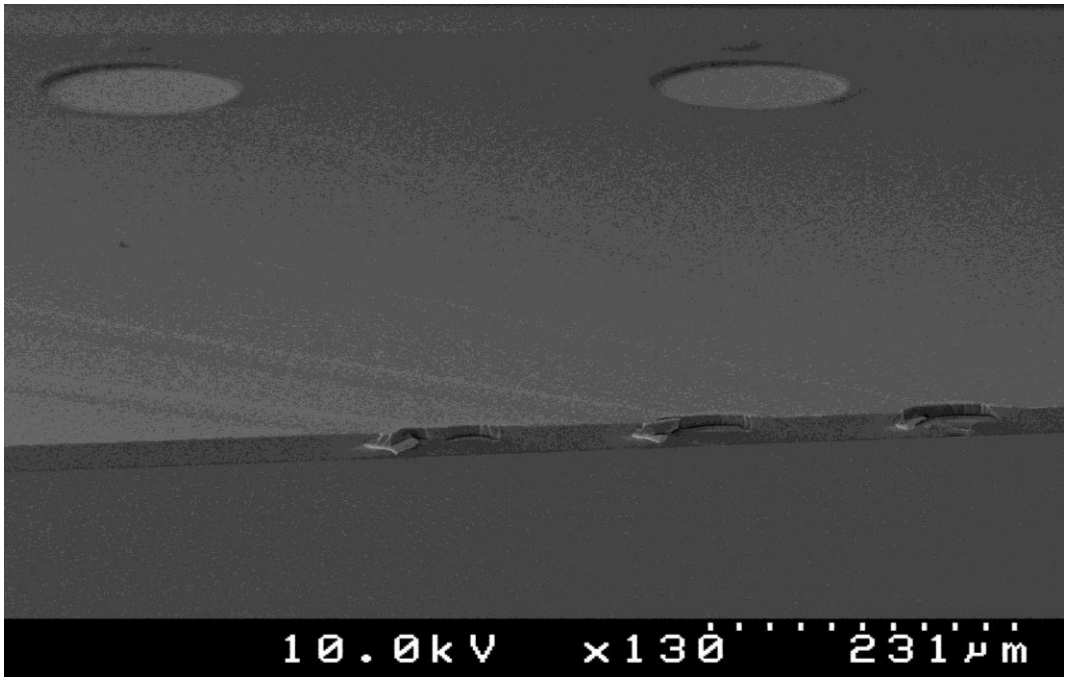


Device Layout on Die (6.3 mm x 6.3 mm)

