2011 ITRS Winter Meeting (Korea)

Environmental, Safety & Health iTWG

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2011 ESH Contributors:

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Agenda

- Roadmap Strategies
- 2011 Summary Overview
- Implications of 2011 ESH Roadmap Changes
- Key challenges
- Green/Sustainable Chemistry across the life cycle
- ESH iTWG objectives for 2012 (and beyond)
- Conclusions

Roadmap Strategies

Existing

- Understand (characterize) processes and materials during development phase
- Use materials that are less hazardous or whose byproducts are less hazardous
- Design products and systems (equipment and facilities) that consume less raw material and resources
- Make the factory safe for employees and the communities where we operate

Additional focus

- Integration of Green Chemistry Principles into the ITRS
- Proactive engagement with stakeholder partners and customers to reset strategic focus of the roadmap

2011 ESH iTWG accomplishments

- Chapter write-up completed ahead of schedule
- Technology requirements tables and potential solutions tables updated
- Radical ‘simplification’ of many of the requirement tables
- Agreement on integrating green/sustainable chemistry into ITRS
- Successful joint workshops on energy with Factory Integration WG and green chemistry with the Emerging Materials WG
- Symposia session chaired on ‘Green Chemistry in the Semiconductor Industry’, given at the 16th Annual Green Chemistry & Engineering Conference in Washington DC in June (promoting ITRS and the Semiconductor Industry)
- Reset and expansion of the domestic US TWG membership
- Establishment of stronger connections to the research consortia (ERC, SRC and IMEC) and suppliers.
- Participation in the Summer Meetings from INEMI and SIA representatives

Great job by ESH team members. Thanks to all who participated and contributed, and special thanks to Jim Jewett, Mike Mocella, Ohgoshi-san and Joey Liu

Implications of the 2011 ESH Roadmap Changes

- After differentiation of EHS requirements based on priority in 2009 (Critical, Important, Useful), now focusing on the top two criteria, further rating these according to two additional subcategories:
  - Data available: there is a consensus definition, and there is adequate data available, to drive meaningful action under the ITRS
  - No data available: there is not a consensus definition, and/or there is inadequate data available, to drive meaningful action under the ITRS
- Radical "simplification" of many tables, eliminating:
  - ESH needs which did not have sufficient Roadmap quality
  - Goals and metrics stated in continuous improvement terms
  - Improvement activities already part of industry practice (not aligned with fundamental roadmap strategic intent)
- Change in how ESH interacts w/ key TWGs
  - Need for more proactive engagement
  - Partnership on cross-thrust goal development

Interconnect Roadmap Example

Chemicals & Materials: 2009

Year of Production	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Interconnect									
Low-κ materials—spin-on and CVD **Important**	Establish PCU* and PE* baselines		Improve PCU and PE by 10% (relative) from baselines			Improve PCU and PE by 10% (relative) from previous values			
Copper deposition processes (conventional and alternative) **Important**	85% copper reclaimed/recycled		90% copper reclaimed/recycled			95% copper reclaimed/recycled			
Planarization methods **Important**	Establish consumables and emissions baselines		> 15% improvement in consumables***			2% reduction in consumables*** per year			
Plasma etch **Critical**	Establish PCU* and PE* baselines, and investigate alternatives with improved ESH impacts.		Improve PCU and PE by 10% (relative) from baselines, including potential use of alternatives with improved ESH impacts			Improve PCU and PE by 10% (relative) from previous values, including potential use of alternatives with improved ESH impacts.			
CVD chamber clean (plasma)	Establish PCU* and PE* baselines, and investigate alternatives with improved ESH impacts.		Improve PCU and PE by 10% (relative) from baselines, including potential use of alternatives with improved ESH impacts.			Improve PCU and PE by 10% (relative) from previous values, including potential use of alternatives with improved ESH impacts.			
Critical	Reduce Global Warming Impact (lower GWP emissions; improved utilization*) without		Reduce Global Warming Impact (lower GWP emissions; improved PCU*) without increasing ESH risk			Reduce Global Warming Impact (lower GWP emissions; improved CU*) without increasing ESH risk			

