ISESH Conference

International SEMATECH's Proactive Approach Towards Chemical Management

Dawn E. Speranza
Project Manager, low-k ESH Division

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International SEMATECH's Mission and Members

TEXAS INSTRUMENTS

AMD

HEWLETT PACKARD

hynix

PHILIPS

intel

MOTOROLA

IBM

agere systems

Infineon technologies

International SEMATECH members will create shared competitive advantage by working together to achieve and strengthen manufacturing technology leadership.

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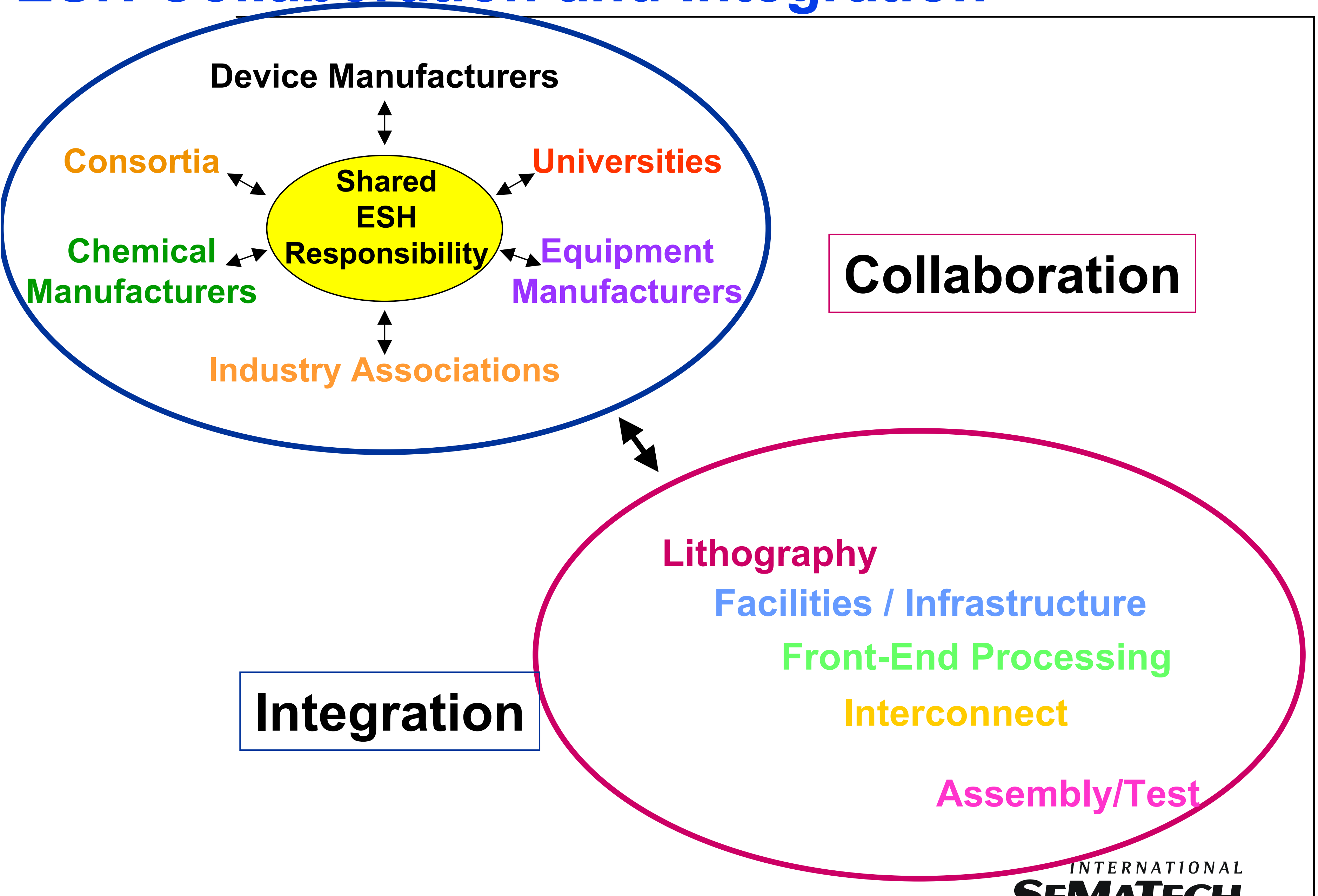
The Importance of ESH

