Moore's Law

- Gordon Moore, Intel
  - 1965, 4 yrs after the 1st planar IC was discovered.
  - Predicted that the number of transistors per IC would double every 18 months.
  - Forecast that this trend would continue through 1975.
  - Through technology, Moore's Law has been maintained
When will computer hardware match the human brain?, Hans Moravec, [http://www.transhumanist.com/volume1/moravec.htm](http://www.transhumanist.com/volume1/moravec.htm)
Computer Artificial Intelligence

Health & Safety Hazards

Brian Sherin
Process & Facility Hazards

Hazardous Energy

Ergonomics

Man-made & Natural Emergencies

Fire & Smoke

Hazardous Production Materials
Hazardous Energies

- Mechanical
  - Robotics
- Electrical
  - High & Low Voltage
- Chemical
  - Reactive materials
- Radiation
  - Non-ionizing radiation
- Thermal
  - Cryogenics & heat sources
- Pressure
  - Pneumatic
  - Hydraulic
  - Vacuum
Hazardous Energy: Radiation

- Ionizing radiation
  - Ion implantation, scanning electron microscopes
- Non-ionizing radiation
  - Static magnetic fields (0 Hz)
  - Sub radio-frequency fields (1 Hz - 3 kHz)
  - Power frequency fields (50 or 60 Hz)
  - Radio-frequency fields (3 kHz - 300 GHz)
  - Infrared energy (700 nm - 1 mm)
  - Visible light (400 - 700 nm)
  - Ultraviolet energy (180 - 400 nm)
  - Lasers
  - Noise (CE-MD: > 75dBA)
Controls

- Lockout / Tag-out Programs
- Isolation devices
- Interlocks
  - Hardware, software, firmware
- Emergency Shutdown
  - Emergency Machine Off (EMO)
- Operator Notification
  - Audio-visual
Controls

- Administrative controls
  - Type 1 (de-energized) through type 4 (> 30 V<sub>rms</sub>, 42.4 V<sub>peak</sub>, 60 VDC, 240 VA)
- Certified critical components
- Guards & Enclosures
- Labeling
Hazardous Production Materials (HPM)

- **Physical Hazard**
  - Explosives
  - Compressed Gases
  - Flammable & Combustible Liquids
  - Flammable solids
  - Organic peroxides
    - Class I through V
  - Oxidizers
    - Class 1 through 4
  - Pyrophorics
  - Unstable Reactives
    - Class 1 through 4
  - Water Reactives
    - Class 1, 2, 3
  - Cryogenic
    - Flammable or oxidizing

- **Health Hazard**
  - Highly toxic or toxic materials
  - Radioactive materials
  - Corrosives
  - Carcinogens, irritants, sensitizers, and other health hazards
HPM Controls

- Building design (H-Occupancy)
  - Quantity dependent
  - Control areas ("fire barrier")
  - Storage & Dispensing rooms
    - Separation of incompatibles
  - Exit & Service corridors
  - Ventilation / Exhaust systems
    - Clean-room recirculation
  - Sprinkler system design
  - Emergency Power
HPM Controls

- **Use & Handling**
  - Chemical containment
    - Storage
    - Delivery
  - Materials of construction
  - Workstation ventilation
  - Sub-atmospheric delivery systems
  - Monitoring & Alarms
    - Gas
    - Liquid
  - Point of use treatment systems
  - Automatic and manual shutdowns
  - Process liquid heating systems
  - Excess flow control / restrictive flow orifices
  - Emergency Plans and Teams
Fire Prevention

- Risk assessment must be performed
  - Evaluate materials of construction, regardless of quantity or application
    - Knobs, buttons, contactors, circuit boards, etc.
- Assess
  - size of each component,
  - total quantity and distribution of components
  - inherent properties of the materials
  - Exposure to oxidizers and ignition sources
Fire Prevention

- Risk Assessment: Process Chemicals
  - Evaluate type, concentration, state, temperature and pressure
  - Evaluate available flow, pressure and quantity of chemicals fed from facility
  - Inherent properties of chemicals (i.e., flammability)
  - Exposure to oxidizers and ignition sources
Fire Prevention

Risk Assessment: Sources of Ignition
- Internal sources
  - Electrical
  - Chemical (exothermic reactions)
  - Sudden changes in process conditions
  - Mechanical friction
- External sources

Risk Assessment: Oxidizers
- Assume oxygen is available in infinite supply to support combustion
- Determine if materials of construction may act as oxidizers under normal conditions or when exposed to heat
Fire Prevention

- Reduction of risk
  - Elimination of contributing factor(s)
  - Engineering control
  - Administrative control

- Detection

- Suppression
  - Approved for application
Ergonomics / Human Factors

- Eliminate or minimize ergonomic and human factors related hazards during installation, operation, and maintenance
  - Awkward postures
  - Repetitive motions
  - Access space, clearances, and reaches
  - Lifting of heavy or bulky objects
  - Difficult displays and hand controls

- Situations:
  - Manual handling
  - Wafer and cassette handling
  - Workstation design
  - Display locations
Process Hazard Analysis

- “What If” Analysis
- HazOp Study
- Procedural HazOp Study
- Fault Tree Analysis (FTA)
- Failure Modes, Effects and Criticality Analysis (FMECA)
SEMI S10 Risk Assessment

- SEMI S10-1296 - Safety Guideline for Risk Assessment
- Provides a consistent method for assessing risk associated with any hazard
- Uses severity and likelihood
- Divides risk level into five categories
  - Critical, High, Medium, Low, Slight
# SEMI S10 Risk Matrix

<table>
<thead>
<tr>
<th>Severity</th>
<th>Risk Assessment Matrix</th>
<th>Frequent</th>
<th>Likely</th>
<th>Possible</th>
<th>Rarely</th>
<th>Unlikely</th>
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<tbody>
<tr>
<td>Catastrophic</td>
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<td>Minor</td>
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</tbody>
</table>

Legend:
- **Red**: Unlikely
- **Green**: Rarely
- **Blue**: Possibly
- **Yellow**: Likely
- **Orange**: Frequent

- **Catastrophic**: 1
- **Severe**: 2
- **Moderate**: 3
- **Minor**: 4