ENVIRONMENT, SAFETY, AND HEALTH

Table 82 Environment, Safety, and Health Difficult Challenges

Five Difficult Challenges ≥ 65 nm, Through 2007	*Summary of Issues/Needs*
Chemicals, Materials and Equipment Management	*New Chemical Assessment* Need for quality rapid assessment methodologies to ensure that new chemicals can be utilized in manufacturing, while protecting human health, safety, and the environment without delaying process implementation. Chemicals in existing uses require reassessment when new chemical restrictions are identified. *Chemical Data Collection* Need to document and make available environment, safety, and health characteristics of chemicals. *Chemical Reduction* Need to develop processes that meet technology demands while reducing impact on human health, safety and the environment, both through replacement of hazardous materials with materials that are more benign, and by reducing chemical quantity requirements through more efficient and cost-effective process management. *Environment Management* Need to develop effective management systems to address issues related to disposal of equipment, and hazardous and non-hazardous residue from the manufacturing process.
Resource Conservation	*Natural Resource Conservation (Energy, Water)* Need to design more energy and water efficient processing equipment. *Chemicals and Materials Use* Need more efficient utilization of chemicals and materials. *Resource Recycling* Increase resource reuse and recycling.
Workplace Protection	*Equipment Safety* Need to design ergonomically correct and safe equipment. *Chemical Exposure Protection* Increase knowledge base on health and safety characteristics of chemicals and materials used in the manufacturing and maintenance processes, and of the process byproducts; and implement safeguards to protect the users of the equipment and facility.
Climate Change Mitigation	*Reduce Energy Use of Process Equipment* Need to design energy efficient larger wafer size processing equipment. *Reduce Energy Use of the Manufacturing Facility* Need to design energy efficient facilities to offset the increasing energy requirements of higher class clean rooms. *Reduce High Global Warming Potential (GWP) Chemicals Emission* Need ongoing improvement in methods that reduce emissions from processes using GWP chemicals.
ESH Design and Measurement Methods	*Evaluate and Quantify ESH Impact* Need integrated way to evaluate and quantify ESH impact of process, chemicals, and process equipment, and to make ESH a design parameter in development procedures for new equipment and processes.

Table 83a ESH Intrinsic Requirements—Near-term

Year of Production	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*DRIVER*
Dram 1/2 Pitch (nm)	*130*	*115*	*100*	*90*	*80*	*70*	*65*	
Chemicals, Materials, and Equipment Management Technology Requirements								
Assessment of Chemical and By-product Properties								
Data accumulation Existing chemicals (include by-product materials)	**Design of Data Base**		**50% of the data/chemical**		**100% of the data/chemical**			*New restrictions*
New chemicals (include by-product materials)					**100% after 2 years of market introduction**			*New processes*
Resource Conservation Technology Requirements								
Energy Consumption								*Sustainable Growth*
Overall fab equipment (KWh/cm2)	**0.5-0.7**		**0.4-0.5**		**0.3-0.4**			
Fab facility (kWh/cm2)	**0.5-0.7**		**0.4-0.5**		**0.3-0.4**			
Tool energy usage per wafer pass (300mm versus 200mm); baseline 1999	**1.5**				**1**			
Water Consumption								*Cost and sustainable growth*
Net feed water use (Liters/cm2)	**5.9**		**3.5**		**3.5**			
Fab UPW use (Liters/cm2)	**6 - 8**	**5 - 7**			**4 - 6**			
Tool UPW Use (Liters/cm2, per wafer pass)	**0.15**	**0.075**		**0.06**				
Chemical Consumption & Waste Reduction								*Environmental stewardship*
Chemical Use (liters/cm2/mask layer)	**Reduced 5% per year**					**Reduced 5% per year**		
Recycle/Reuse Systems	**Infrastructure improvement**	**Thorough recycle/reuse system**			**Innovative recycling technologies**			
Waste recycle rate (%)	**60%**	**65%**			**70%**			
Climate Change Mitigation Technology Requirements								
Reduce PFC emission	**10% absolute reduction from 1995 baseline by 2010 as agreed to by the WSC**							*Voluntary agreement*
Workplace Protection Technology Requirement								
Equipment safety, gases and chemical leaks, and equipment stability during an earthquake	**Conformance to S2 Safety Guidelines and S8 Ergonomic/Human Factor Guidelines**			**Conformance to revisions of S2 Safety Guidelines and S8 Ergonomic/Human Factor Guidelines**				
Safe Interface of Automated Material Handling Systems (AMHS) and manufacturing equipment			**Standardized control features and procedures**					
Safe Robotics			**Standardized control features and procedures**					
Comprehensive exposure data	**Data collection**		**Comprehensive industrial hygiene(IH) exposure data for operations and maintenance**					
	Collaboration among government, industry, academia, and companies regarding new exposure data							
Personal protection equipment (PPE)	**Investigation of PPE**		**Test and rate PPE**					
Material Safety Data Sheets (MSDS)	**Employee awareness for new technologies**		**Comprehensive data**					
Equipment Risk Assessment (Health and Safety)	**Case Study**		**Common Algorithm**			**Common Application**		
Reduced chemical exposure	**Workers isolated from chemicals and by-product for non-routine operation and maintenance**							
Ergonomic Improvement	**Basic Study for 300mm**		**Minimized/eliminated physiological stresses**					

