Understanding Contactor Pin Wearout

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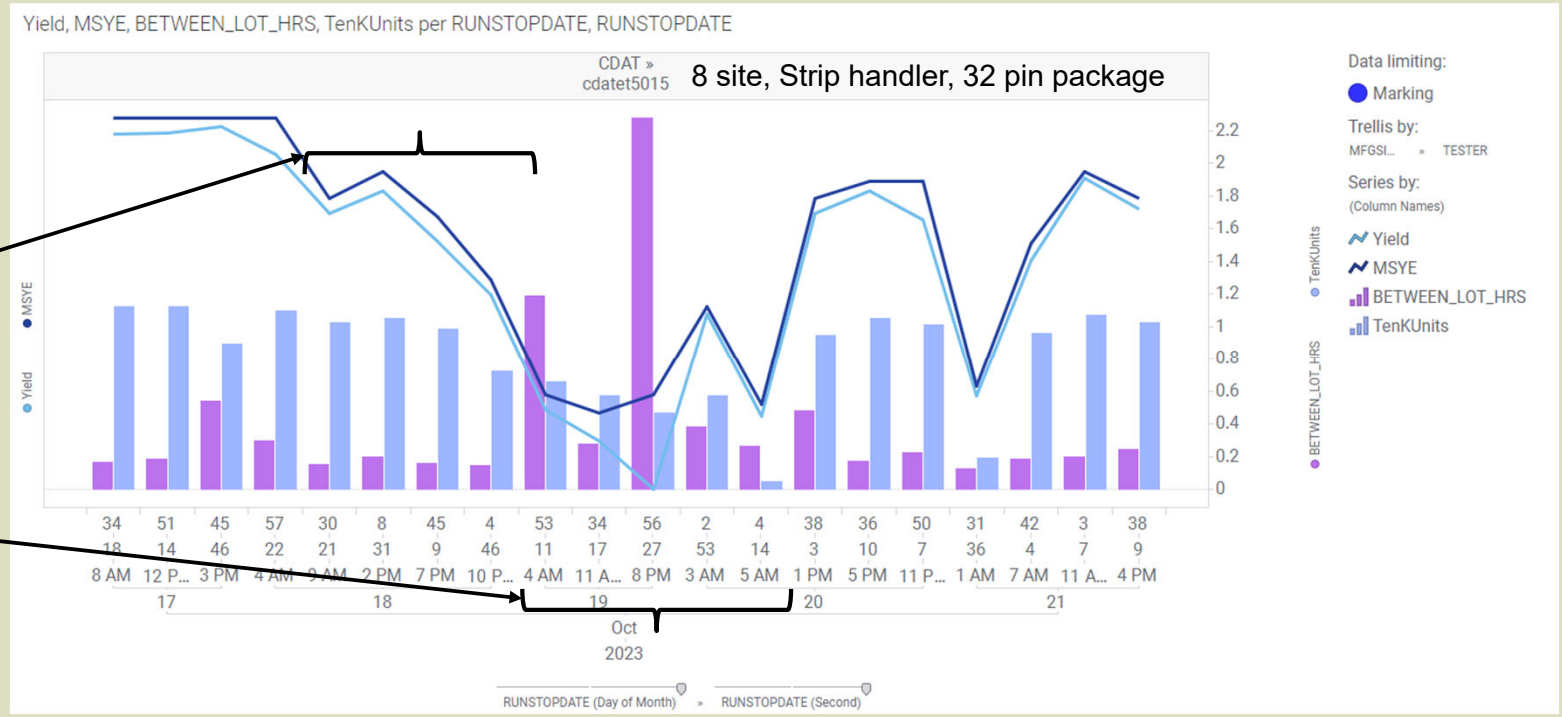
Overview

- Two views of contactor failures
- Contactor pin specification
- Requirements
- Evaluation
  - Apparatus
  - Experiment
  - Results
- Conclusions / Questions