CVD chamber clean (plasma)	Establish PCU* and PE* baselines, and investigate alternatives with improved ESH impacts.	Improve PCU and PE by 10% (relative) from baselines, including potential use alternatives with improved ESH impact

	ESH impacts.								
Critical	Reduce Global Warming Impact (lower GWP emissions; improved CU*) without increasing ESH risk		Reduce Global Warming Impact (lower GWP emissions; improved CU*) without increasing ESH risk			Reduce Global Warming Impact (lower GWP emissions; improved CU*) without increasing ESH risk			

Illustrating the qualitative, continuous improvement elements that were present in the RM

Current Interconnect Table change

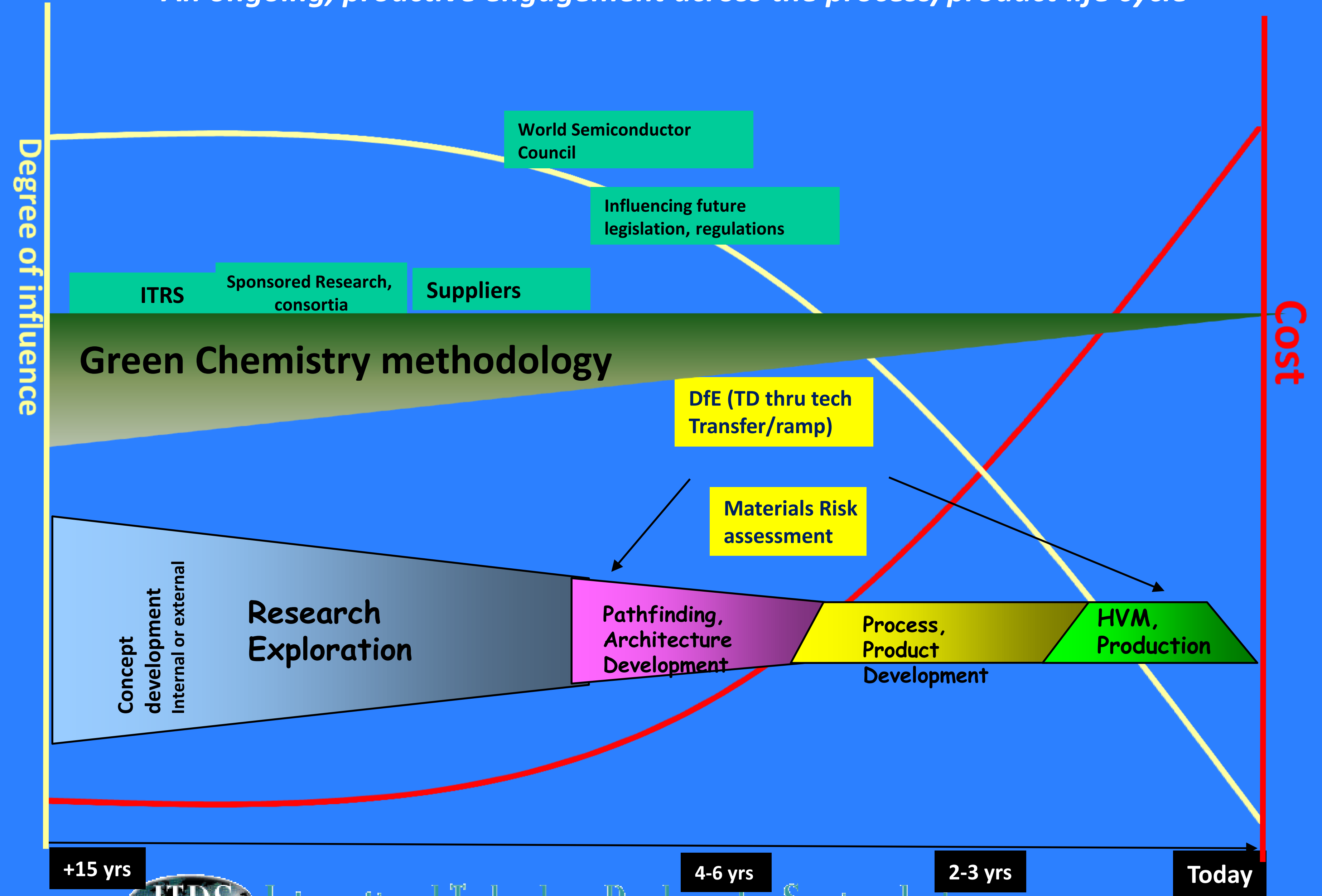
Chemicals & Materials: 2011

Year of Production	2011	2012	2013	2014	2015	2016	2017	2018	2019
Interconnect									
Low-κ materials—spin-on and CVD	Establish Roadmap quality goal and metrics		Meet established goal and metrics			Meet established goal and metrics			
Important									
Copper deposition processes (conventional and alternative)	85% copper reclaimed/recycled		90% copper reclaimed/recycled			95% copper reclaimed/recycled			
Important									
Planarization methods	Establish Roadmap quality goal and metrics		Meet established goal and metrics			Meet established goal and metrics			
Important									
Plasma etch	Establish Roadmap quality goal and metrics		Meet established goal and metrics			Meet established goal and metrics			
Critical									
CVD chamber clean (plasma)	Establish Roadmap quality goal and metrics		Meet established goal and metrics			Meet established goal and metrics			
Critical									
Surface preparation	Establish Roadmap quality		Meet established goal and metrics			Meet established goal and metrics			

CVD chamber clean (plasma)	Establish Roadmap quality goal and metrics	Meet established goal and metrics
Critical		

For all those requirements that were tactical or non-quantitative, the above flags were inserted as a placeholder, to focus future efforts

Integrating Sustainable/Green Chemistry Methodology = An ongoing, proactive engagement across the process/product life cycle



Key Challenges

- Increasing regulatory landscape
  - Proliferation and ambiguity of requirements, complexity of rules
  - Trend toward tighter restrictions (emphasis on evaluation of chemical risks) and the precautionary approach to managing chemicals
  - Increased need to share chemical usage information
- Natural resource usage and availability
- Climate change implications and impact on future technology development and innovation
- Broader view of ESH issues across the supply chain, the technology life cycle (process/product) and connections to governance, social responsibility
