

# ELECTROMIGRATION

## Electromigration

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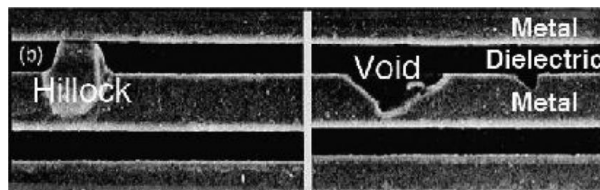
- Electromigration is a potential wear-out failure mode for semiconductor devices utilizing metal conductors of inadequate cross-sectional area (too large of a current density)
- The effect occurs only in metal conductors
- Under high current densities, metal atoms move within a conductor
- The effect is much worse for DC current (unidirectional)
  - AC current (bidirectional) helps repair damage
- Movement of metal atoms is much worse at high temperatures
- Failures can often occur after weeks/months/years of use which makes it a particularly worrisome and expensive failure mode

# Electromigration

- Metal ions in a conductor are acted upon by:
  1. An electric field caused by the potential difference across the conductor—towards the negative direction
  2. A transfer of momentum from conducting electrons colliding with metal ions—towards the positive direction
- The second force is larger and results in metal ions moving towards the positive direction and *voids* moving towards the negative direction
- Reference: Black, James R. "Electromigration—A brief survey and some recent results." *IEEE Transactions on Electron Devices* 16, no. 4 (1969): 338-347.

# Electromigration

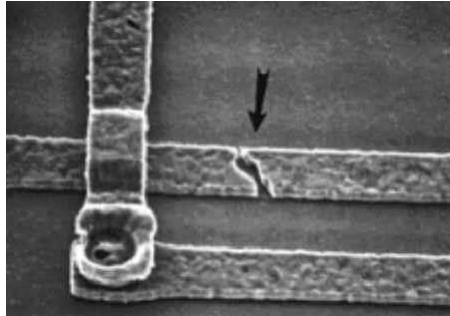
- Electromigration has two primary failure modes:
  1. Opens (voids)
  2. Shorts caused by "hillocks" or "whiskers"



# Electromigration

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- Circuit void caused by electromigration



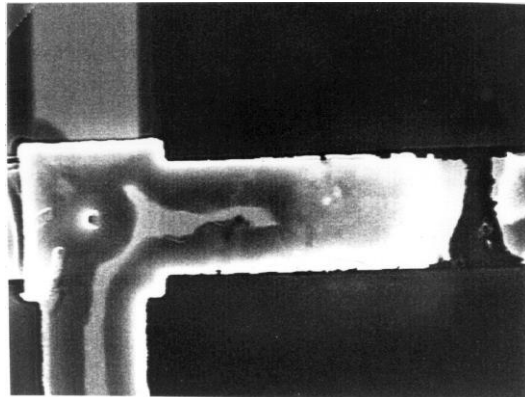
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# Electromigration

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- Open wire failure



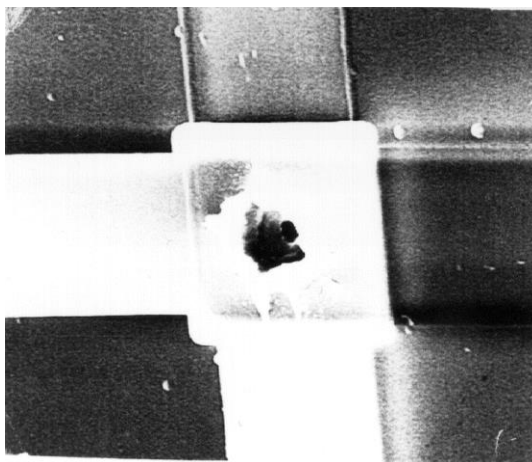
**Limits dc-current to  $1 \text{ mA}/\mu\text{m}$**

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# Electromigration

- Open contact plug failure

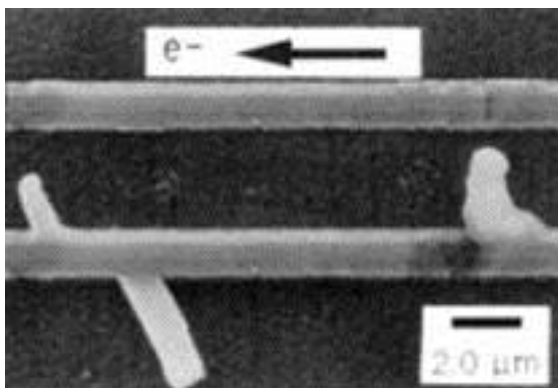


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# Electromigration

- Hillock formation
- Short circuit failure



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Source: *CSL, METU* 39

# Electromigration

- Hillocks formed in a Cu line during electro-migration test