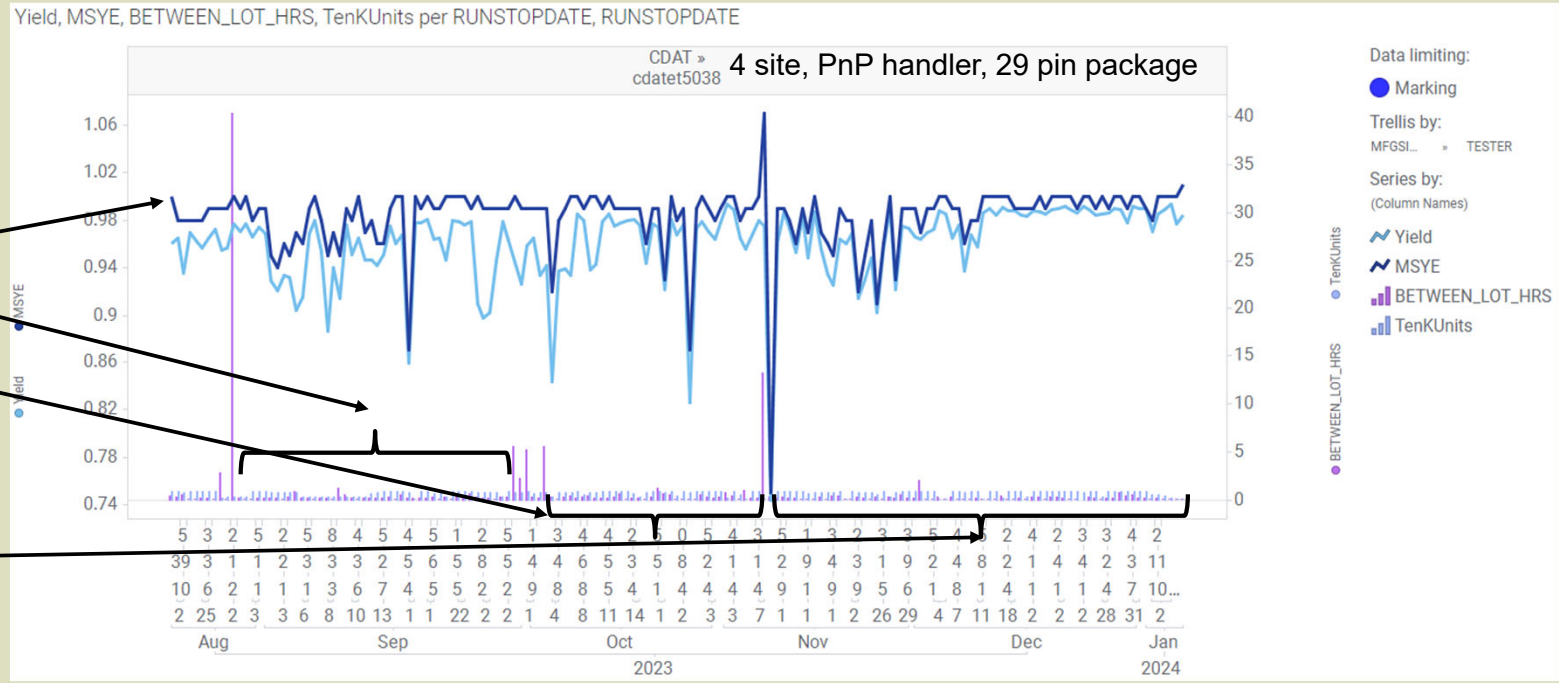
Contactor Lifetime Matters

- Yield tracks S2S yield
- S2S yield due to contactor fails
  - Yield degrades for 24 hours before action taken
- Repair cycle
  - Repair or replace contactor
  - Took 5 repair cycles
    - Repair work
    - Validate yield



Frequent Contactor Failures

- Short time to contactor repair
- Initial setup
- ~45,000 cycles
- ~50,000 cycles
- ~75,000 cycles



Specification of Pins Used in Evaluation

4. Mechanical Characteristic

No.	Description	Condition	Specification
1	Probe length	-1. Operating length -2. Free length	3.22 -0 mm (3.62) mm
2	Spring force	-1. Operating length : 3.22 -0 mm	0.235N ±0.049N (24gf±5gf)
3	Life Cycle	Operating length : 3.22 -0 mm(mating continuously) Preloaded : 3.47 mm(fixed length)	200,000 cycles (at120cycles /minute continuously)
4	Operating Temp.		-55 to +130 degree C
5	Storage Temp.		-10 to +50 degree C

5. Electrical characteristic

No.	Description	Condition	Specification
1	Contact Resistance	-1. Operating length : 3.22 -0 mm(travel continuously)	Initial 75 mΩ Max.