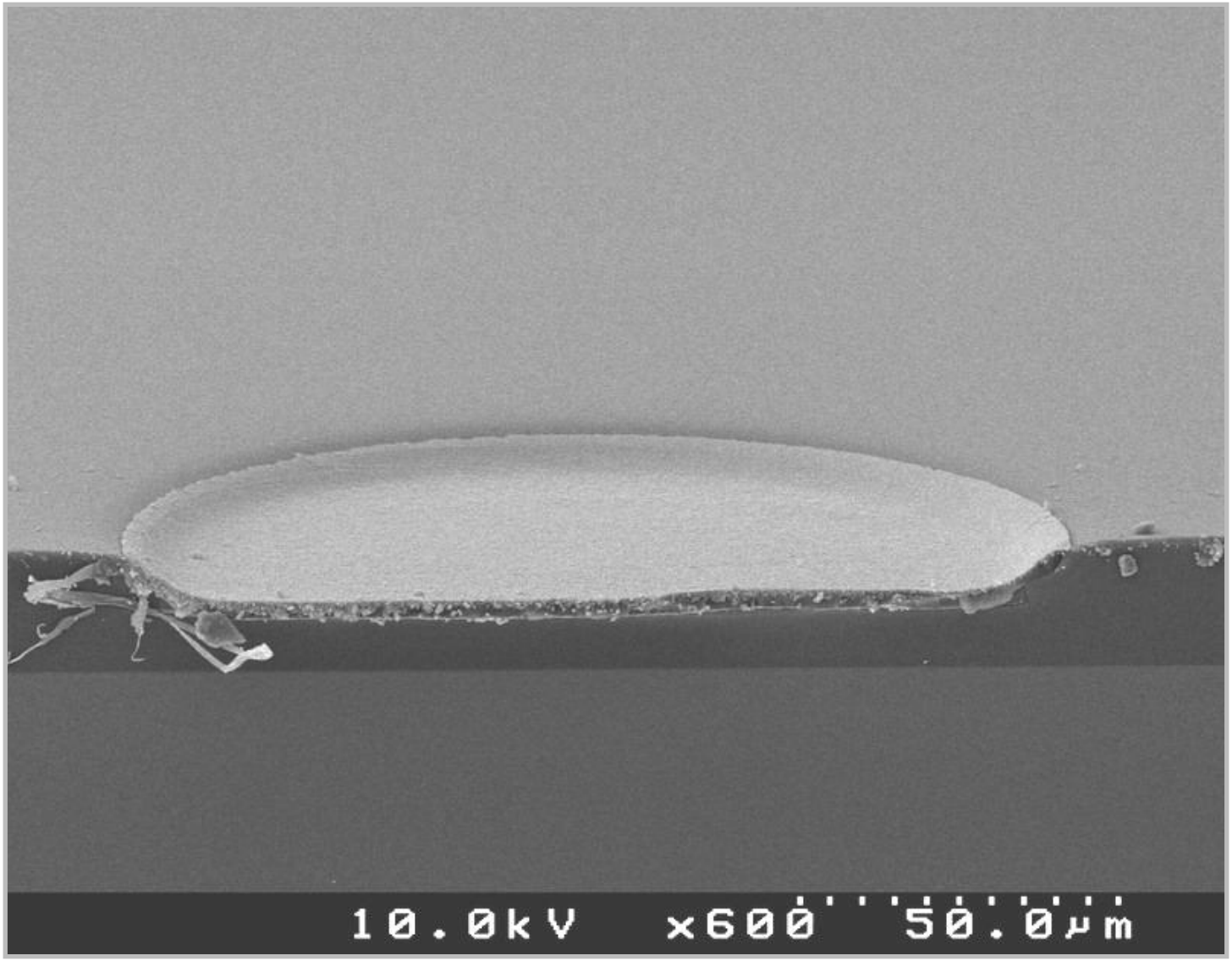


SEM Image of Full Device

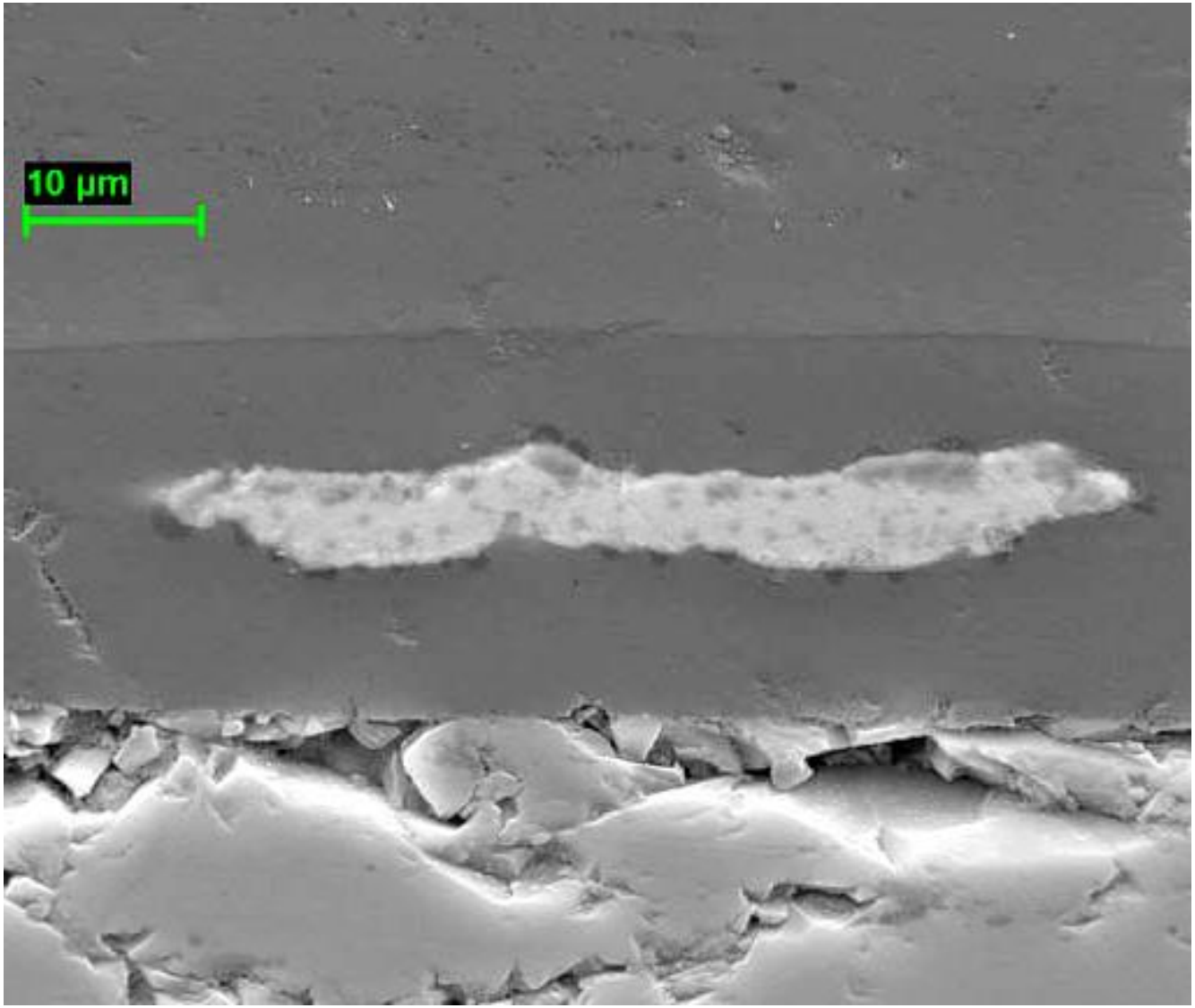
- Metal-1
  - Titanium: 100Å
  - Copper: 5000Å
- Avatrel-1
  - 10 μm
- Metal-2
  - Copper: 4 μm
- Avatrel-2
  - 10 μm
- Metal-3
  - Nickel: 3000Å
  - Gold: 500Å



