First Insertion Failure of Dual In-Line Memory Modules

PURDUE MATERIALS ENGINEERING

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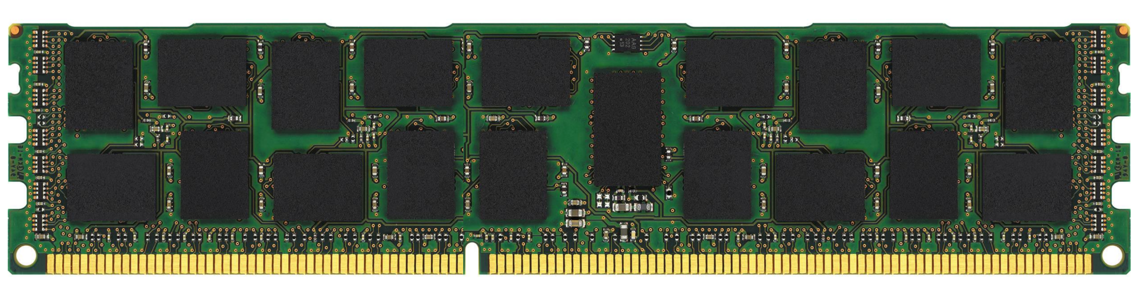
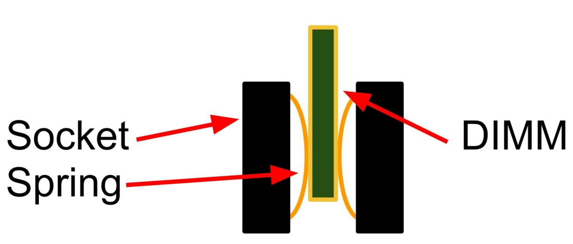
First insertion failure of Dual In-line Memory Modules (DIMMs) is a detrimental, industry-wide issue. Potential causes of failure were investigated by analyzing DIMM pins and server sockets with Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), and Optical Microscopy. DIMMs were inserted into servers to test for failures. After testing, contamination was determined to be the most likely failure cause.