- 200K cycles @ 120 cycles/minute is **27.8 hours**
- 120 cycles/minute is 7200 Cycles/Hour

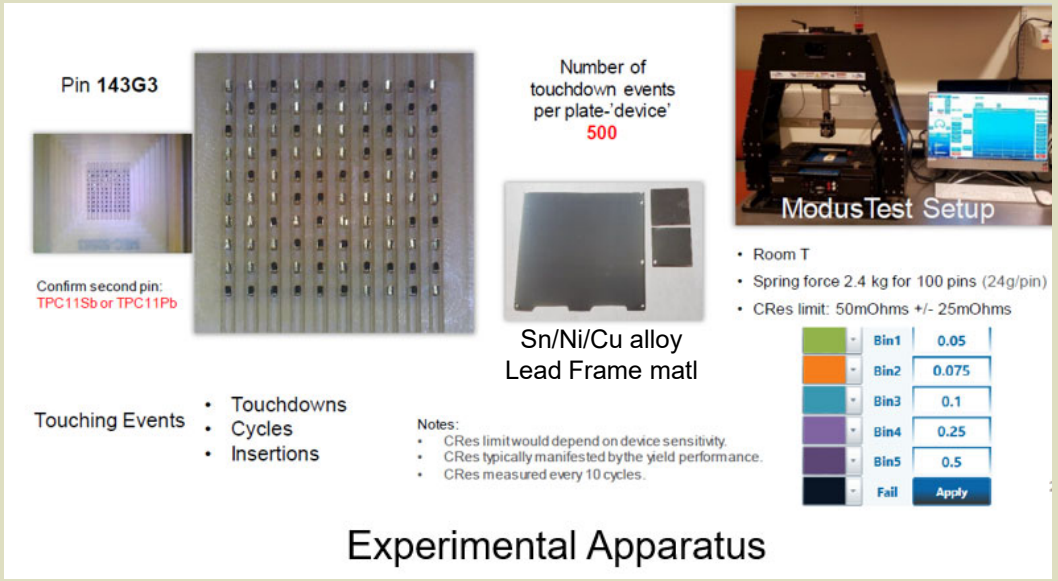
HandlerClass	Sprint Cycles/Hr	Wearout Hrs at Sprint
PnP	1200	166
Gravity	1400	143
LFStrip	3500	57
FFStrip	4500	44
Turret	23000	9

Requirements

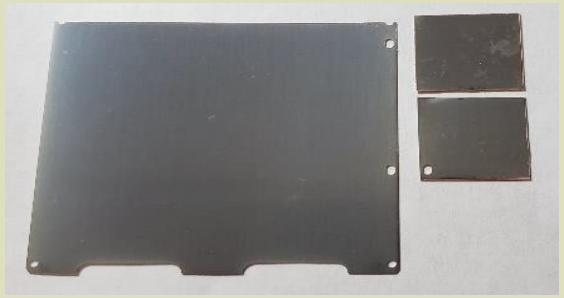
- Wearout @ 200k cycles is productivity restriction
  - Single pin failure requires repair
  - Wearout spec does not provide statistics
    - There must be some variation between pins
    - Is there a bathtub curve?
- Not achieving 200k cycles between contactor repair
  - Need to understand why
    - Multiple types of failure from F/A
      - Special causes (contamination, damage)
      - Wearout (presumably typical statistical reliability curve)
      - Difficult to to an analysis on production failures – too many variables
  - Start by evaluating wearout in controlled conditions

Apparatus

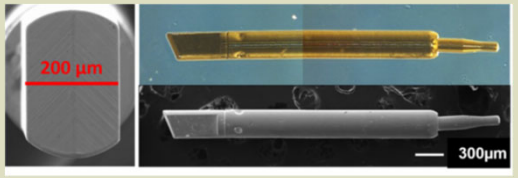
- Modus Test commercial Open/Shorts/Leakage tester
- Modus Test commercial device cycler
- Custom touchdown plate
  - Built from leadframe material to simulate device pins
  - GROUNDed as reference voltage
  - Acts as “DUT” in the apparatus
- Custom contact pin retainer plate
  - Acts as “Contactor” in the apparatus
  - Kelvin Force/Sense at each pin
  - 10 contact cycles per measurement
  - Starts as 10x10 matrix



