SB 14 UPDATE

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Scope of Presentation

- Introduction to SB 14
  - Purpose
  - Requirements
  - Applicability
- Semiconductor Industry SB 14 Findings
  - Source Reduction Measures Implemented
  - Source Reduction Proposed in 2002

SB 14 Introduction

- Hazardous Waste Source Reduction and Management Review Act of 1989 (SB 14)
- Health & Safety Code Section 25244.12 et seq.
- California Code of Regulations, Title 22, Section 67100 et seq.

SB 14

- Purpose:
  - Reduce generation of hazardous waste at its source
  - Document hazardous waste management information and make that information available
- Required SB 14 Documents
  - Source Reduction Evaluation Review and Plan (Plan)
  - Hazardous Waste Management Performance Report (Performance Report)
  - Summary Progress Report (SPR)

SB 14

- Applicability Threshold
  - >26,400 lbs. Hazardous Wastes
  - >26.4 lbs. Extremely Hazardous Wastes
    - Routinely generated
    - Exempted Waste Streams
- Four-Year Cycle
  - 1990, 1994, 1998, 2002, 2006,…
- Current Reporting Deadline: September 1, 2003

SB 14: Industry Assessments

- DTSC calls in SB 14 documents from selected industries
- Semiconductor Industry
  - Assessment of the Semiconductor Industry Source Reduction Planning Efforts, October 1994
  - Recently called in 2002 documents to update assessment report

Caveats/Notes

- Not claiming expertise on semiconductor manufacturing
- Discussions on SB 14 documents are usually very general
- To complete assessment report, may require contacting facilities for more information
- Consider this forum as a networking opportunity

Successful Approaches to Source Reduction

- Management commitment
- Team effort
- Work with equipment supplier and consultants
- Industry associations

Waste Groups

- Wastewater
- Solvents
- Corrosive Liquids
- Contaminated Debris
- Others

Source Reduction Measures Implemented

Wastewater

Process/Equipment Modification

- Recirculation filter systems installed in the cleaning and etching baths.
- Bath changes done less frequently based on number of wafers processed
- Replaced wet sink with spray tool for pre-diffusion cleans. Reduction was :
  - Ammonium hydroxide: 85%
  - Hydrogen Peroxide: 72%
  - Hydrochloric Acid: 67%

Wastewater

Process/Equipment Modification

- Old process benches replaced with new benches that have automatic shut-off systems that prevent constant overflow of process wastewater.
- Reduced slurry flow rate during polish and pad conditioning. Reduced wastewater by 110,000 lbs.
- Increased use of dry etch tools

Wastewater

Product Reformulation:

- used gallium arsenide instead of silicon wafers. Reduction was ~45%

Reuse:

- Reuse of reclaimed water as make-up water in cooling towers and scrubbers. Around 15% is recycled back.

Suppliers:

- Obtained substrate from supplier in a clean state

Solvents

Process/Equipment Modification:

- Automatic in-place cup wash instead of solvent sink cup cleaning – extended cup cleaning from daily to monthly – reduced ~25,000 lbs of mixed solvent wastes
- Extended allowable number of lots that could be run through a batch of chemical before it needed to be changed
  - Reduced waste by ~45%

Solvents

Process/Equipment Modification

- Optimized spin rate
- More precise photoresist dispense pumps installed.
- Installed a vent fog jet gun to dispense solvents. Reduced solvent waste by 90%.
- Used dry pumps on vacuum equipment. Reduced oil.
- Vapor prime application of HMDS

Solvent

Process/Equipment Modification

- Acetone and IPA were eliminated in many wipe-down operations by using deionized water
- Used spin drying for certain components.
  - Reduced IPA use by ~20%
- Solvent cleaning of dry etch tools was replaced with aqueous slurry blast cleaning
  - Reduction was ~30%

Solvents

Process/Equipment Modification:

- Contaminated condensate waste was eliminated when certain organic solvents vapor from fabrication process were re-routed to a thermal oxidation unit. Eliminated ~1,000,000 lbs.

Solvent

Improved Process Maintenance:

- Reduced the water content in the solvent waste stream. Reduced solvent waste by ~40%.