Project Description

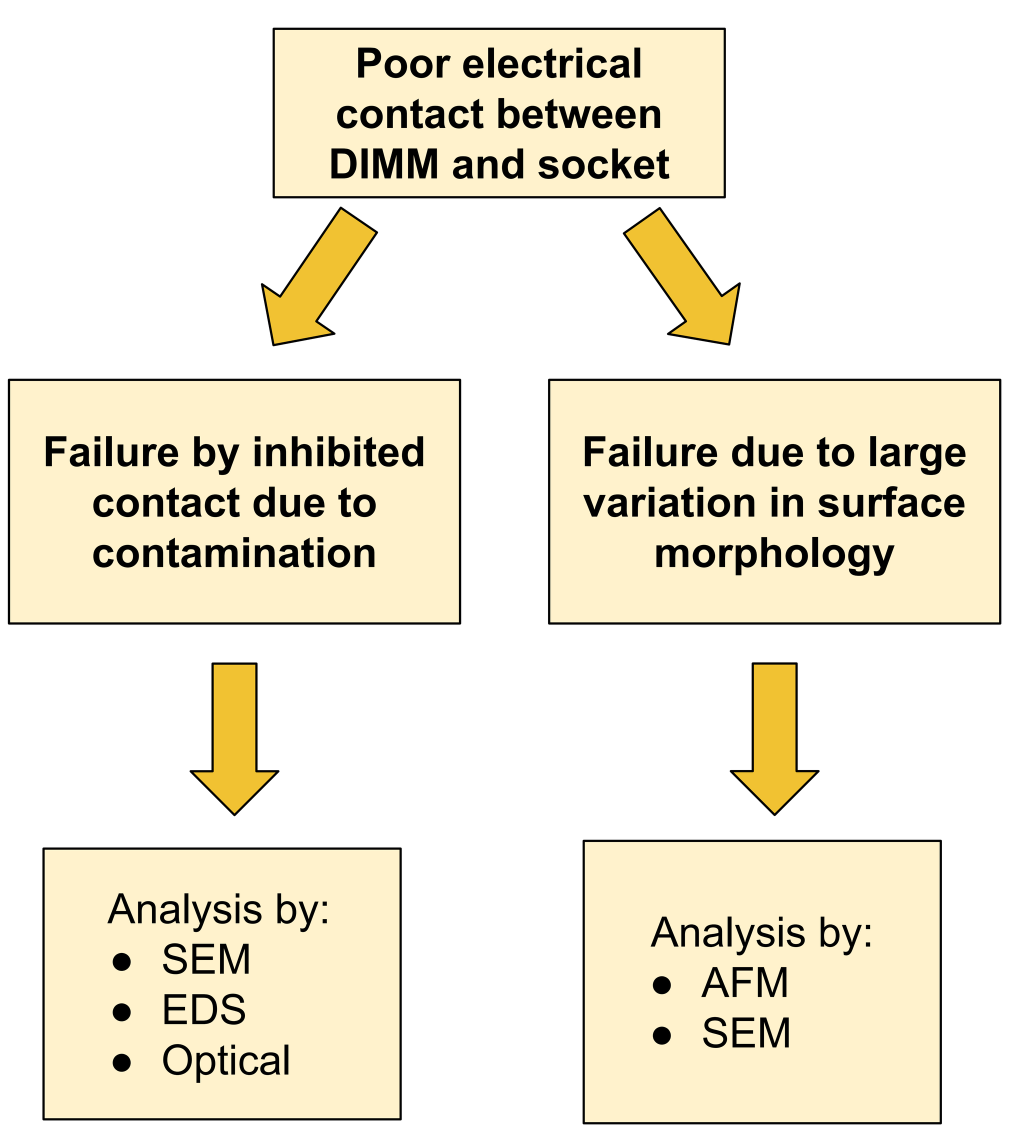
During server assembly, DIMMs are inserted into server sockets. Upon initial insertion, the servers fail at a problematic rate. This is called first insertion failure. When a failure occurs, failed DIMMs must be reinserted and the server must be rebooted. This reduces production rate and causes financial loss across the entire industry. This project investigated the root cause of failure.





Top: Image of a DIMM
Left: Cross-sectional diagram of the DIMM pin/socket spring interaction.

Causes of First Insertion Failure



The initial hypothesis was that failure was primarily caused by surface roughness variation. After characterizing DIMMs and sockets, it was determined that surface contamination on DIMM pins is a more likely cause of failure.

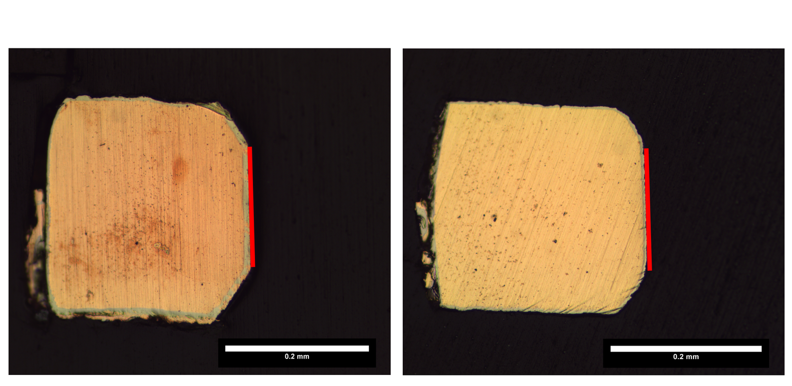
Sockets

Sockets from two different suppliers (noted as 1 and 2) were investigated in terms of:

- Spring morphology
- Spring separation

Contact geometry was investigated by comparing cross section images. Supplier 1 uses a sharper angle; no other obvious differences observed. The contact area of Supplier 1 is 6% narrower than Supplier 2.