- **The semiconductor industry is one of:**
  - Great importance to the world economy
  - Rapid technology evolution
  - Rapid growth
- **As a result, the semiconductor industry:**
  - Utilizes natural resources (water, energy)
  - Utilizes chemicals
- **ESH is therefore of crucial importance for:**
  - Sustainable growth
  - Understanding new materials and processes
  - Preventing adverse impacts to people or the environment

ESH Collaboration and Integration



We Face Several Major Technology Challenges

- **157 nm and Post-optical lithography**
  - New resist formulations
  - New exposure technology
- **Low-k & High-k dielectrics**
  - Organometallics & silicas
  - New low-k proprietary polymers and precursors
  - New cleaning chemistries
  - New wafer cleaning technologies
  - Gate stack changes
  - New etch chemistries

Major ESH Challenges

- New Chemical identification and potential ESH impacts with little known data
- Chemical Management (hazardous chemicals replacement, reduction, and control)
- Water and Energy Conservation
- Effluent Treatment
- PFC Emissions Reduction
- Equipment Standards and Design

Challenges of Chemical Management

- Technology evolution is driving the accelerated rate of introduction of new chemical materials for 157nm lithography, high-k, gate stacks, low-k inter-level dielectrics

- The S/C industry needs to acquire ESH data for these new chemicals in a timely fashion to enable chemical suppliers to make an adequate ESH evaluation to enable the safe introduction

To address the challenge of chemical management

- **International SEMATECH (ISMT) initiated a project focused on the ESH assessment of new semiconductor chemicals**
- **The project delivered key initiatives and results that I will be discussing in this presentation.**
  - Chemical Data Matrix
  - Formation of Chemical Data Council (CDC)
  - Establishment of three new (ISMT) data assessment projects

Chemical Data Assessment Project

Main Focus – To Determine a methodology for Suppliers to Use in developing ESH data for new chemistries in a timely manner by:

- **Defining the needed ESH data types**
- **Obtaining consensus on data Types**
- **Prioritizing when each data type is needed**
- **Formalizing how to collect the data types**
- **Reviewing chemical predictive models**
- **Identifying gaps in existing systems**

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ESH Data for New Chemicals - Approach

- Membership formed - device manufactures, tool manufacturers and chemicals suppliers in developing timely and adequate ESH data
- Team started at ‘ground zero’ and developed a list of data points for each ESH area; (Environmental, Safety - chemical/physical information, and Health – toxicology)
- Contracted with Colorado State University to assist in developing the ESH data types
- Definitions were developed in order that all participants were in agreement with each data type

ESH Data Phases – Life of a Candidate Chemical

New chemicals entering the semiconductor manufacturing process are expected to have a life history that falls into four general categories (phase 1, 2, 3, and 4).

- **Phase 1 is defined as that period before entrance into a facility**
- **Phase 2 pertains to candidate chemicals, one that has been chosen for demonstration**
- **Phase 3 are chemicals used during the first year of manufacturing**
- **Phase 4 pertains to chemicals on long-term track within manufacturing or greater than one year**

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Chemical Data Matrix – End Result

- A uniform list of ESH data types with definitions and methods for development
- Identifies which data types are important to obtain at each phase of evaluation
- Provides Chemical suppliers a list of data types that are expected during chemical development
- Provides S/C manufacturers with specific available information to make decisions on chemical approval and usage