- The 300/450 transition, as a driver for environmental innovation (materials, tools and process development)
- Novel chemicals (nano-materials, III-V compounds, etc)

ESH iTWG 2012+ Objectives

- **2012**
  - Complete reset of iTWG and dTWG (US) membership teams, define sub-team structure, successful kick-off of teams
  - Drive completion and buy-off of Green Chemistry WP for defining strategy and roadmap plan for integration into ITRS (collaboration with ERM)
  - Develop strategy for alternatives assessments to drive more sustainable/greener materials choices (guidance on tools, potential standards)
  - Develop strategy for driving innovative ESH advances through the 300/450 mm transition
  - Develop guidance for research focus for nano-materials, prioritize chemicals for research focus
  - Explore predictive systems and control methodologies
  - Define energy conservation/efficiency/metrics (collaboration with FI)
  - Continue broadening of ITRS engagement with adjacent industries (pharma, chemical); develop symposia session to promote semiconductor industry work in ESH innovation
  - Metric/metrology criteria development for ESH requirements

- **Long Term Focus**
  - Apply Sustainable/Green Chemistry methodology across the process and product life cycle for the industry
  - Change paradigm of EHS to proactively addressing issues and driving innovation for the environment

Conclusions

- Radical simplification of ESH technology requirements tables & potential solutions tables in 2011
  - Elimination of tactical requirements, focusing on strategic, long range goals, where data is needed
  - Transitional state of RM will serve as a foundation for resetting ESH tables
  - Consensus achieved on integrating Sustainable/Green Chemistry principles, as a vehicle for implementing roadmap changes
- Broadening the focus and visibility of the ITRS
  - Establishing connections to adjacent industry associations, technical societies
  - Better engagement with research consortia,
  - Inclusion of new members into the ESH WG
- Identified key focus areas and strategies for ESH
  - Emphasize active engagement and partnering with key technical WGs
  - Plans defined for 2012 and beyond
  - Creation of sub-team groups, to better focus development of strategies and guidance to the industry, which engage with each Technical WG
- Key collaboration with partner TWGs on broader issues
  - 2 Workshops on Energy organized with Factory Integration
    - Alignment between facilities and ESH
    - Definition of energy metrics for ITRS tables
  - 2 Workshops with ERM on Green Chemistry concept and value