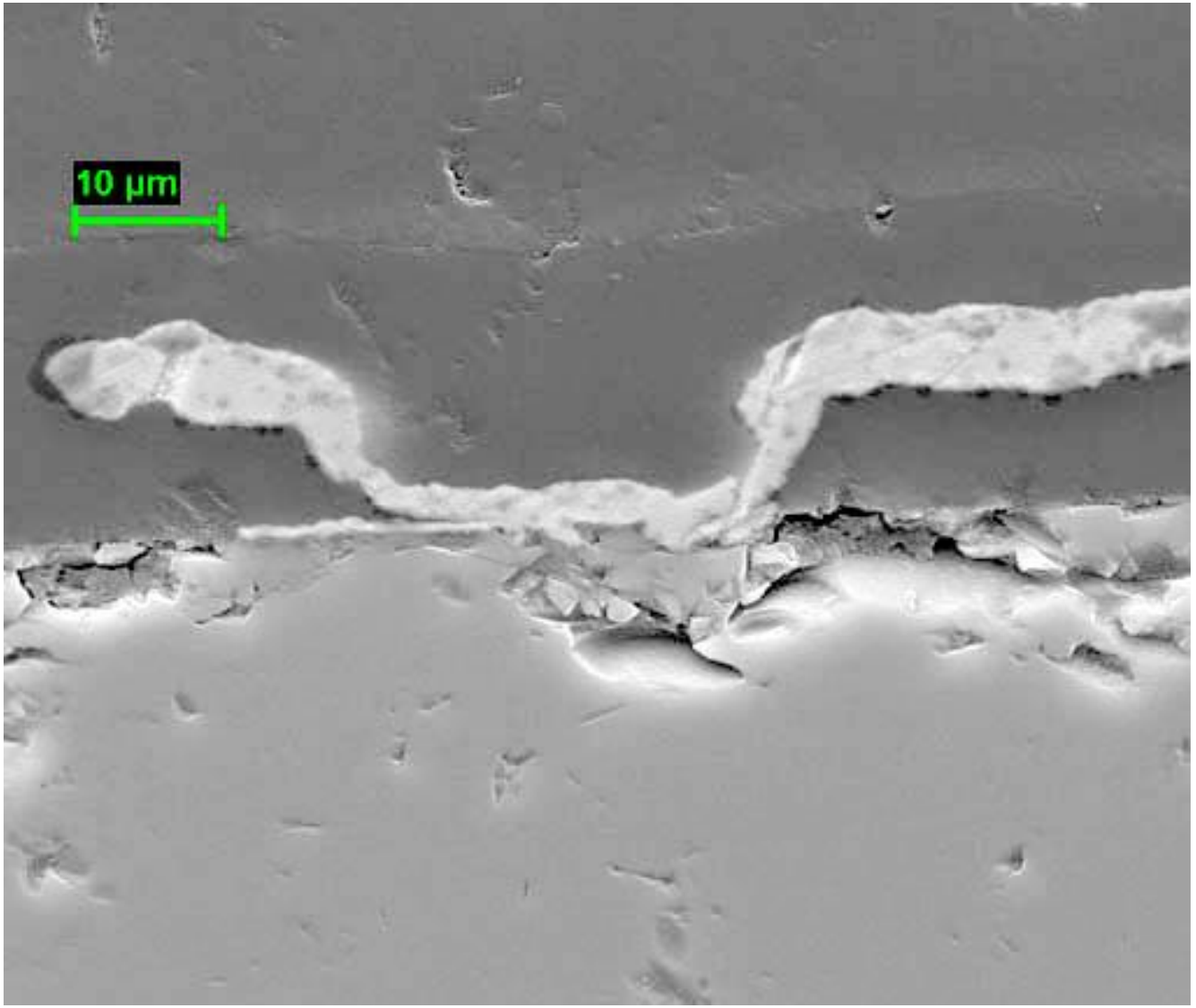
SEM Image of Metal-3 Bond Pad



SEM Image of Buried Metal-2 Copper Trace



SEM Image of Metal-1 and Metal-2

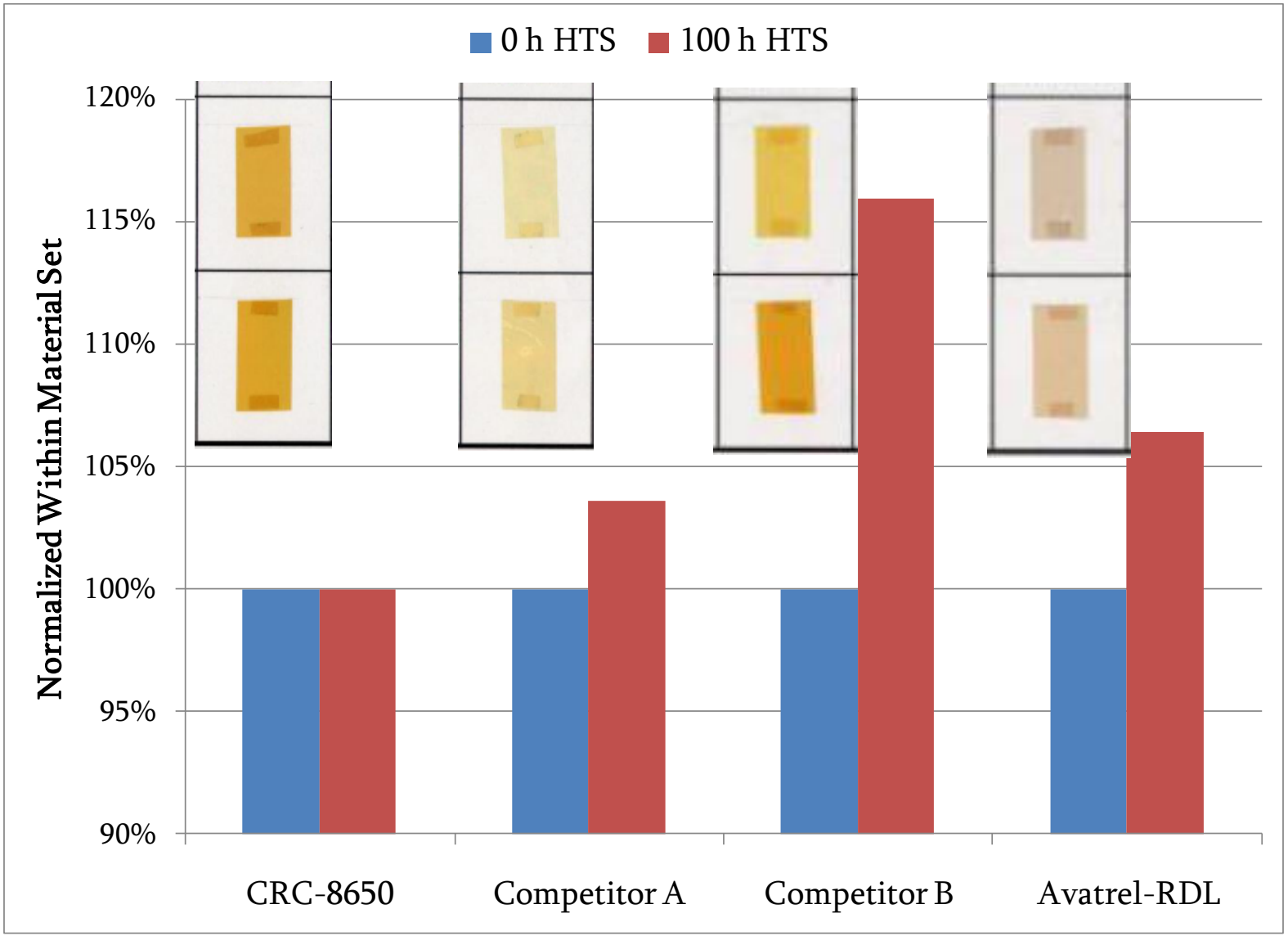


Reliability Testing

Thermal Cycling (T/C) -55°C -> 125°C JEDEC 22, A104-A	0	100	200	500	1000	Cycles
Thermal Reflow 260°C	0	3	5	10	Cycles	
Pressure Cooker (PCT) 125°C, 2.3 atm, 100% RH JEDEC 22B, A102-B	0	48	96	240	Hours	
High Temperature Storage (HTS) 150°C in air JEDEC 22B, A103-A	0	168	450	1000	Hours	
	Passed			Pending		

