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Biography:
As president and technical manager of an independent testing laboratory, Chris is intimate with the bare board and assembly standards, including the finer details and matters of contention. With 24 years at Robisan, he's a seasoned referee between users and suppliers. His current areas of interest include: Pb-free survivability and reliability, coupons, capability and qualification, and conversion of customer requirements for conformance/compliance.

Title:
Is the ENIG Process Evil, or is it Maybe QA, Engineer or Sales Guy?

Executive Summary:

The case of processing issues with Electroless Nickel/Immersion Gold (ENIG) is well documented, even as it endures as a very popular surface finish. Certainly the market says that quality ENIG has some advantages over other surface finishes. This presentation will present data surrounding the question of whether best practice process control and quality assurance are sufficient to ensure reliable solderability after multiple reflow cycles. Or is it perhaps a frequent case of bath longevity and process capability being oversold?

This presentation will also address mitigation strategies such as:

Ni bath control (fewer MTOs)
XRF control charting
The new IPC spread test solderability “W” coupon after reflow preconditioning

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Is the ENIG Process Evil or is it Maybe QA, Engineer or Sales Guy?

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Overview

- ENIG is a High-Risk/High-Reward Finish
- It seems that ENIG bath capabilities may be oversold
- Process Engineers may not have the information or resources they need
- QA and the specifications/test methods they use are inadequate to prevent defect escapes

Scope of the data used

- Dozens of real-world failures
- Mostly class 3 or 3/A
- Mostly complex boards (>14 layers, HDI, sequential lam)
- Some flex
- At least 4 different bath brands (often we don’t know)

Can a Surface finish be Evil?

- Of course not- it has no morals
- However, it can easily carry relatively huge risk into programs that generally accept VERY little risk. Why?
  - Very complex processes, difficult to control
  - Industry standard quality assurance is not aligned with the FMEA cycle

Is the Chemistry Sales Guy Shady?

Well, it is *SALES, however,*

- most engineers claim to de-rate the quality X life of the baths
- Most engineers claim that failure occurred in compliant baths
- Sales reps are often not provided constructive feedback from their customers

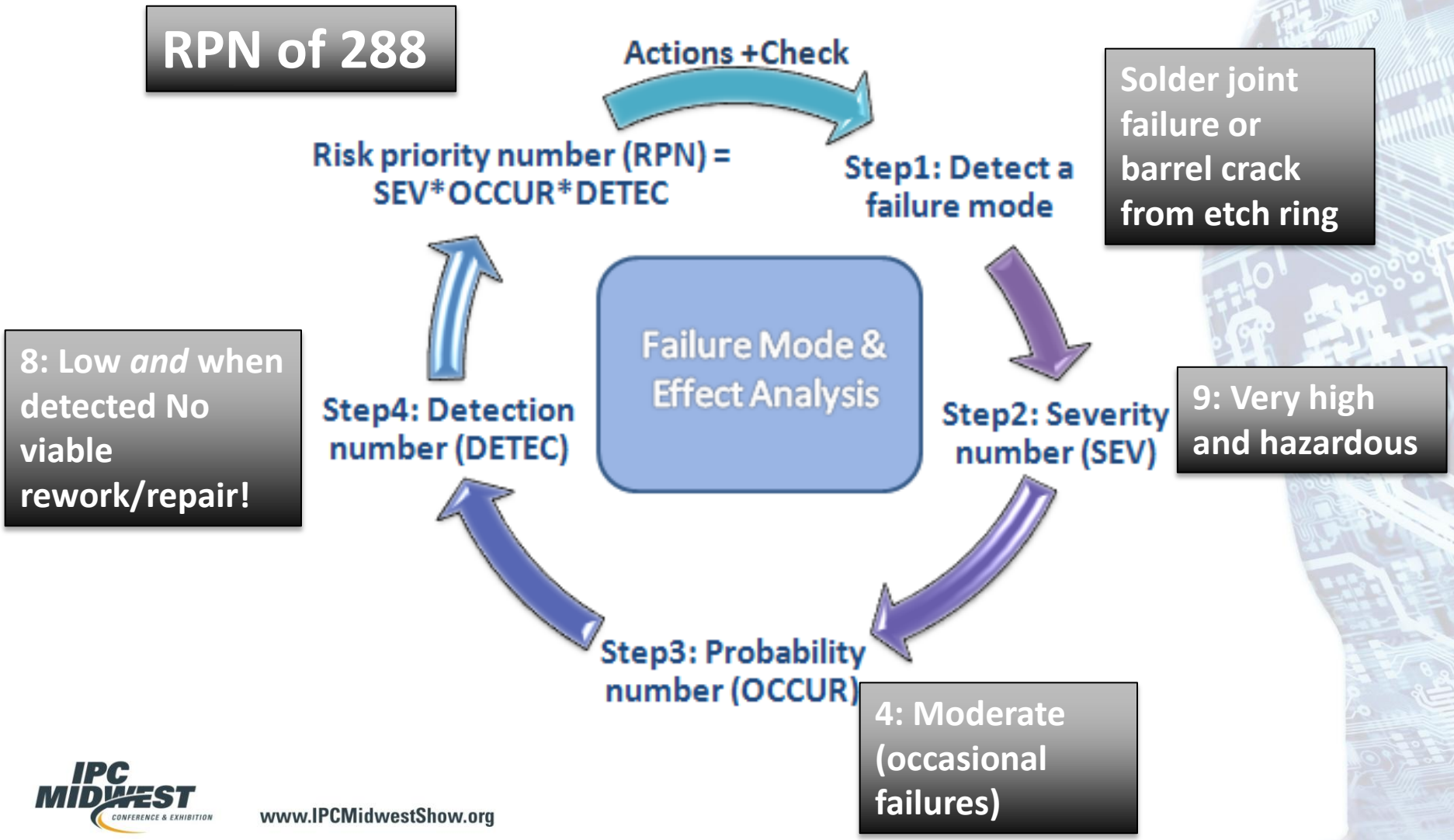
What can be done?

- Find the senior scientists, patent holders, etc.
  - if shopping, qualify the support from these people
  - If already in failure mode
    - collect irrefutable evidence for them.
    - Cross-check CAPA with the vendor's competitors, or independents

Is the engineer looking the other way?

- On the design side:
  - Does the drawing explicitly specify IPC-4552?
  - Does the design use single-sided plug/tent without forcing ENIG prior to solder mask?
- On the fabrication side:
  - There is lots of information out there about how to control the processes. Does engineering have the knowledge and resources to implement? Is cost/production driving risky engineering decisions?