Recycling

- Installed multiple segregated waste collection system to recycle off-site

Solvent

Material Substitution:

- Replaced wax with tape as a masking during mesa etch. Reduced amount of degreaser solvent used to remove wax

Supplier:

- Obtained Germanium substrates in clean state, reducing the solvent cleaning wastes.

Corrosive Liquids

Process Baths:

- Extended bath life by recirculating BOE to remove particulates and other contaminants
- Developed entirely new wet benches in cooperation with its equipment suppliers and reduced sulfuric acid consumption by 30 %. Also, ultra pure water usage was cut by 50%

Corrosive Liquids

Collection/Generation

- Identified that there were occasions when excess water was entering the HF collection system which increased the volume of waste.
  - Reduced by 125,000 lbs.

Reuse:

- Direct reuse of corrosive liquid containing high concentration of lead and copper:
  - ~860,000 lbs. was shipped for direct reuse.

Contaminated Debris

Equipment Modifications:

- Extended polish pad life
  - Installed programmable conditioning unit that controls pad uniformity
  - Used product wafers during qualification to verify polish process control eliminated the need for test wafers.

Contaminated Debris

- Solvent-contaminated gloves and wipes were reduced by replacing grease pens used to mark diffusion furnace data cards with water-soluble pens. Reduced wastes by 50%.

Others

Equipment Modifications:

- Baghouse wastes: A new abatement system (BOC Edwards-Zenith system) was installed, and is in the testing phase.
  - Up to 100% reduction of actual baghouse waste is expected.
  - Will generate more wastewater

Others

- Pyrophoric solids: Most VPE (vapor phase epitaxy) reactors were replaced with EMCORE reactors and Aixtron reactors --- these are nitride reactors and do not generate pyrophoric wastes.
- Resins: Eliminations of the carbon exchanger resin in the C4 process. Reduced wastes by ~10,000 lbs./yr

Proposed Source Reduction Measures

Proposed Measures

- Some facilities proposed measures that have already been implemented by other facilities:
  - Increased use of dry etch tools
  - Optimize control of photoresist head
  - Install lower volume pumps
  - Minimize water contamination of solvent and acid wastes

Proposed Measures

- Some facilities proposed measures that have already been implemented by other facilities:
  - Segregate NMP and other photoresist strippers for recycling
  - Install auto dispense system in sulfuric cleaning sink
  - Install chemical sensors in the acid bath of the diffusion tube cleaners.

Wastewater

Photoresist:

- Improve final rinse and eliminate backside wiping.
  - Expected reduction is ~37,000 pounds per year of NMP
- Eliminate use of NMP on certain stages of lift-off process by using CO_2
  - Expected reduction is ~ 46,000 lbs. of HW
  - Technically feasible as this has been tested on products similar to the facility's.
  - High capital appropriation, must be evaluated carefully.

Solvent

- Eliminate mounting wax during etching.

Grind Process:

- Closed loop filtration --- The generated water with arsenic can be returned and reused to the front end of the process if filtered appropriately.

Corrosive Liquids

- Install Ozone Generator System in sulfuric cleaning sink

Others

- Toxic Gas Scrubber Wastes: Reformulate resin: By switching to a higher capacity resin, facility anticipate a 30% increase and expects to reduce waste stream by ~20%

Success Stories

Success Story: Analog Devices

- HF and Acid Waste Treatment Retrofit
  - Conversion from Magnesium Hydroxide/Calcium Chloride to Calcium Hydroxide
  - Goal: Reduce HF and Acid Waste Treatment Costs by 30%

Analog Devices:
HF and Acid Waste Treatment Retrofit

- Original HF Waste Treatment System used two chemicals:
  - Magnesium hydroxide
  - Calcium Chloride
- Acid Neutralization System also used magnesium hydroxide

Analog Devices:
HF and Acid Waste Treatment Retrofit

- Conversion must:
  - have >30% cost savings
  - not add operator time or require more maintenance
  - not require addition of new equipment to the system
  - meet Santa Clara limits for pH and Fluoride concentrations

Analog Devices:
HF and Acid Waste Treatment Retrofit

- Established targets on chemical cost, sludge generation, disposal cost, labor, effluent quality, and timing.
- Identified possible alternatives:
  - NaOH & $CaCl_2$
  - $Ca(OH)_2$