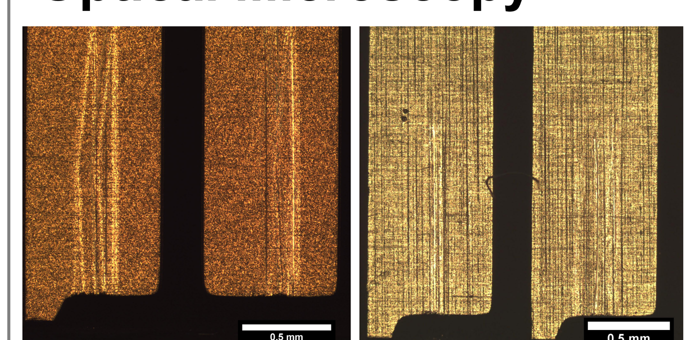
Cross sections of the springs; Left is from Supplier 1 and right is from Supplier 2. Red line indicates contact area.



The gap distance between springs are compared using optical microscopy. The spring gap is 4% smaller in Supplier 1 sockets compared to Supplier 2 sockets.

DIMMs

Optical Microscopy



Left: Wipe marks on pins from supplier A
Right: Wipe marks on pins from supplier B

DIMMs from the two suppliers, A and B, were analyzed.

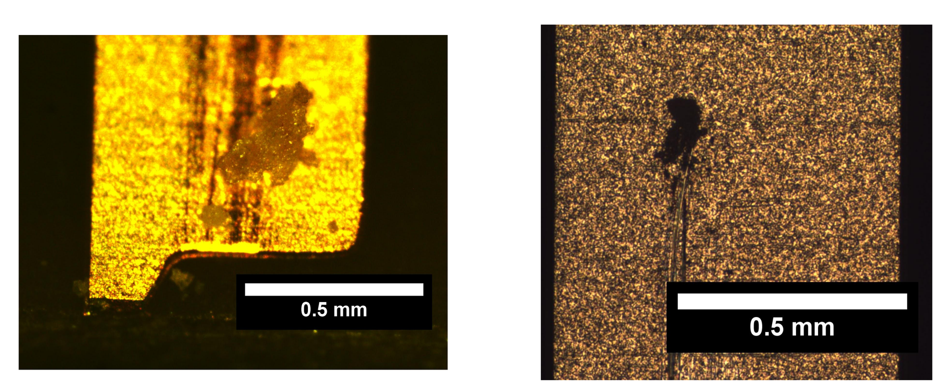
Differences noted in:

- pin shape
- surface features
- morphology

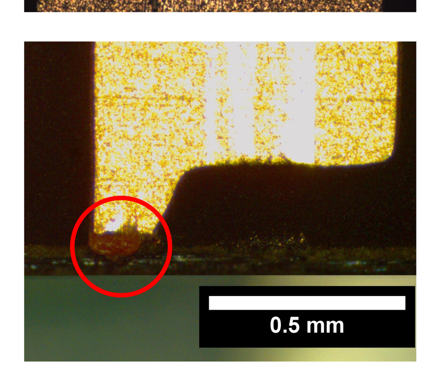
10 DIMMs were thoroughly analyzed, with the remaining 240 briefly scanned. Three abnormalities were discovered:

- Fibrous smudges
- Amorphous smudges
- Accumulation on the bottom of pins

Accumulation occurred on up to 40% of the pins of some DIMMs. Smudges appeared less frequently, only one or two on occasional DIMMs.