FMEA Cycle

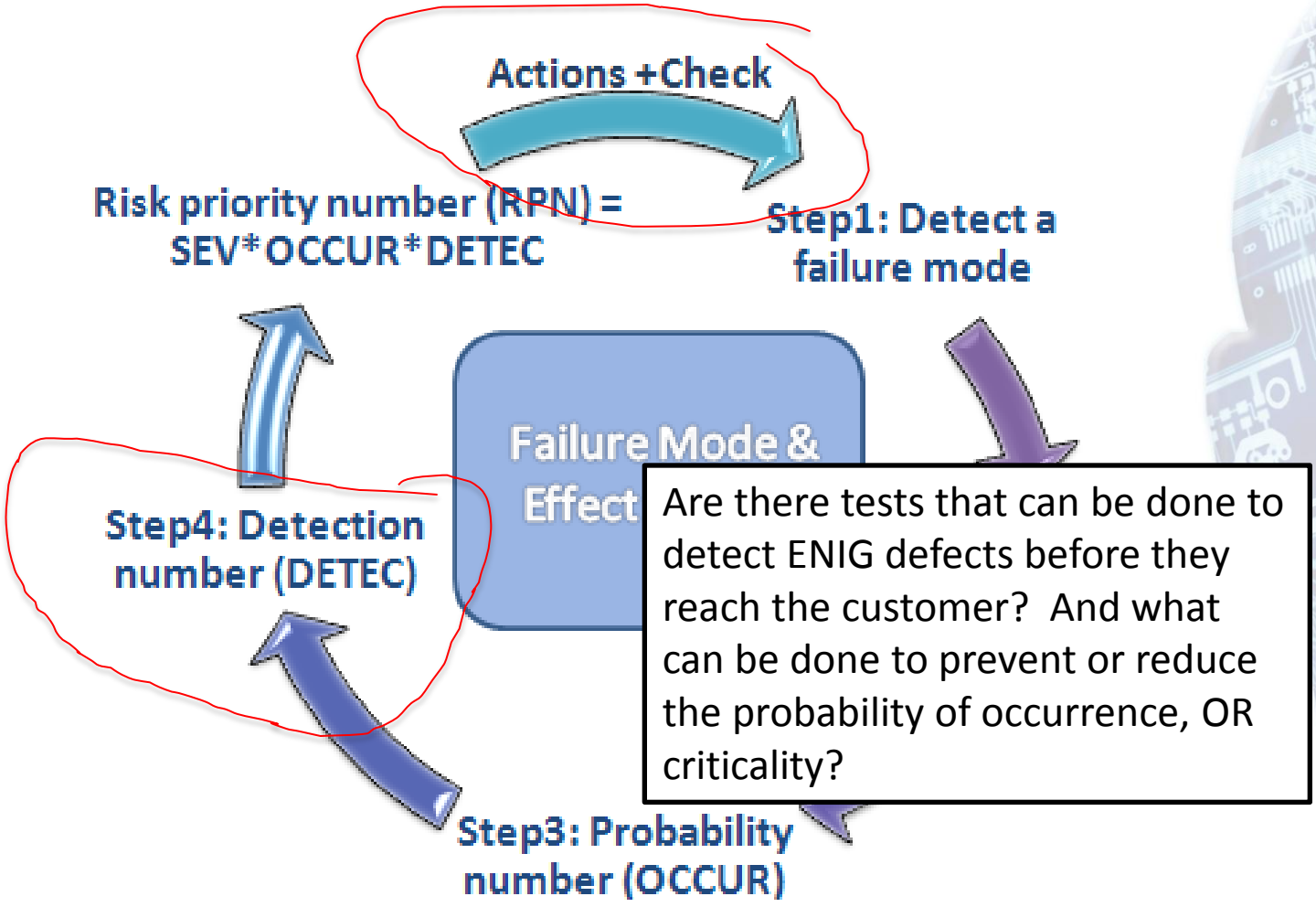

RPN of 288
Actions +Check
Solder joint failure or barrel crack from etch ring
Risk priority number (RPN) = SEV*OCCUR*DETEC
Step1: Detect a failure mode
Failure Mode & Effect Analysis
8: Low *and* when detected No viable rework/repair!
Step4: Detection number (DETEC)
Step2: Severity number (SEV)
9: Very high and hazardous
Step3: Probability number (OCCUR)
4: Moderate (occasional failures)

Criticality ranking

MIL–STD–882 uses five probability levels:

Description	Level	Individual Item
Frequent	A	Likely to occur in the life of the item
Probable	B	Will occur several times in the life of an item
Occasional	C	Likely to occur some time in the life of an item
Remote	D	Unlikely but possible to occur in the life of an item
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced

What is QA thinking???



Non-compliance with IPC-4552

- 6010 series does not explicitly require compliance
- Durability of coating rating 3 Preconditioning prior to J-STD-003 test A or A1 is very rarely performed, except for Class 3/A
- J-STD-003 specified flux is often not used
- The vast majority of control data for P content, and Au thickness is statistically useless

Finish is required in vias

3.3.3 Plating and Coating Voids in the Hole Plating and coating voids **shall not** exceed that allowed by Table 3-6.

Table 3-6 Plating and Coating Voids in the Hole

Material	Class 1	Class 2	Class 3
Copper[1]	Three voids allowed per hole in not more than 10% of the holes.	One void allowed per hole in not more than 5% of the holes.	None
Finish Coating[2]	Five voids allowed per hole in not more than 15% of the holes.	Three voids allowed per hole in not more than 5% of the holes.	One void allowed per hole in not more than 5% of the holes.

Note 1. For Class 2 product, copper voids **shall not** exceed 5% of the hole length. For Class 1 product, copper voids **shall not** exceed 10% of the hole length. Circumferential voids **shall not** extend beyond 90° of the circumference.

Note 2. For Class 2 and Class 3 product, finished coating voids **shall not** exceed 5% of the hole length. For Class 1, finished coating voids **shall not** exceed 10% of the hole length. Circumferential voids **shall not** extend beyond 90° for Class 1, Class 2 or Class 3.

Red flags

- Did the XRF machine cost less than your car?
- Is there a temperature/humidity chamber in the lab?
- Can you sing the alphabet faster than the integration time of the XRF?
- Does the lab find unprotected bare Cu in vias nonconformant?
- Temperature of the bath, MTOs, bath controllers and charts

Above and beyond

- Get statistically valid P content data from EDS, and then correlate to XRF
- Develop fuzzy model for how P content varies, as well as other Ni defects like morphology, cycling layers, co-deposits, voiding
- FIB sectioning
- Spread tests

ENIG and hole solderability

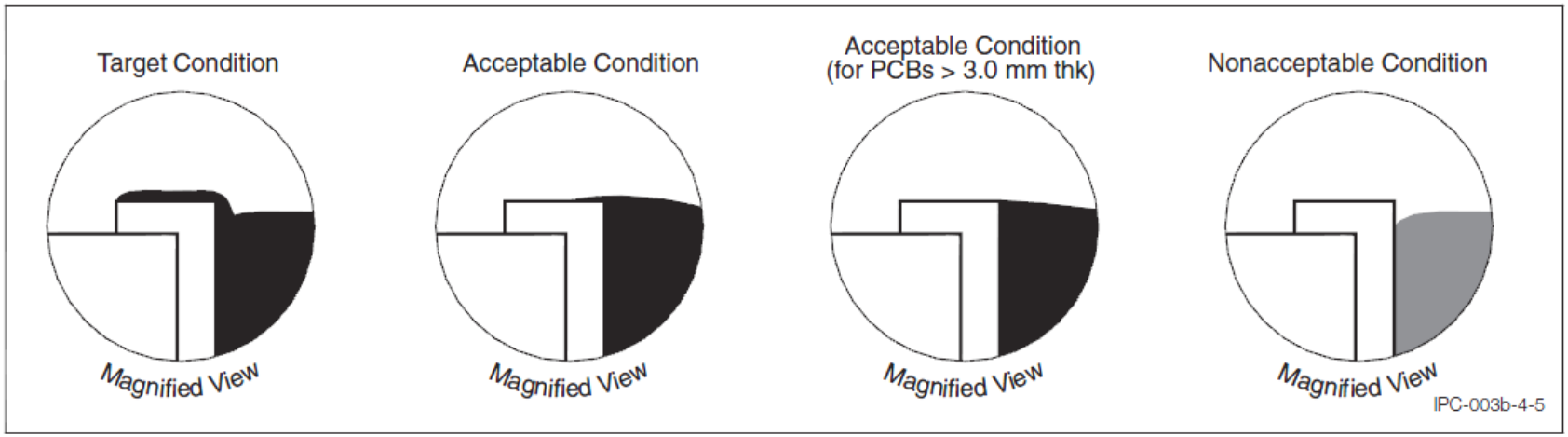
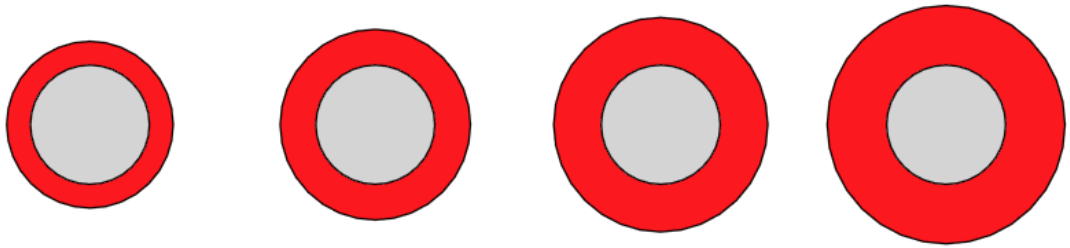


