EMI/ESD and Tool Uptime

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ESD/EMI Effects on Tool Uptime

- Tool malfunction due to ESD/EMI
- Parametric errors due to ESD/EMI
- Process variations due to ESD/EMI
- ESD exposure to processed parts
What is EMI?

- **ElectroMagnetic Interference** is electromagnetic emission that causes equipment malfunction.
- No matter how strong emission is, if it doesn’t cause problems, it is not an interference, i.e. not EMI.
- Therefore, the impact of EMI is judged not only by how much emission is generated, but also by how it gets from “here” to “there” and by how immune the equipment is to EMI.
How EMI Manifests Itself

• Outright equipment lock-up
• Software errors
• Tools do things they weren’t supposed to do
• Erratic response
• Parametric errors
• Sensor misreading
Sources of EMI in Cleanrooms

- ESD Events
- Poorly-designed equipment
- Poorly installed equipment
- Poorly maintained equipment
- Mobile phones, two-way pagers and walkie-talkies
Equipment Lock-Up: False Signals

- Electromagnetic fields induce seemingly legitimate signals into electronics circuits which leads to circuit malfunction
- Often, the electronics circuit does not suspect that it was affected by EMI
- Today’s high-speed circuits are much more susceptible to ESD-induced high-speed transients
- Virtually impossible to reproduce at will – difficult to diagnose
Sensor Malfunction

- Strong electromagnetic fields induce voltages and currents in circuits
- In sensors such signals can affect legitimate signals and cause false readings
- Consequences:
  - disrupted process
  - good components failed
  - bad components passed

TDMA mobile phone caused false readings in sensor of magnetic head tester and finally caused error message after failing several good GMR heads
ESD-Caused EMI in Cleanrooms – Example

- Wafers are charged to the limit
- SMIF pods with wafers are placed on steel cart
- Cart is charged by the wafers via capacitive coupling
- Wheels are insulators – cart cannot discharge
- EMI propagates throughout the fab causing lockup of wafer handlers
How Can a Discharge Happen Under an Ionizer?

Charge is created instantaneously when two dissimilar materials are separated.

Accumulated charge is being dissipated slowly by ionized air or via dissipative path with high resistance. This slow discharge may take several seconds.

If a contact is made before full discharge, ESD Event takes place.

All static-dissipative measures take time to remove the charge. With fast-moving objects and rapidly accumulating charges there is always dynamics of charge creation and dissipation.
EMI Caused by Equipment

- Every electric or electronics device generates electromagnetic field
- If this field is too strong and has certain properties, it is good candidate for EMI
- Poorly-maintained equipment is good source of EMI (DC brush motors, bad grounding)
- EMI-generating equipment often causes problems for itself
Propagation of Electromagnetic Emission

- **Radiated**
  - Electromagnetic field composed of electric and magnetic fields propagates via air path just as emission from a mobile phone would reach the base station.
  - This field would create voltages and currents in any metal object, i.e. wire, PCB trace, etc.

- **Conducted**
  - The most neglected type of propagation.
  - High-frequency currents move via power, ground and data cables and inject undesirable signals into equipment.

- **Mixed**
  - Radiated emission generates signals in wires and cables. These signals are then injected into equipment via conductive path.
EMI Grounding: What is Different?

• For static dissipation ground should provide conductive path to “zero” potential.

In order for it to be good EMI ground, it also should:

• offer very low impedance at high frequencies
• dissipate all the high-frequency residual signals
• not to channel EMI from one tool to another
Ground Bounce

- EMI (internal and external) induces voltages in equipment’s ground
- Current flows from equipment’s ground to facility’s ground
- If ground path is imperfect, voltage drop develops
- Equipment ground “bounces”
- Circuit signal levels are no longer valid
- Equipment malfunctions
Verifying Good EMI Ground

- Good ground is an “infinite sink.” No matter how much energy is provided to it, good EMI ground should have NO voltage on it.
- Just like a multimeter or a static field voltmeter shouldn’t see any DC voltage on a good ground, there should be no high-frequency voltages as well.
- If there is ANY voltage present on the ground, this ground must be improved.
- Monitoring high-frequency emission reveals level of EMI on ground
Difficulties in EMI Troubleshooting

- In order for EMI to cause problems, EMI occurrence should coincide with the most vulnerable step in equipment operation.
- One equation with several variables.
- EMI-related problems are often disguised as software errors.
- EMI-related problems are nearly impossible to reproduce and verify.
- It is difficult to treat the problem based on a guesswork.
Continuous ESD/EMI Monitoring

• Continuous monitoring will tell you at all times about EMI/ESD problems whether you are present or not.
• Continuous EMI monitoring is essential in correlating EMI occurrences and equipment malfunction -- eliminates guesswork.
• Real-time alarms on excessive EMI/ESD Events will assist operators in providing EMI/ESD-safe environment
• Continuous EMI/ESD monitoring gives factual time-stamped records and allows correlation of the precise time of malfunction with the offending EMI/ESD activity and find out the origin of EMI/ESD activity
SEMI E-78
Requirements