Table 83a ESH Intrinsic Requirements—Near-term (continued)

	Year of Production	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*DRIVER*
	Dram 1/2 Pitch (nm)	*130*	*115*	*100*	*90*	*80*	*70*	*65*	
	Design for ESH (DFESH)								
Was	Environmental load/impact assessment (LCA)	**Case Study**		**Common Algorithm to identify, access, and accept risk**			**Common Algorithm to identify, access, and accept risk**		
Is	Environmental load/impact assessment (LCA)			**Common Algorithm to identify and assess risk**					
Was	Chemical Risk Assessment (Health and Safety)	**Case Study**		**Common Algorithm to identify, access, and accept risk**			**Common Algorithm to identify, access, and accept risk**		
Is	Chemical Risk Assessment (Health and Safety)			**Common Algorithm to identify and assess risk**					
	Material Balance	**Pollutant release, and transfer disclosure (PRTR)**				**PRTR data acquisition system**			*New materials and restrictions*
		Common Test Methods, Protocol, and Application							
	Regulatory Requirements	**Collection of requirements, guidelines, policy trends, and others**							

White–Manufacturable Solutions Exist, and Are Being Optimized	White
Yellow–Manufacturable Solutions are Known	Yellow
Red–Manufacturable Solutions are NOT Known	Red

Table 84a Chemicals, Materials and Equipment Management Technology Requirements—Near-term

Year of Production	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*Driver*
DRAM ½ Pitch (nm)	*130*	*115*	*100*	*90*	*80*	*70*	*65*	
Interconnect								
Low κ materials – spin on and CVD	**Lowest ESH impact solvents/ CVD precursors**		**Emissions modeled**		**ESH benign processes**			*Speed, signal loss*
Copper processes	**Lowest ESH impact plating chemistries**		**Plating bath recycle**		**ESH benign processes**			*Speed, reliability*
Advanced metallization	**Lowest ESH impact processes/ emissions characterization**				**ESH benign processes**			
Planarization	**Slurry minimization**		**Slurry recycling**		**Slurry-less planarization**			*Planarity*
Plasma processes	**Etch abatement**		**Alternative etch chemistries**			**Lowest ESH impact etch chemistries**		
	Characterization of plasma by-products				**Lowest ESH impact etch chemistries**			
Front end Processes								
High κ materials	**Characterization of high κ precursor materials**		**Lowest ESH impact high κ materials**			**ESH benign processes**		*Transistor performance*
	Characterization of low-hazard deposition methods			**Low-hazard deposition methods**	**ESH benign processes**			*Transistor performance and device development*
				High κ materials without potentially toxic/bioaccumulative metals (Pb, Ni)	**Lowest hazard metal compounds**			*Device development*
Doping	**Sub-atmospheric delivery system**				**Lowest hazard dopant materials and processes**			
Surface Prep	**Fundamental research on surface/interface science**		**Ongoing research and integration of solutions**		**Optimized surface preparation processes**			
	Alternative wafer rinse methods			**Incorporation into new rinse/clean tools**				
	Characterization of alternative cleaning methods			**Incorporation into new clean tools**		**ESH benign cleans**		
	Elimination of sulfuric acid							
Front end etch	**Characterization of plasma by-products**				**Plasma process simulation-optimized processes for by-product destruction**			

White–Manufacturable Solutions Exist, and Are Being Optimized
Yellow–Manufacturable Solutions are Known
Red–Manufacturable Solutions are NOT Known

Table 84a Chemicals, Materials and Equipment Management Technology Requirements—Near-term (continued)

	Year of Production	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*Driver*
	DRAM ½ Pitch (nm)	*130*	*115*	*100*	*90*	*80*	*70*	*65*	
	Lithography								
	New Equipment								*Reduced feature size*
	Optical			**Characterization of ESH Impacts**		**Minimal ESH Impact for hazardous chemicals and material compatibility**			
	e-Beam			**Characterization of ESH Impacts**		**Minimal ESH Impact for ionizing radiation, ergonomics, chemical consumption, and disposal**			
	EUV			**Characterization of ESH Impacts**		**Minimal ESH Impact for non-ionizing radiation, ergonomics, chemical consumption, and disposal**			
Add	*EUV*					***(Propose) Non-PFOS PAG for EUV Resist***			
	Radiation	**Fundamental research on X-ray exposure**		**Requirements for x-ray exposure PPE and/or equipment defined**					
	New Materials			**Characterization of ESH Impacts**		**Minimal ESH Impact for new chemicals, purification requirements, wastes, and emissions**			
Was		**Identification of PFOS applications**				**PFOS Alternatives**			
Is		**Identification of PFOS applications**		**PFOS Alternatives for non-critical uses***		**PFOS Alternatives for critical uses***			

White–Manufacturable Solutions Exist, and Are Being Optimized	White
Yellow–Manufacturable Solutions are Known	Yellow
Red–Manufacturable Solutions are NOT Known	Red

Add notes to Table 84a

**Critical uses of PFOS includes use in a photomicrolithography process to produce semiconductors or similar components of electronic or other miniaturized devices" as a:*

–Component of a photoresist (including PAGs and surfactants)

–Component of an anti-reflective coating