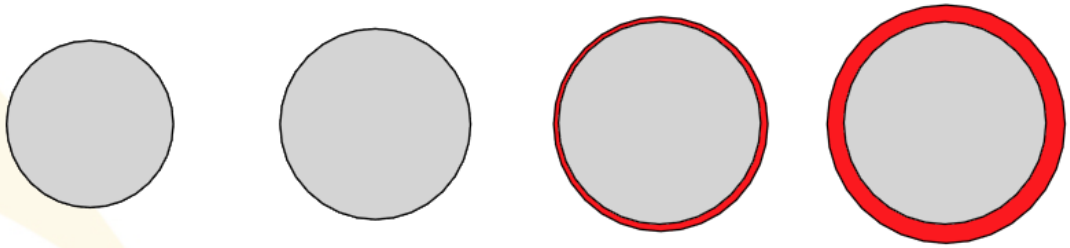
Figure 4-5 Effectiveness of Solder Wetting of Plated-Through Holes - Class 3

A novel spread test is needed

- Before reflow

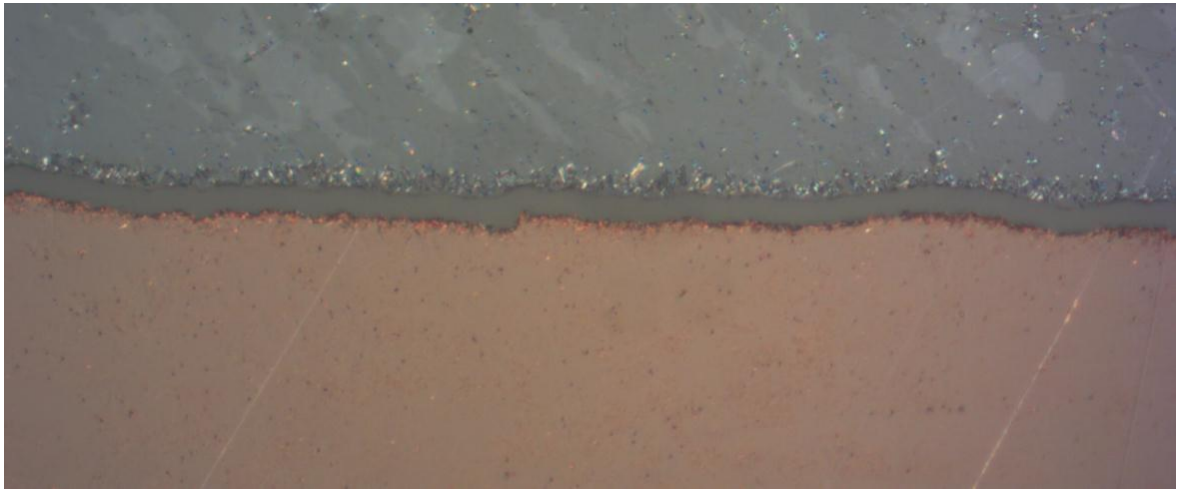


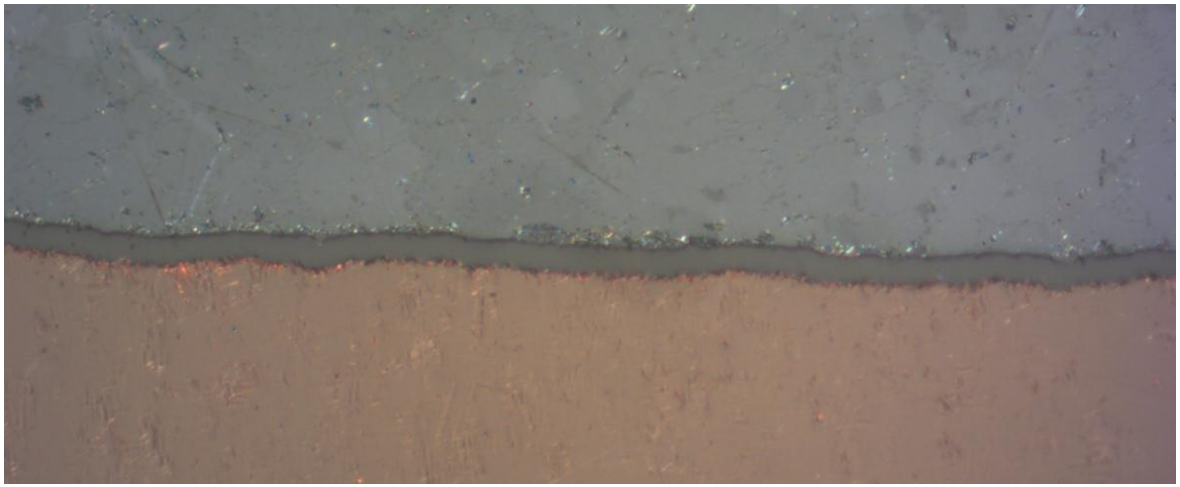
- After reflow



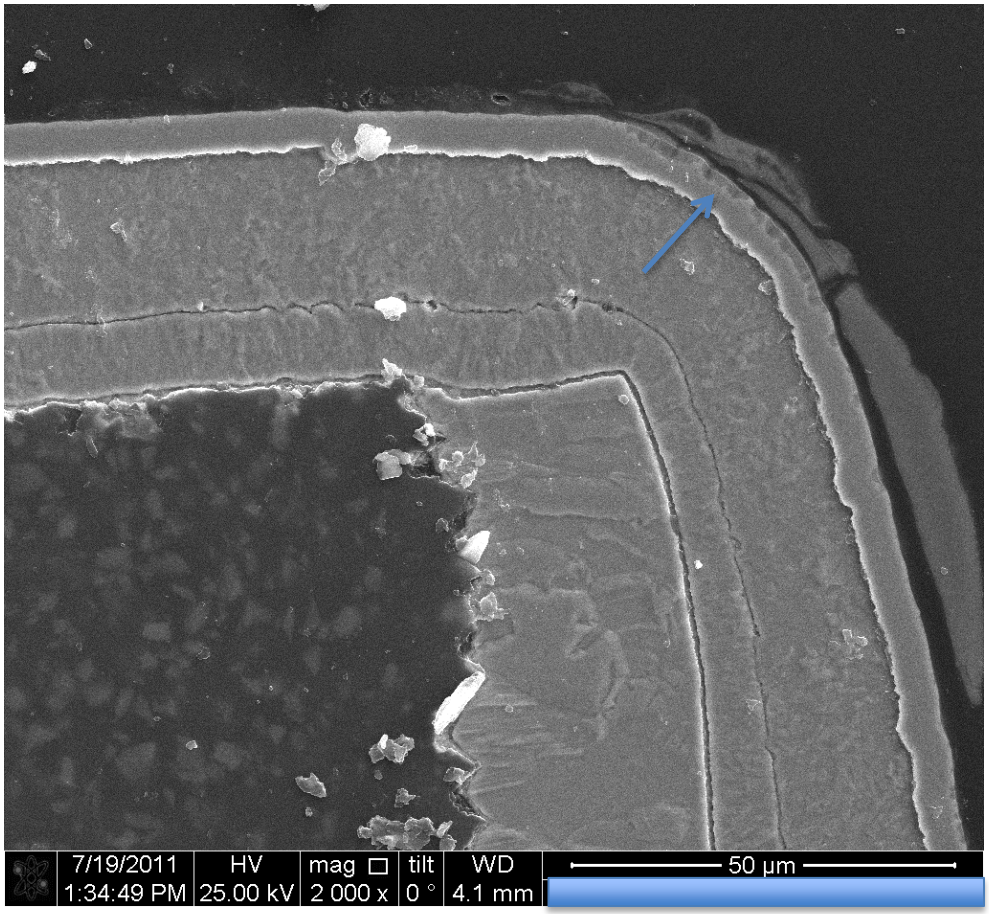
Optical microsections can be very helpful