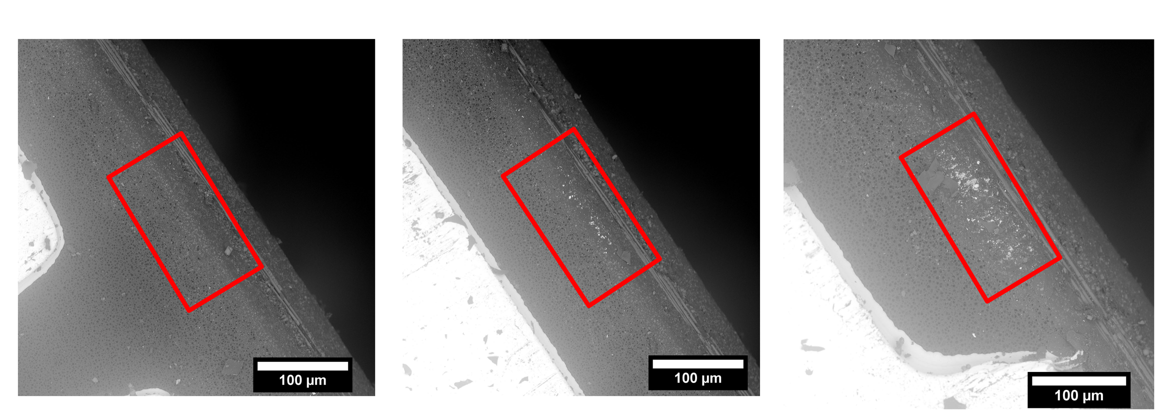


Above: Fibrous smudge on the surface of the pin
Above right: Amorphous smudge on the surface of the pin
Right: Accumulation collected at below the pin, indicated by red circle



SEM

Optical Microscopy revealed changes to the board below the pins during insertion. SEM was used to further investigate their origin. The size and location of these board features indicate that the source is the socket springs.



Left: No feature on edge of board below the pin
Middle: Minor feature on board with some gold particles
Bottom: Major features on board with large amount of gold particles

Using EDS on the DIMMs and sockets, we determined:

- Wipe marks were not deeper than the gold coating
- Board is a flame-retardant plastic
  - Board contains calcium and silicon from the glass fibers
- Accumulation contains the same type of plastic along with calcium and silicon
- Amorphous smudges are a similar plastic to the board
- Board feature contains gold flecks from pins

Off-site analysis by FORESITE Inc. determined that the amorphous smudges may contain a flame-retardant plastic.

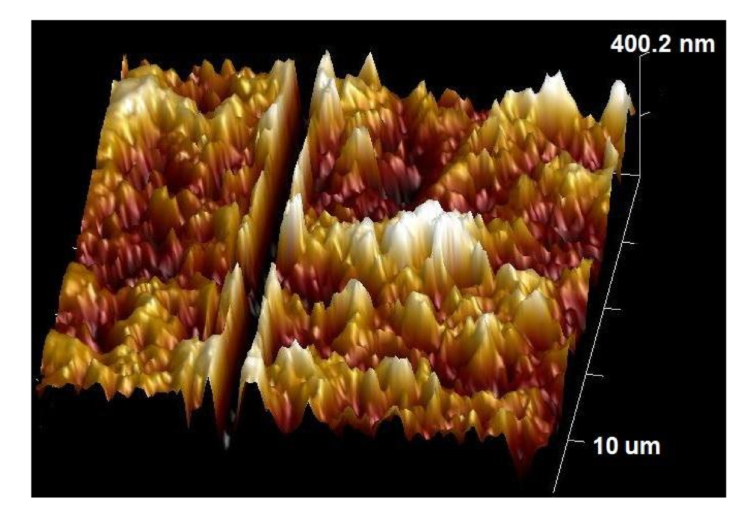
Insertion Tests

Three rounds of insertion tests were performed. Both servers contained 24 sockets: 17 from Supplier 1 and 7 from Supplier 2.