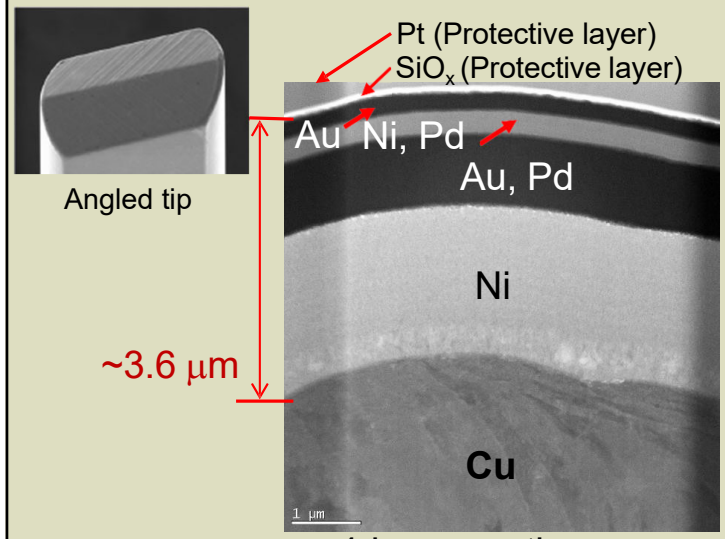
Experimental Apparatus



New Pin Construction



SEM Image TEM Image



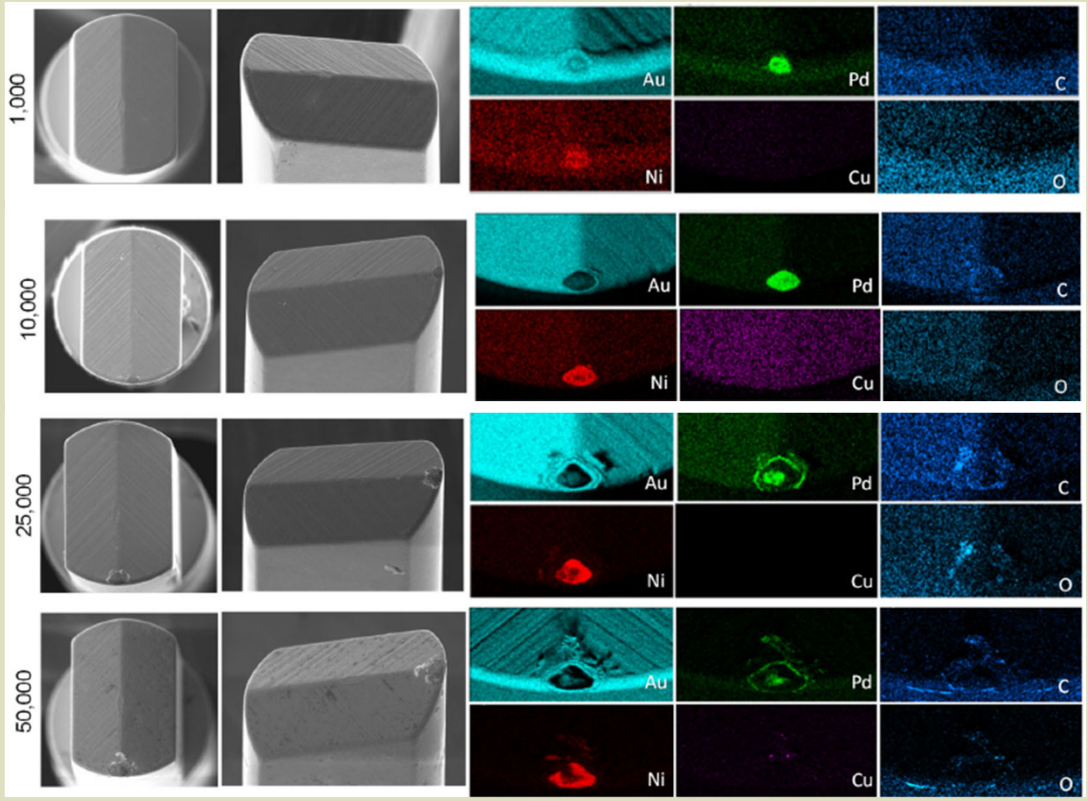
Angled tip

4-layer coating
Cu core

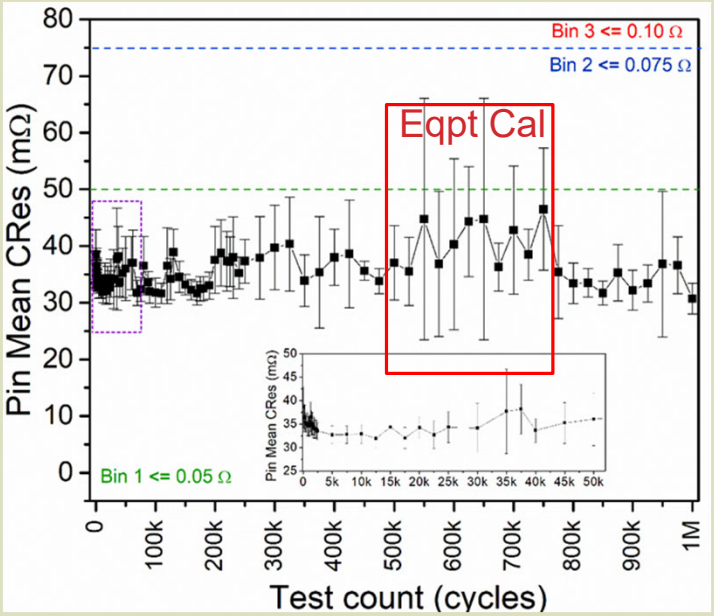
- Angled contact tip
- Multiple layers of conductors
  - Cu core
  - Au, Ni/Pd, Au/Pd, Ni
  - Protective layers are from TEM prep

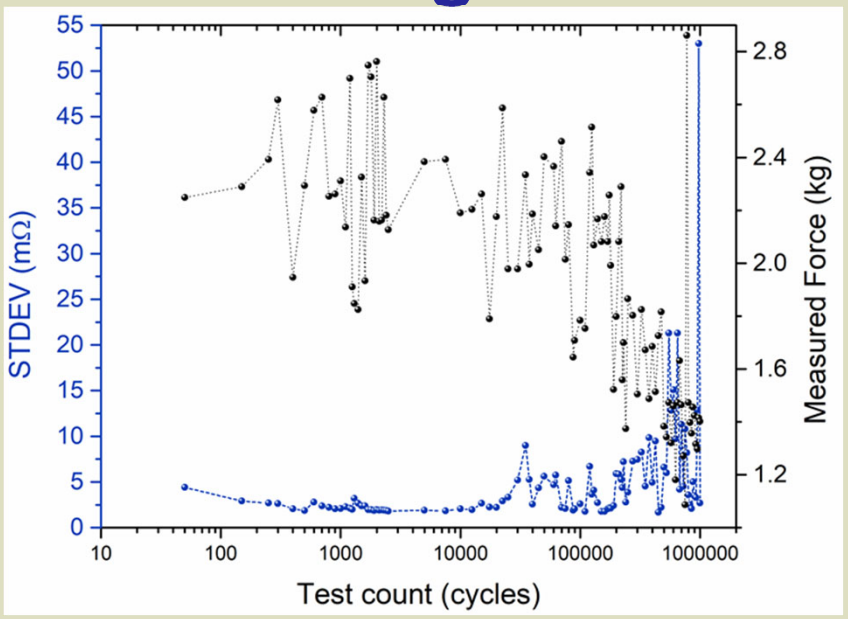
Pin Contact Cycle Degradation

- 1,000 cycles
  - Au worn away
  - Contact on Pd
  - Ni visible
- 10,000 cycles
  - Au gone
  - Contact on Pd/Ni
- 25,000 cycles
  - Contact on Ni
- 50,000 cycles
  - Pd gone
  - Contact on Ni



Pin Performance Change





- Average CRes stable to 1M cycles
  - Controlled conditions – no special causes
  - Cres variance begins to increase around 200k cycles
- Contact force drops rapidly after 100k cycles
  - Total contactor force (Measured Force) normalized to account for pins removed for analysis

Conclusions and Questions

- Pin may not be meeting the 200k spec for contact force
  - Does this contribute to contact related fails in production?
- Pin does meet the spec for CRes well past 200k cycles
- Contact pin conductor layers worn off by 25k cycles
  - Contact on Ni seems to have same CRes performance regardless of which material is in contact
  - Why have all these complex conductor layers if they only last a few thousand touchdowns?
- We know a lot more about this pin than we did
  - Raises many new questions
  - May identify opportunities for improvement and/or cost reduction

Glossary

- TEM – Transmission Electron Microscope
- SEM – Scanning Electron Microscope
- EDS – Energy-Dispersive X-ray Spectroscopy
- S2S – Site to Site (yield comparison metric)
- PnP – Pick and Place (handler type)
- LFStrip – Lead Frame strip (handler type)
- FFstrip – Film Frame strip (handler type)
- F/A – Failure Analysis
- TD – touch downs
- CRes – Contact Resistance

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