Ni dissolution

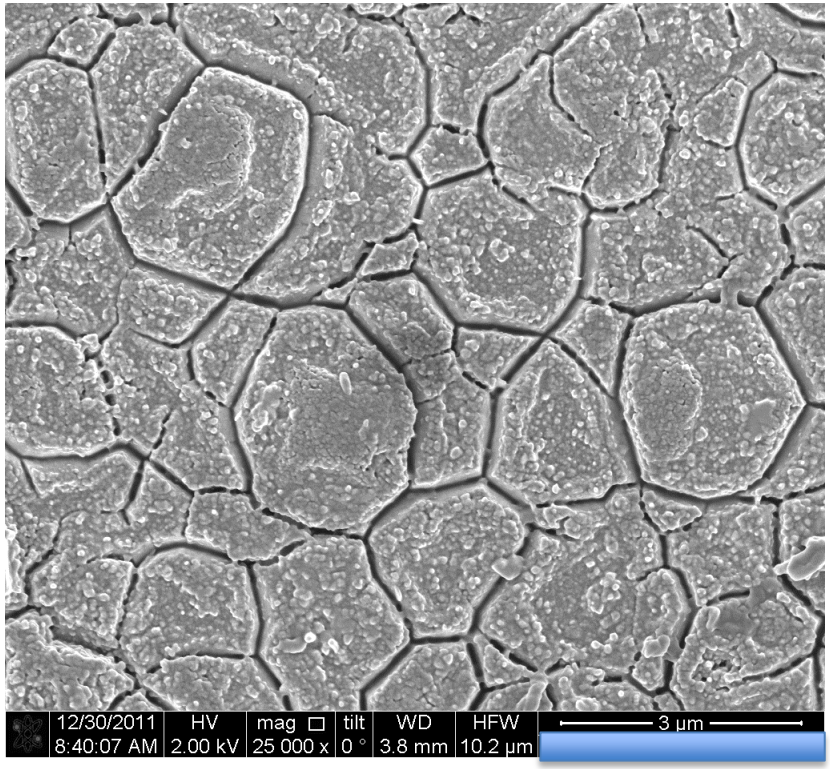


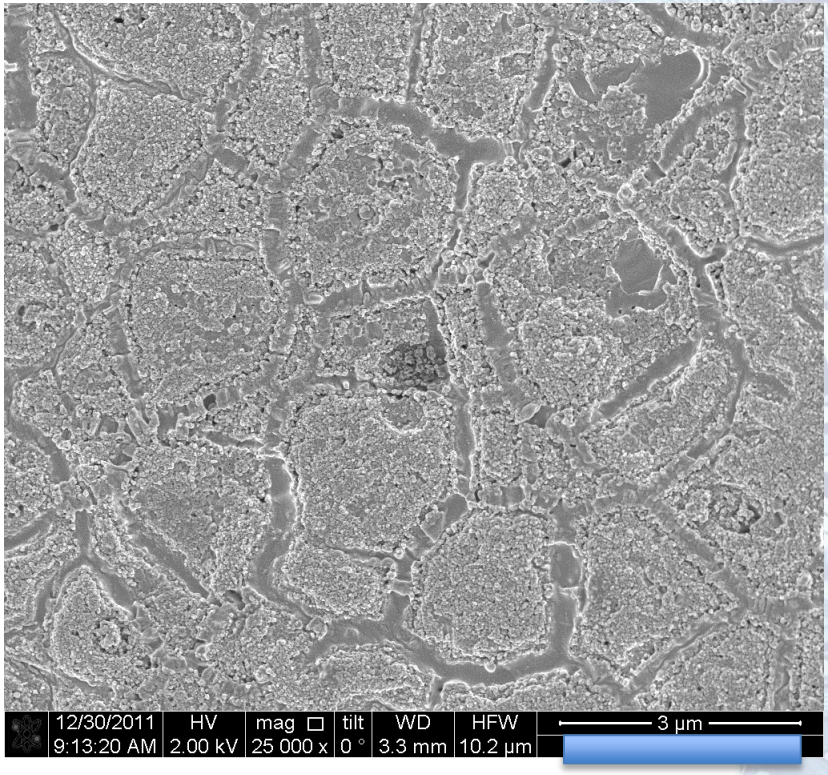


Canary in the coal mine

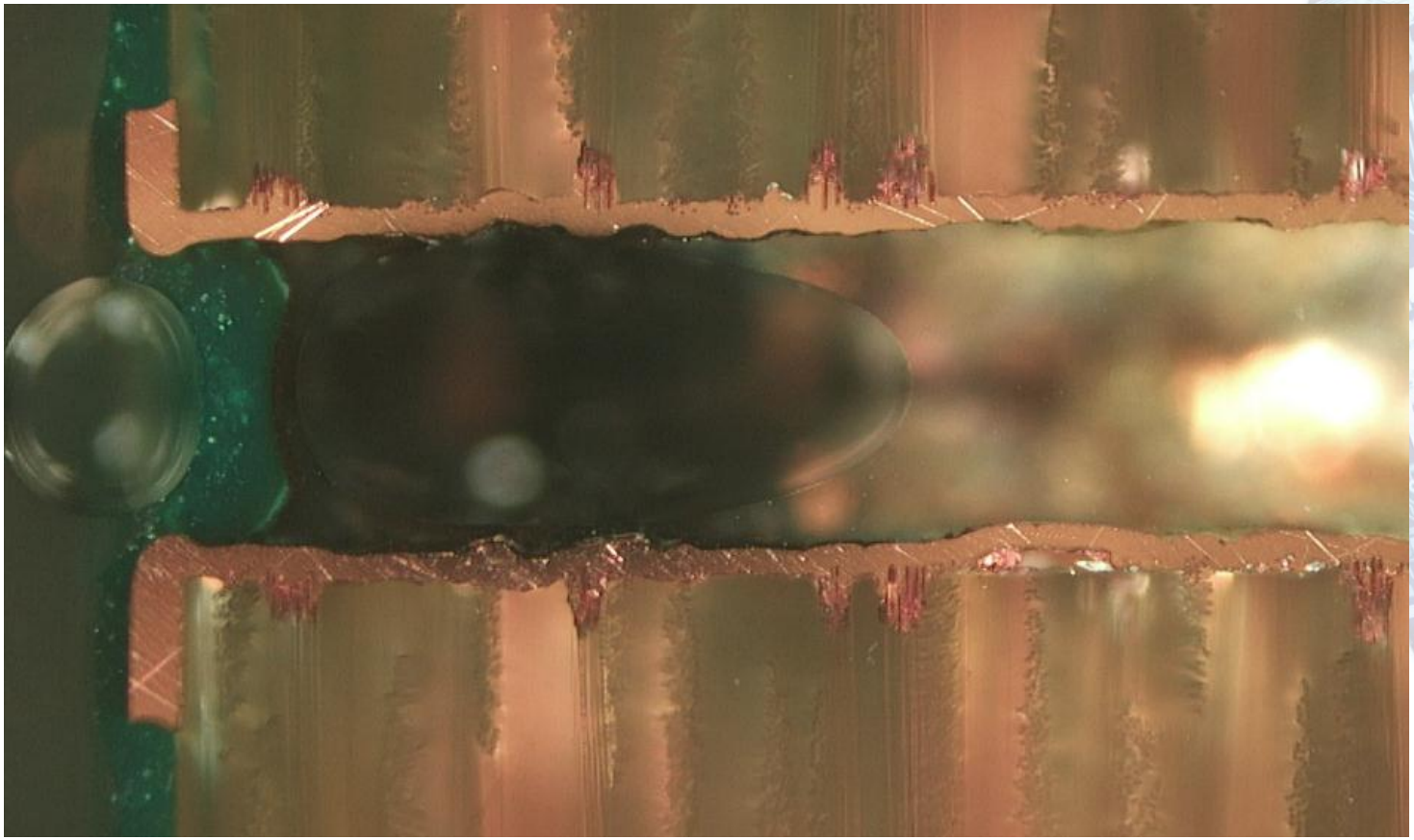