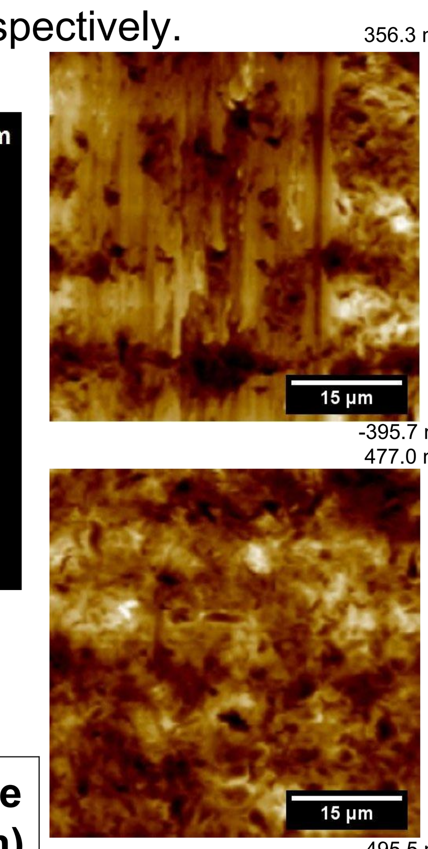
- 225 DIMMs (175 A, 50 B) were inserted into server #1, 1 failure obtained (Supplier A/Socket 1).
- 225 DIMMs were inserted into server #2, no failures
  - Previous failure tested and found to work
- 225 DIMMs were inserted into server #1, 1 new failure obtained (Supplier A/Socket 2)

AFM

- Roughness of DIMM pin surfaces analyzed with AFM to determine its influence on failure
- Used roughness parameter Ra
- Two areas were quantified: **on** and **away from** wipe marks, with 113 and 70 scans, respectively.



Above: 3D AFM image of "gouge" mark.
Above right: **On** wipe mark *Right*: **Away from** wipe mark



Test area description	95% Confidence Interval (Ra, nm)
Away from Wipe mark	91.7 to 97.3
On Wipe Mark	89.8 to 103.4
Failed DIMM	91.1 to 96.5
Supplier B away from wipe mark	143.0 to 170.6

Left: AFM Roughness (Ra) results (equation below). All values are in nm and from Supplier A DIMMs unless indicated otherwise.

$$R_a = \frac{1}{n}\sum_{i=1}^{n}|y_i|$$

The roughness analysis indicated no significant difference in Ra on and away from wipe mark areas, indicating that the morphology of these areas is not a large influence on failure.

Discussion

Sockets

- With our small sample size of insertions, no correlation with socket supplier and failure can be concluded

Surface roughness

- Supplier B DIMMs were ~50% rougher than Supplier A, but do not have a significantly different failure rate
- Failed DIMM roughness did not significantly vary from the overall average (away from wipe mark)

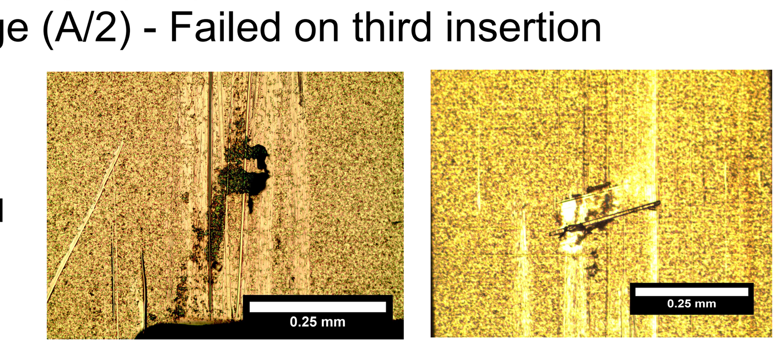
Contamination

Contamination is the most likely cause of failure.

Two foreign materials were found on the two failures:

- ❑ Amorphous smudge (A/1) - Failed on first insertion
- ❑ Fibrous smudge (A/2) - Failed on third insertion

Left: Amorphous smudge found on failed DIMM (A/2)
Right: Fibers found on failed DIMM (A/1)



- These smudges were not present prior to insertion
- Both these foreign materials occur in the area where the spring makes contact with the pin
- Their presence indicates that the failure is due to a physical blockage of the electrical contact.
- Failure after multiple insertions indicates that failures due to contamination interfering with the electric connection

Recommendations

After concluding that contamination from smudges is the most probable cause of failure, we recommend investigating this further with a larger scale experiment. Cleaning the pins or sockets may improve insertion results and reduce failure rate.

Acknowledgements

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