Chemical Matrix - Phase 1 Data Types

Acute Toxicity - Oral, Dermal, or Inhalation LD50/LC50
Mutagenicity-bacterial
Mutagenicity-chromosomal
Skin Irritation
Specific PPE material recommendations
Appearance
Autoignition Point
Boiling Point
CAS Number
Chemical to Class of Chemical Compatibility
Chemical (process) to Materials of
Color
Decomposition
Density/Specific Gravity
Empirical Chemical Formula
Evaporation Rate

Flash Point
Melting Point
Molecular Structure
Molecular Weight
NFPA Rating
Odor Characteristics
pH
Pyrophoricity
Reaction By-Products
Reaction with Metal
Saturated Vapor Concentration
Synonyms
Vapor Density
Vapor Pressure
Water Reactivity
Global Warming Potential (GWP)
Ozone Depletion Potential

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Product Development Timing & ESH Considerations

Phase 1 ----------------Phase 2 --------------------Phase3 --------------Phase 4------------

Short-Term Concerns	Medium-Term Concerns	Long-Term Concerns
Reactivity Flammability Acute Effects	Biological Monitoring Emissions/Waste Workplace Assessment and Protection	Cancer and Reproduction Life-Cycle Analysis Environment Equipment Life Liability Protection

- 10 | - 9 | - 8 | - 7 | - 6 | - 5 | - 4 | - 3 | - 2 | - 1 | 0 | 1 | 2

Years to Manufacturing

Integration

Fundamental Research — Supplier R&D

Governmental Considerations

Demonstration — Mfg. Ramp

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CHEMICAL DATA ASSESSMENT PROJECT (1998-2000)

New Technology ESH Assessment Projects 2001-2002

Formation of Chemical Data Council (CDC) Oct. 2001- Present

New Technology ESH Assessment

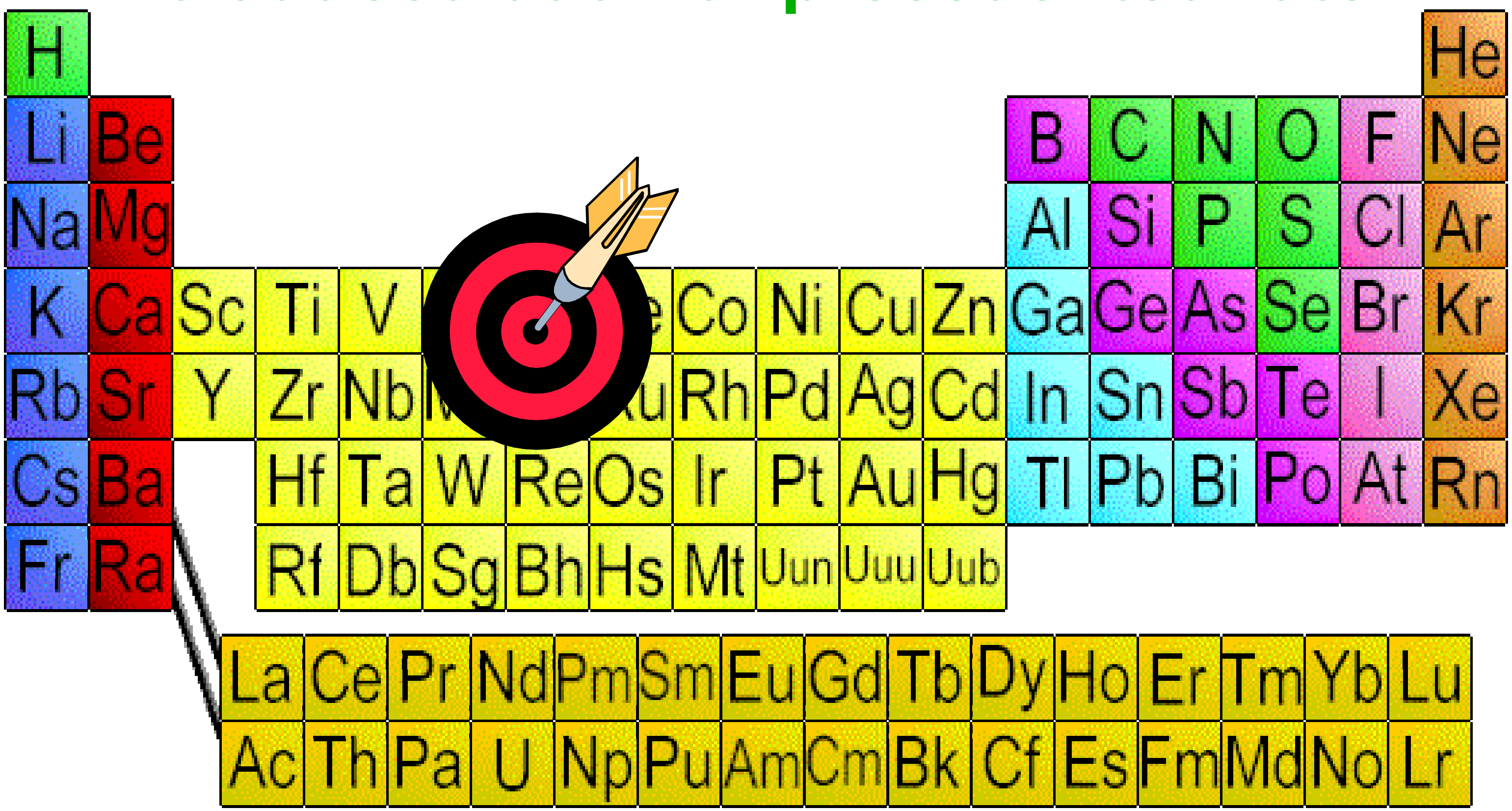
<u>Objective</u>: Early Identification of ESH Issues associated with new process materials prior to process insertion.