Board side / Component Side

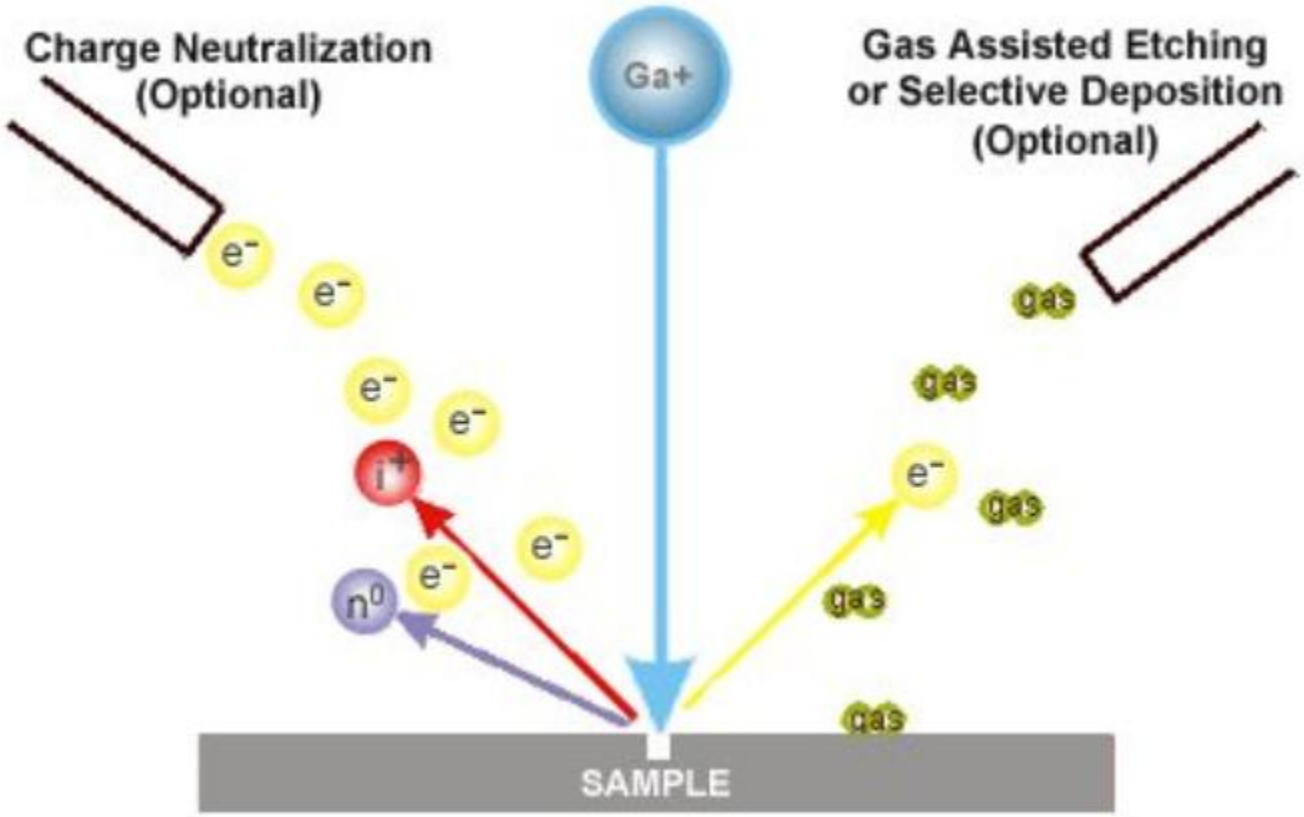




Ni pretreat caused Cu Corrosion



FIB sectioning



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