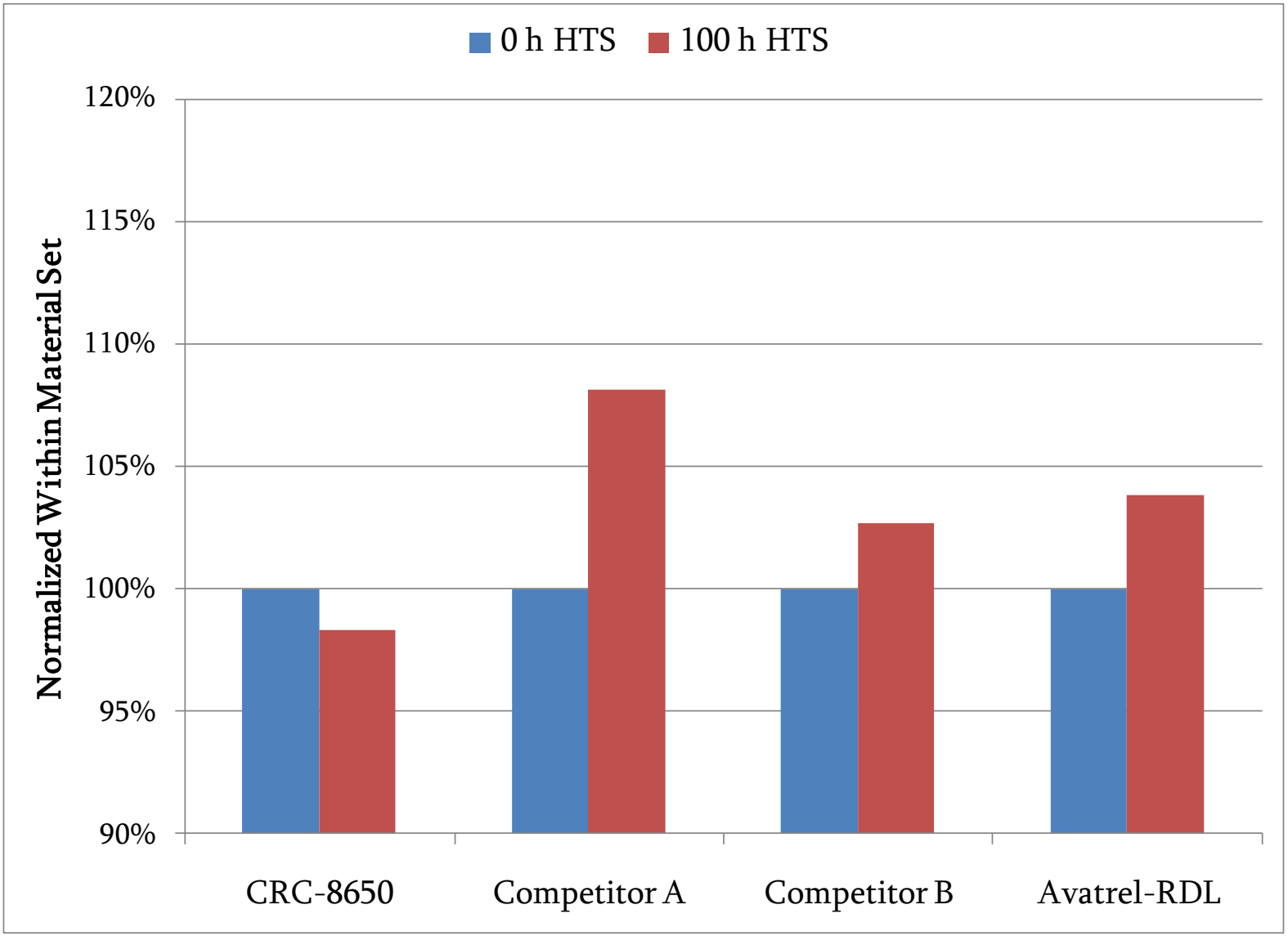
Stability of Tensile Modulus post-HTS

- 150°C in Air



Stability of Tensile Strength post-HTS

- 150°C in Air



Summary

- Avatrel® Redistribution Material
  - Thermal Properties: high T_g, good stability
  - Electrical Properties: low CTE and low dielectric constant
  - Wafer Properties: low shrinkage and low residual stress
  - Imaging: thick film, high aspect ratio, tunable sidewall angle
  - Low Temperature Curability
- RDL devices have been successfully fabricated with positive reliability results
- Commercial qualification is ongoing
- Aqueous versions are being developed