Projects utilized the chemical data matrix to obtain ESH data types

- **Advanced Lithography**
- **Advanced Gate Stack**
- **Low-k**

New Materials Everywhere!

New materials & processes are being introduced at an unprecedented rate



Laura Mendicino-Motorola

ESH Assessment – Why?

- **Provides early information on ESH risks/issues**
  - New chemical materials and formulations
  - Not widely used – semiconductor specific
  - Not much ESH data available on mixtures and some of the ingredients
- **Avoids delays in process implementation**
- **Allows selection of personal protective equipment (PPE) appropriate to risk**
- **Characterize emissions and controls**

ESH Assessment – How?

- **Alignment of ESH with Technology Area**
  - Technology mentors and information exchange established between two groups
- **Collaboration with Other Organizations**
  - Minimal duplication, complementary activities
  - Utilize resources by working in parallel to find solutions quickly
- **Interaction with suppliers and member companies**

ESH Assessment – What's Involved?

- **Identify candidate chemistries**
- **Initial Assessment of MSDS**
  - Evaluation using Chemical Data Matrix
    - Utilized many data bases
    - Requested additional data from suppliers
- **Identify how the chemicals are being applied, deposited, etched and processed**
- **Emissions characterization**
- **Industrial Hygiene (IH) Survey**

Chemistries Evaluated 2001

High-k	Amines produced upon contact with moisture. Not TSCA listed. ESH focus on decomposition byproducts. Further amines testing may be needed during maintenance.
Litho	Most ESH considerations with Litho are associated with organic solvent. For 193 & 157nm, common, well researched, industry solvents expected. Intellectual Property issues – proprietary components CAS#s not released. Perfluoro alkyl sul fonate (PFAS) issue- reformulation of resists
Low-k	Resin and some solvent chemical data unavailable, initiating more stringent ESH controls. IH testing: solvents not detected over established exposure limits but further crystalline silica testing may be needed. Air emissions tests on the spin-coat/bake/anneal show mostly edge bead remover/purge solvent, ammonia and trace silica compounds and PFC generation.