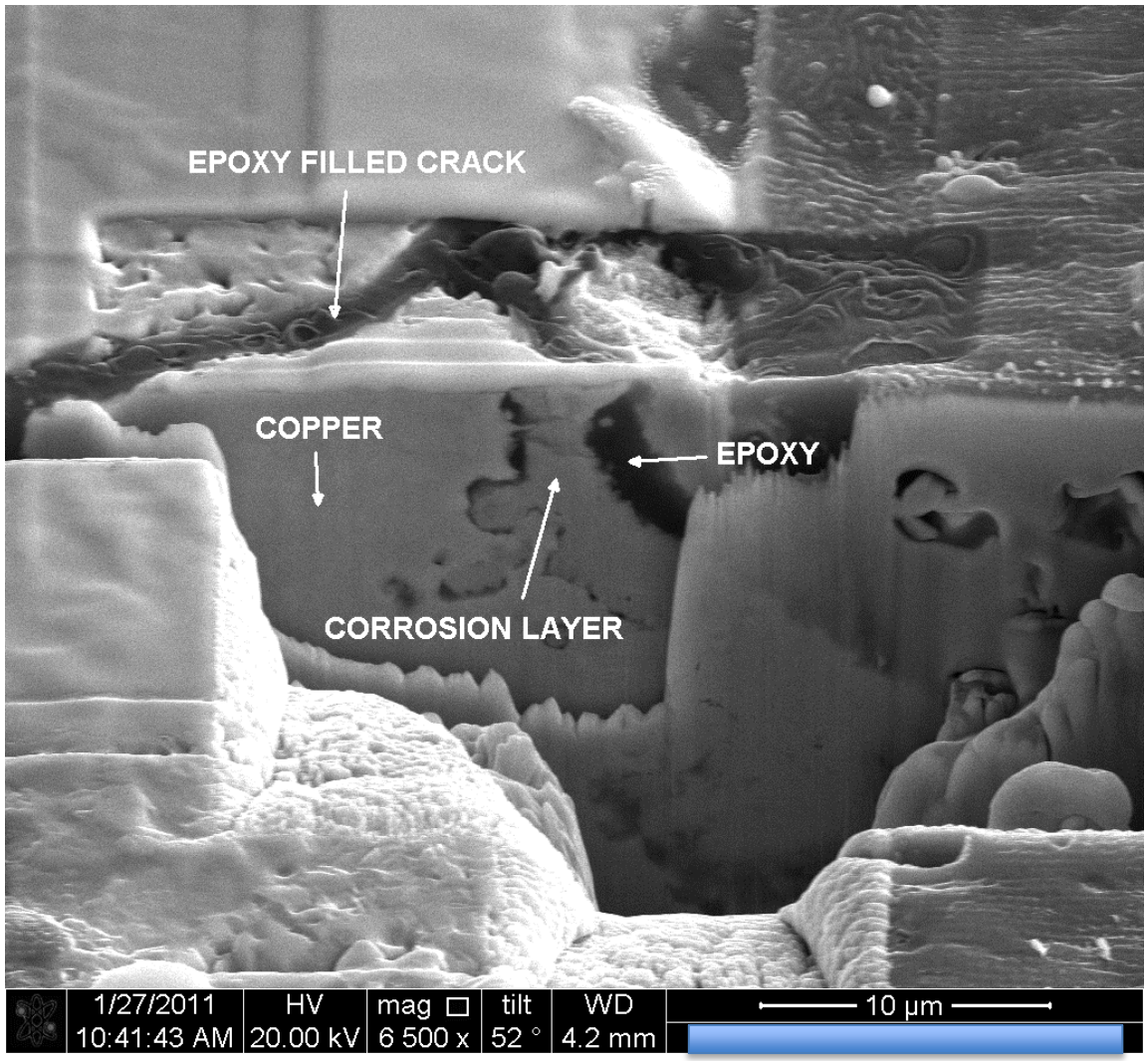
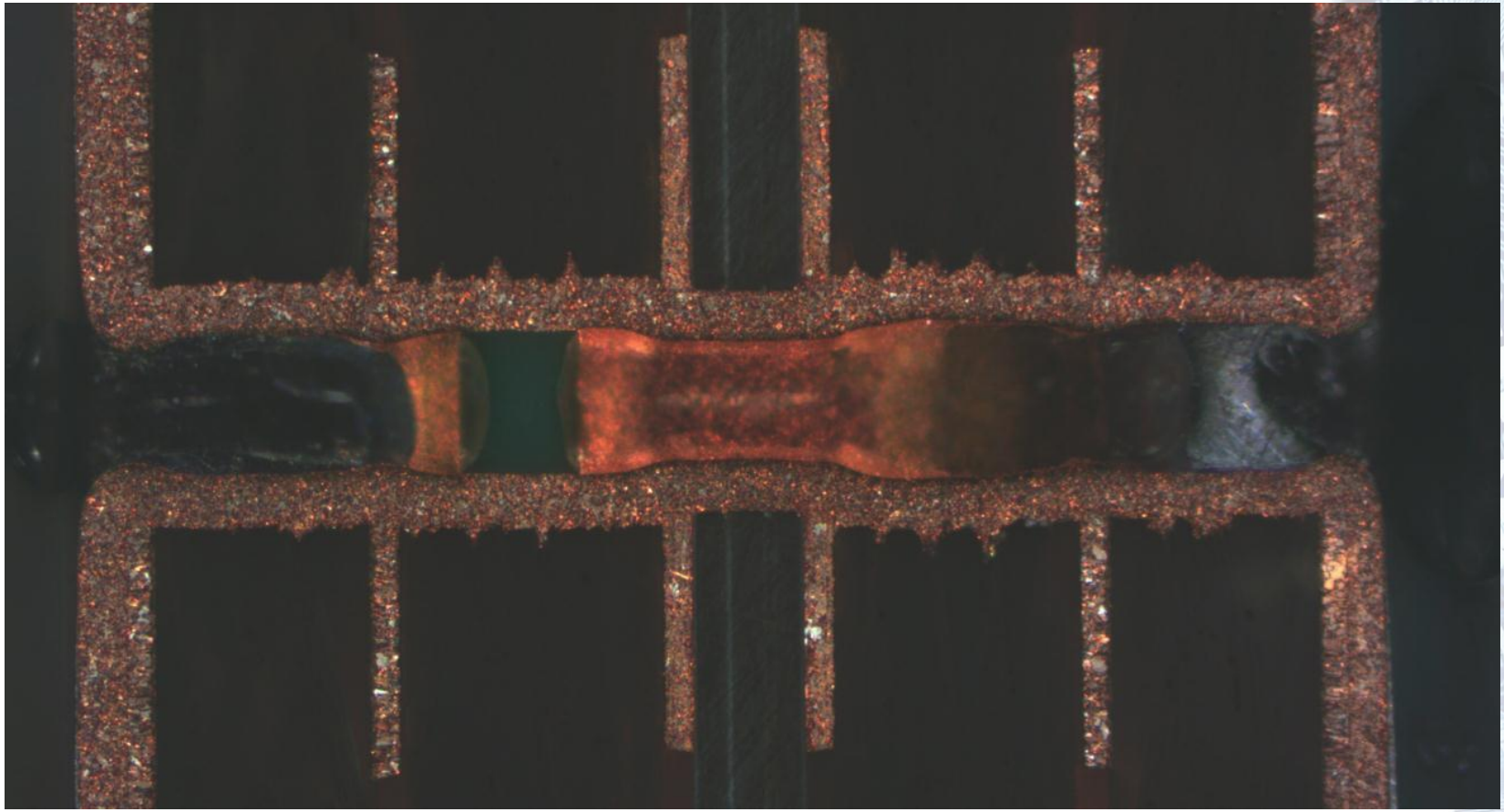
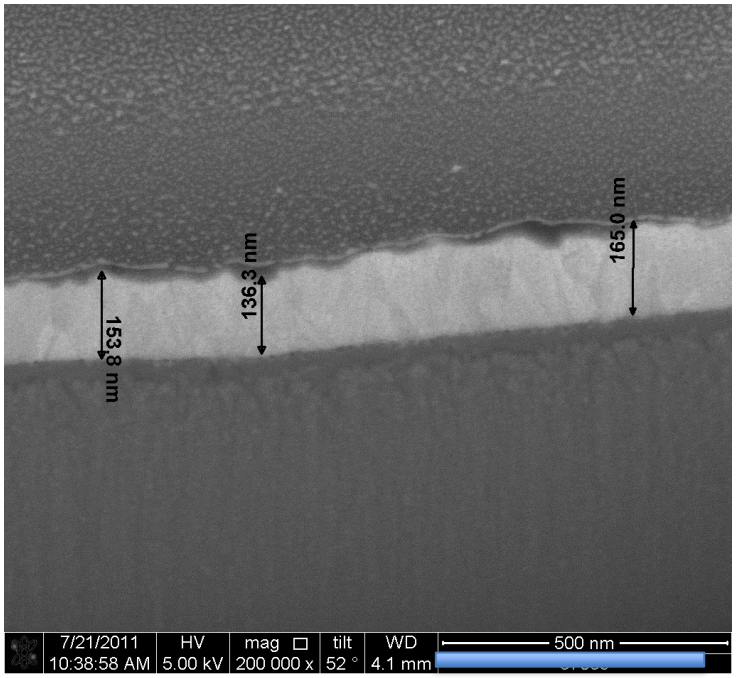
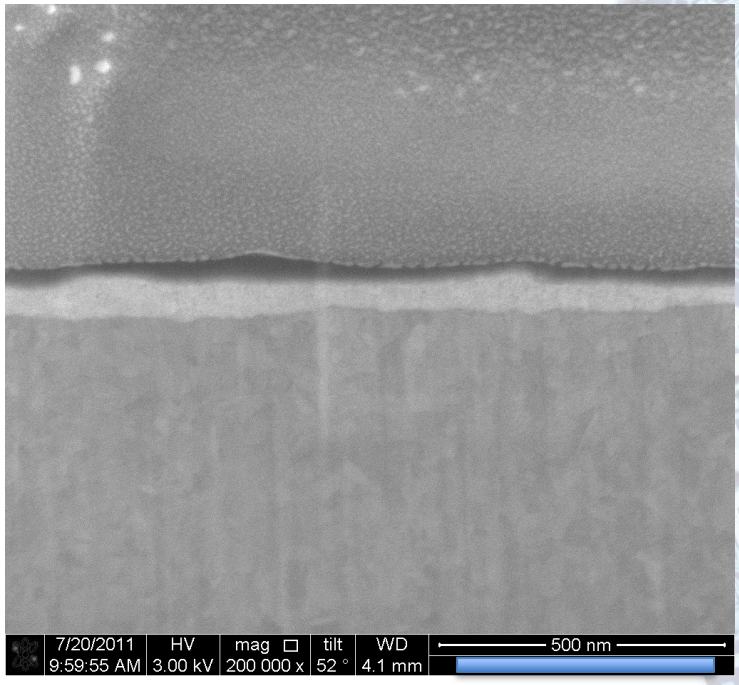