Back-up

Green (sustainable) Chemistry Principles*

1. Prevent waste
2. Maximize atom economy
3. Design less hazardous chemical syntheses
4. Design safer chemicals and products
5. Use safer solvents and reaction conditions
6. Increase energy efficiency
7. Use renewable feed stocks
8. Avoid chemical derivatives
9. Use catalysts, not stoichiometric reagents
10. Design chemicals and products that degrade after use
11. Analyze in real time to prevent pollution
12. Minimize the potential for accidents

* Anastas, P. T. and Warner, J. C. *Green Chemistry: Theory and Practice*, Oxford University Press: New York, 1998.

Relating ESH Difficult Challenges & Green Chemistry

Difficult Challenges ≥16nm	Summary of Issues	Green Chemistry Principles
Chemicals and materials management	• *Chemical Assessment* • *Chemical Data Availability* • *Chemical Exposure Management*	• *Design less hazardous chemical syntheses* • *Use safer solvents and reaction conditions* • *Use renewable feed stocks* • *Avoid chemical derivatives* • *Use catalysts, not stoichiometric reagents*
Process and equipment management	• *Process Chemical Optimization* • *Environment Management* • *Global Warming Emissions Reduction* • *Water and Energy Conservation* • *Consumables Optimization* • *Byproducts Management* • *Chemical Exposure Management* • *Design for Maintenance.* • *Equipment End-of-Life*	• *Prevent waste* • *Maximize atom economy* • *Increase energy efficiency* • *Minimize the potential for accidents*
Facilities technology requirements	*Conservation* *Global Warming Emissions Reduction*	• *Analyze in real time to prevent pollution*
Sustainability and product stewardship	*Sustainability Metrics* *Design for ESH* *End-of-Life Reuse/Recycle/Reclaim*	• *Design safer chemicals and products* • *Design chemicals and products that degrade after use*

ERM ITWG Potential Insertion Opportunity Matrix

Table ERM14 ITWG Earliest Potential ERM Insertion Opportunity Matrix

Application	Ge & III-V	Carbon Nanotubes and other Metal Nanotubes	Nanowires	Graphene	Oxide Nanoparticles	Metal Nanoparticles	Novel Macromolecules	Self Assembled Materials	Complex Metal Oxides	Spin Materials (Fe, Co, Mn, Ni, etc.)
Process Materials										
Lithography										
Device: Memory										**MRAM**
Device: Logic										
Interconnect										
Packaging										

LEGEND

Earliest Potential Insertion	Current Apps	3-5 yrs	5-10 yrs	10-15 yrs	15+ yrs	Not on the Roadmap

ESH Sub Team Structure – Emerging Themes/Challenges

	Subteam	2012 (and beyond) Challenges
1	Assembly & Packaging Focus: 1) AT materials issues 2) Impact of process materials on product content	• Alignment/engagement strategy with iNEMI ; Pb-free solder for bumps in all applications (phase-out of European exceptions)
2	Emerging Research Materials Focus: 1) Green Chemistry Integration, 2) Nanomaterials	•
3	Factory Integration Focus: 1) Natural Resource usage 2) Carbon footprint Metrics, standards development, 3) Green Fab design	POU abatement DRE and uptime tracking ; accurate measurement of GHG emissions
4	Front-end processing Focus: 1)	Use of fluorine for chamber cleans (zero GWP); characterization of new process materials
5	Interconnect Focus: 1) New materials,	TSV etch GHG use
6	Lithography Focus:	High EUV energy requirement; PFOS-free resists
7	Metrology Focus: 1) identify new measurement challenges	