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Preliminary Assessment Findings

- Limited sampling data due to low volume use
- Sample results indicated that during the surveys, solvents were well below established occupational exposure limits
- Suggest that additional air and bulk sampling be conducted when wafer throughput is more representative of manufacturing conditions
- Suggest standard IH controls should be implemented during maintenance procedures until proven otherwise

Summary Report – Chemical Matrix

- **Data Completeness**
  - Good completeness of Phase 1 data types
  - Variability in quality of MSDS
  - Variability in response of suppliers for additional information
  - Limited data on some components: chemicals exclusive to semiconductor industry
  - No human or environmental toxicity testing performed due to reactivity
  - Focus on decomposition products/solvents – good data availability
  - Formatting issues

Summary Report – Chemical Matrix

- **Data Types Typically unavailable**
  - High-k, Low-k, Litho:
    - COD, Organic Carbon/Water Partition Coefficient, Neuorotoxicity, Immunotoxicity, Respiratory Sensitization, Benchmark Dose, Reference Dose, Slope Factor, Biomagnification, Phytotoxicity
  - Specific technology area:
    - High-k: EHS information lacking for parent metal compounds (silicon, zirconium & hafnium) other than OELs and basic toxicity data
    - Litho: proprietary issues prevent data availability on non-solvent components
    - Low-k: resin data lacking, solvent data incomplete for phases 2-4

Summary Report – Chemical Matrix

- **Significance of Unavailable Data**
  - Only “suspect” or high-volume chemicals well studied
  - 1998 EPA determined:
    - 43% had no public data, only 7% had complete data
  - Available Chemical/Physical and Environmental data are relatively constant but, Human Health/Toxicity is highly variable
  - Significance of unavailable data is highly site specific, depending on chemical volumes, handling methods, process equipment, and the ESH controls utilized

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Chemical Data Matrix – Next Steps

- Continue to evaluate new chemistries using Phases 1-4 of Chemical Matrix during 2002
- Exploring Access Database to help with data formatting issues
- Evaluate pros/cons of matrix, enhance where feasible
- Continue to pursue supplier interaction and acceptance of Matrix through Chemical Data Council and other forums

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Chemical Data Council (CDC) Formation

- Upon completion of the Chemical Data Assessment project, member companies felt it prudent to establish a council to further develop and continue the work of the data assessment project

- Council was established to provide a forum for member companies and suppliers to reach common goals of advancing ESH chemical data acquisition

- Provide an advanced chemical assessment proposal to an International organization for implementation across the industry

Chemical Data Council (CDC)

- **Formed October 2001**
- **Great representation from chemical suppliers, tool suppliers, and member companies**
- **Focus on understanding different perspectives of chemical management from different point of views**
  - chemical suppliers
  - Member companies
- **Comprehensive review of existing chemical supplier product stewardship processes**
- **Looking for an effective mechanism to obtain chemical data that meets the needs of end users**

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CDC

Next Steps

- CDC to provide a guidance document of history, lessons learned, to help facilitate transfer of material to an International Organization

Future Direction/Keys to Success

- Implementation of Chemical management practices by collaboration amongst international ESH organizations, device manufacturers, suppliers, and academia
- Fine tune the chemical management practices established to date based on feedback from the International SEMATECH's ESH Data Assessment projects, tasks and related councils
- Integration of ESH considerations and design criteria into technology development and manufacturing organizations

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Summary and Conclusions

- **While the semiconductor industry is exceptional in its use of state-of-the-art exposure control and environmental emissions abatement technology, it is also prudent to have ESH chemical data in order to perform accurate hazard and risk assessments.**

- **To continue to be a leader in ESH the SEMICONDUCTOR industry must:**

  Collaborate among international ESH organizations, device manufacturers, suppliers, and academia

  AND continue to

  Integrate ESH into technology development and manufacturing (Lithography, FEP, Interconnect, Assembly/Test, Facilities)