With ENIG mask contamination can be very dangerous

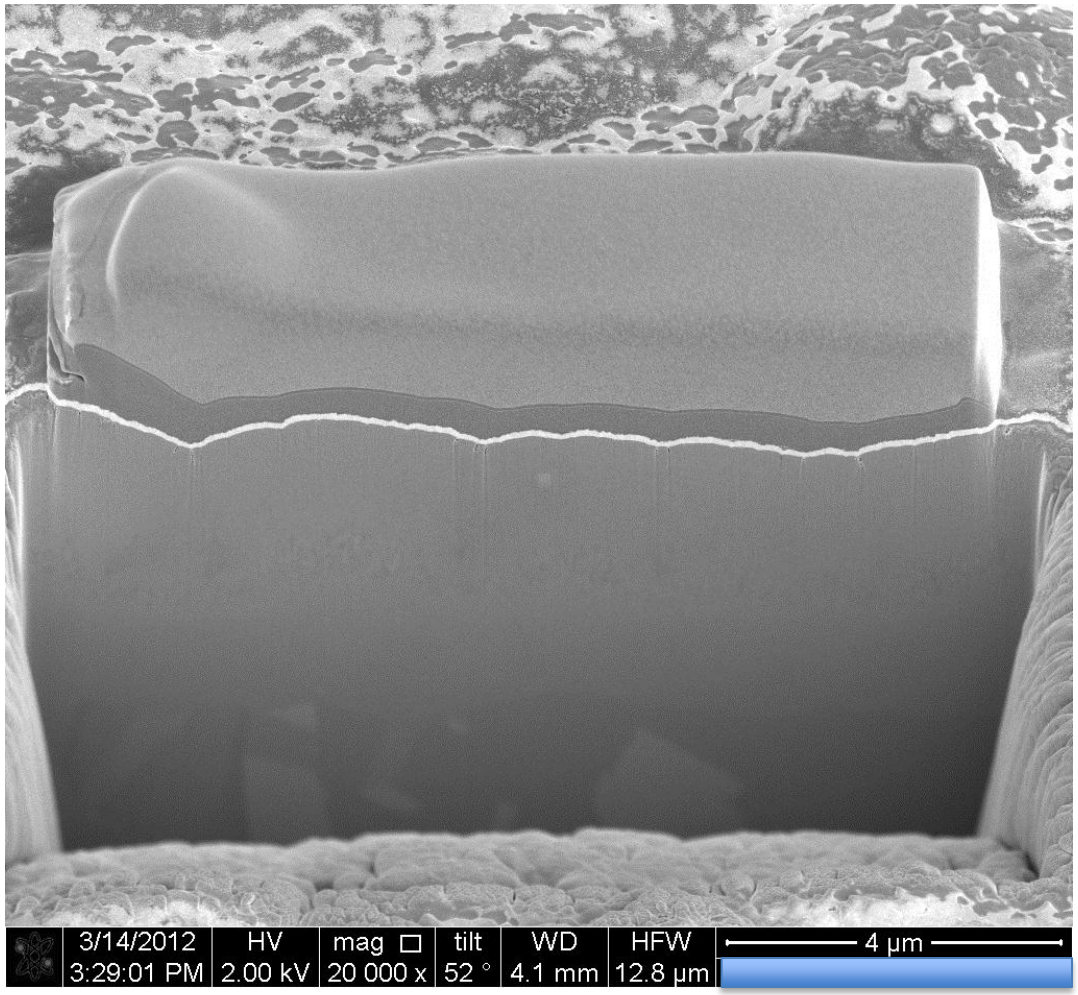


Au thickness sanity check

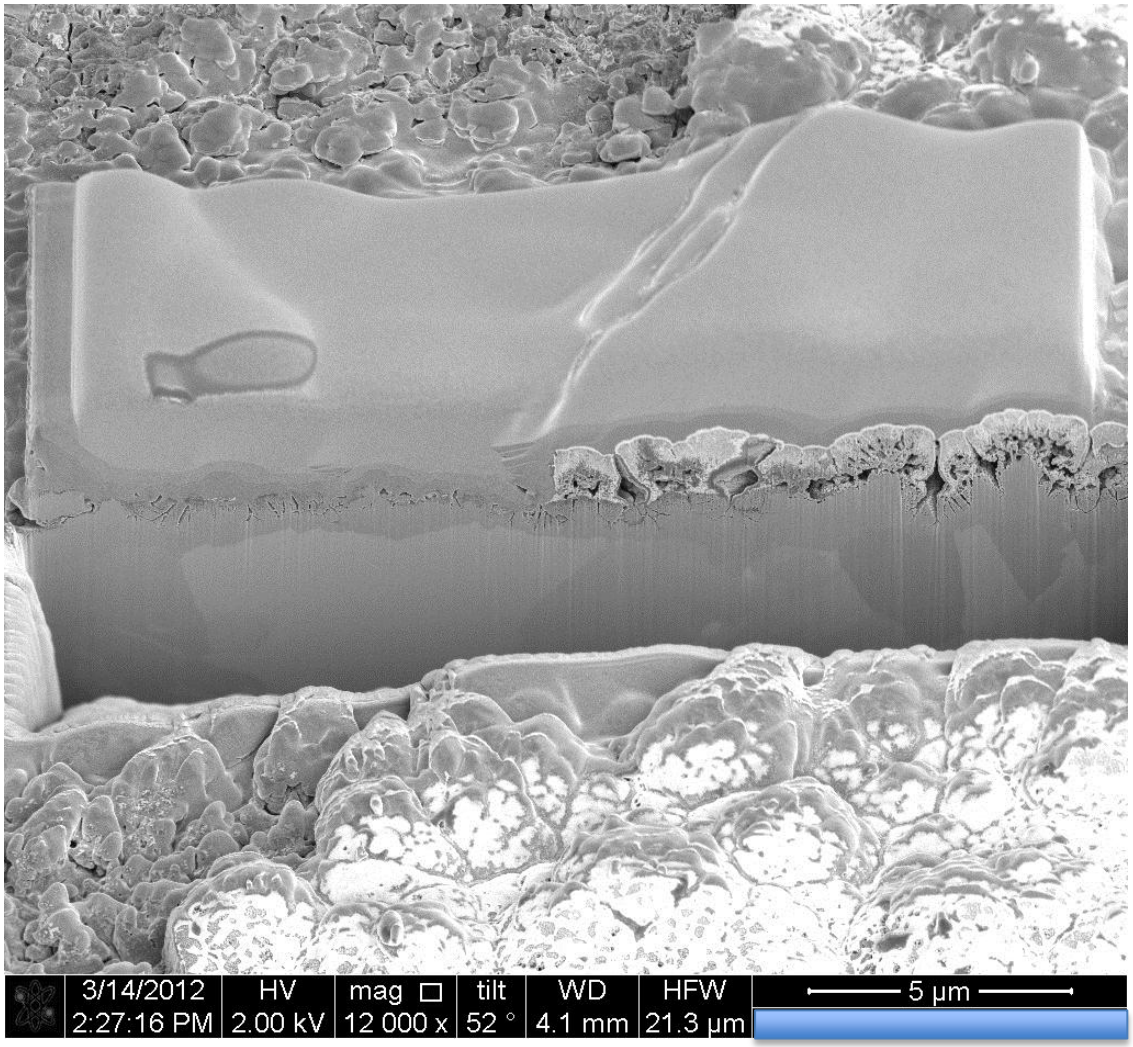




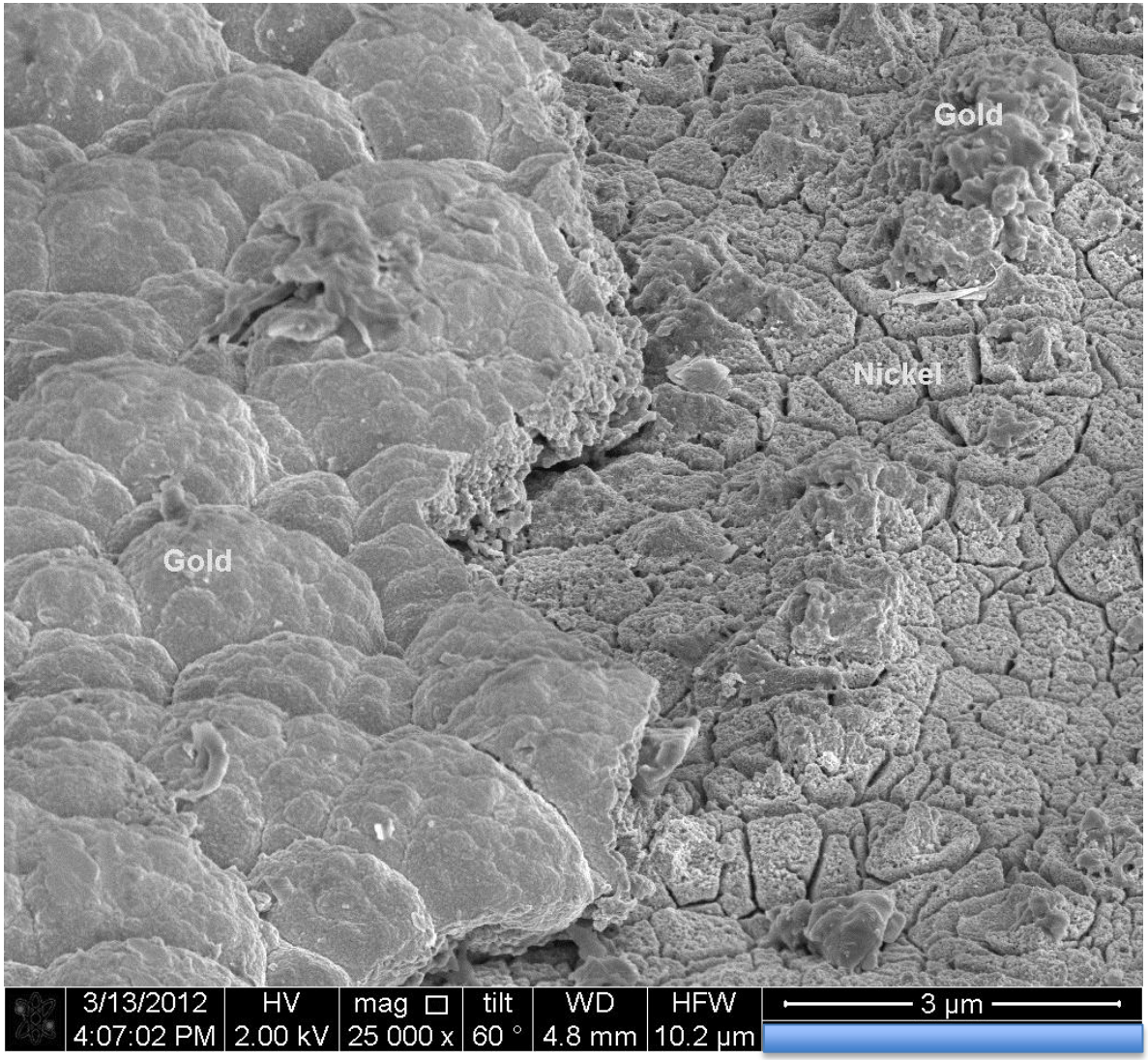