• SEMI E-78 regulates exit charge for ESD damage and EMI
• ESD environment changes all the time
• Continuous monitoring guarantees continuous compliance with E-78

<table>
<thead>
<tr>
<th>Level</th>
<th>ESD Control (nC)</th>
<th>Equipment Malfunction</th>
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<td>1200</td>
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EMI/ESD Monitoring Tools

- Tool-level
  - EM Aware® monitors for tools
- Facility-Level
  - EM Aware® monitors
- Audit tools
  - EM Eye® field strength meter
EM Aware® ESD/EMI Monitors

- ESD Events
- EMI
- Electrostatic Voltage
- Ionizer Balance
- Ionizer Decay
  - All parameters are monitored using the same antenna
  - All outputs are provided via single cable
- Ionizer Feedback Control (for properly equipped ionizers)

CTC034: ESD Events and transient EMI
CTC023: continuous EMI in broad band
How Does EM Aware® Represents ESD Events?

- ESD Events last only nanoseconds. No reasonable data acquisition system can accept data at such rate.
- EM Aware® assesses the power of an ESD Event and represents each event as a pulse with the fixed width of ~17mS
- Magnitude of a pulse is a function of event’s strength and the distance from the event
- This way ESD Events can be recorded and viewed with many data acquisition systems
Where to Monitor?

- Sensitive equipment
- Known EMI offenders
- Ground plates
- Power lines
- Anywhere ESD/EMI is of concern
Localization of EMI Sources
Using EM Aware® on a Grid

Localization of EMI sources and correlation with tool lockups is easy.

Bang!
Create EMI map of your facilities

- Determine your EMI “hot spots”
- Similar equipment should have similar EMI signature. Deviations may mean trouble

- Do not let problems just “sit there” -- devise plan of action and follow-up

Charts courtesy of Texas Instrument
“Hot” Ground

Heavy load. Not enough “drainage” capacity. Strong interference between different tools.

Pictures courtesy of Texas Instrument
“Cool” Ground

Light load. Sufficient “drainage” capacity. Little interference between different tools.

Pictures courtesy of Texas Instrument
ESD Audit: Grounds

- Measure field strength near
  - each ground plate
  - grounded tool cover
  - grounding wires
- Recommended distance from the grounded surface: 0.5” or 10mm
- Measure both average and peak values
- Data log the readings and make them part of EMI Audit Report
- Guidelines:
  - Measure background field strength away from ground
  - Bring meter close to ground and measure the difference
  - If the difference is 2x or less, consider it passable
  - If the difference is 3x or more, this ground needs to be reviewed and corrected
ESD Exposure to Components

- Reticles can be seriously damaged by induced electrostatic field
- Wafers and reticles can attract particles if highly charged
- Highly-charged wafer can produce very strong discharge on transfer in the tool
- Wafer, die-level and packaged components can be damaged by ESD Events
- All of the above reduces throughput of the tools
Specific Applications of EM Aware® on the Front End

• Complete ESD Environment Monitoring:
  – ESD Events, Static Voltage, Ionization Properties
  – Isolation of reticles exposed to ESD

• EMI Monitoring in Various Tools for malfunction and lockup:
  – Steppers (errors, interferometer issues, etc.)
  – Stockers (malfunction and lockups)
  – Wafer Handling (exit charge, lockups)
  – EMI on ground and power lines propagating throughout the facility
Specific Applications of EM Aware® on the Back End

- Special model of EM Aware to be built into tools
- Interface with the tool

EM Aware ESD monitors built into IC handlers such as Epson 6000 (shown) automatically sort out ICs exposed to high levels of discharge. Alarm to an operator is issued when occurrences of discharges is too high. Data log of ESD occurrences is provided.
EM Aware®
Starter Kits

Starter Kit CTK2A6
Includes everything needed for ESD Audit and Diagnostics (except computer)
6 EM Aware monitors react to ESD Events and Electrostatic Fields
EM Eye® Electromagnetic Field Strength Meter

- 2MHz...2GHz
- Verification of EMI Environment
- Measures, counts and data logs ESD Events and EMI Events
- Checks quality of ground
- Provides documented record of your environment
- Locates sources of EMI and ESD
- Calibrated
Why EMI Matters Now More than Ever?

- Smaller geometries of today’s devices make them much more susceptible to EMI
- The new circuits work at higher speeds and now “notice” the ultra-short spikes that older slower circuits ignored
- Higher frequencies used in today’s electronics create more emission due to better antenna factor
- Today’s circuits work at lower voltages: as low as 1.8V. Much lower levels of EMI are needed for their disturbance.
- The trend doesn’t look promising.
EMI is not Going Away Anytime Soon

- Be prepared
- Be proactive
- Train your staff in EMI
- Work with facts
- Monitor EMI Environment
- Improve EMI Environment
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