FIB sections get you the truth



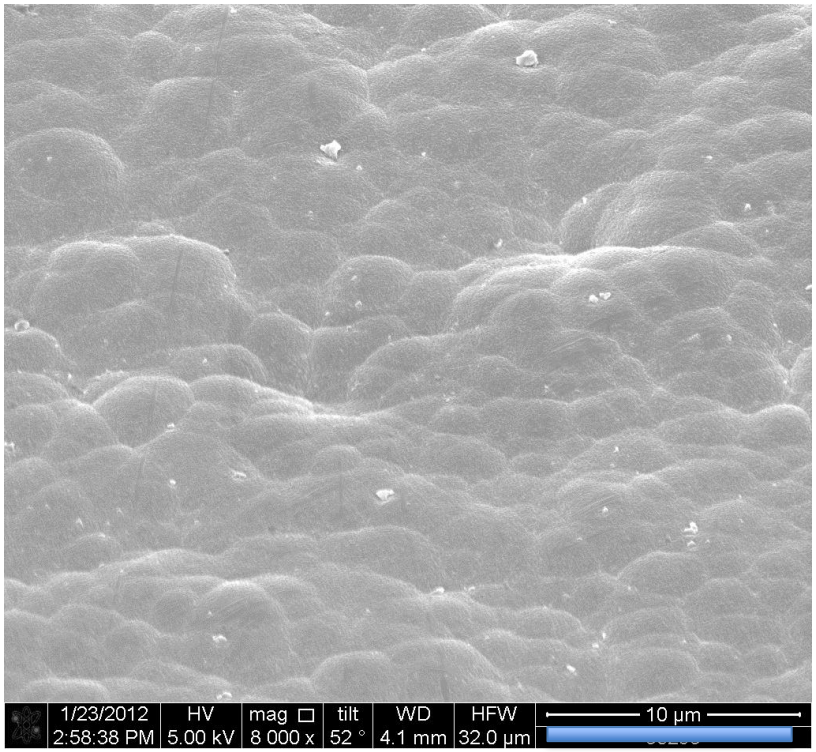
How thick is that gold?

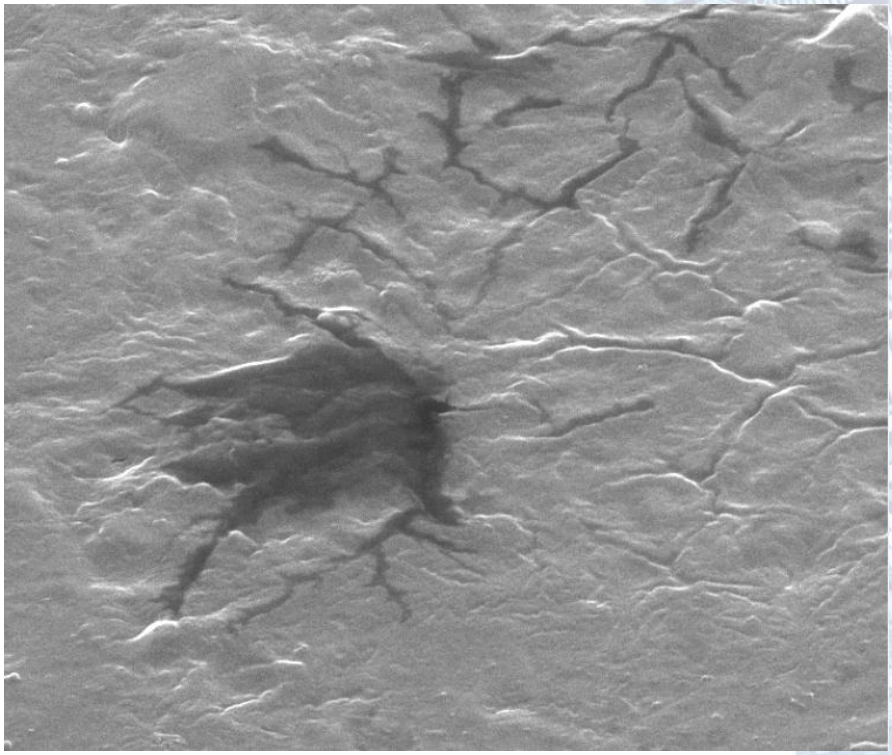


Simple top-down SEM can work



Any Mudcracking = Bad





Laminar or spongy layers = BAD