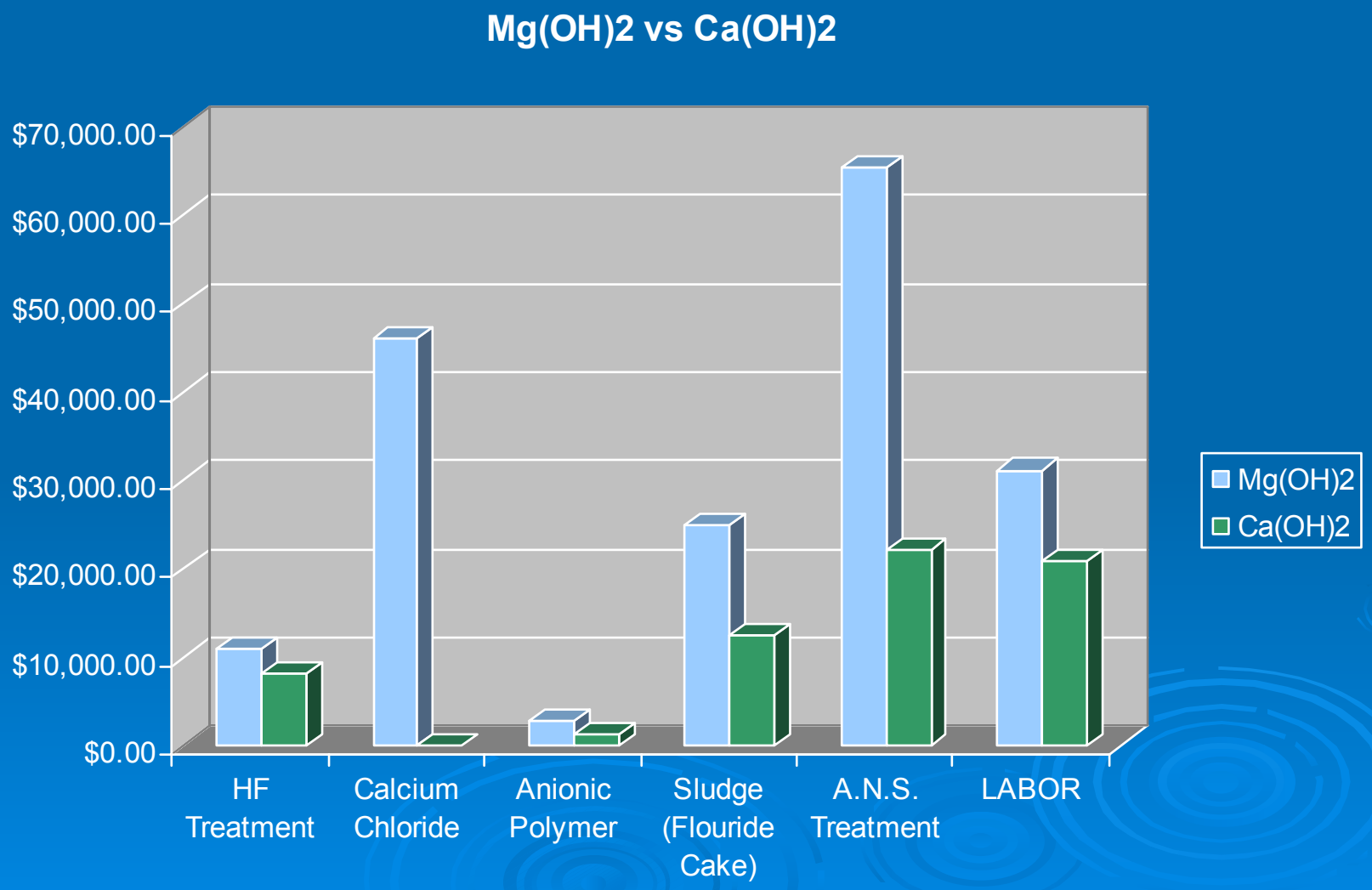
Analog Devices:
HF and Acid Waste Treatment Retrofit
-- Results--

Type	Metric	Target Value	Obtained Value
Chemical Cost	$125,000/Yr.	$87,000/Yr.	$31,400/Yr.
Effluent	PH=8.0-9.0 ppm=120-180	PH=8.0-9.0 ppm=120-180	PH=8.0-9.0 ppm=30-180
Sludge (CaF2) Generation	136,500 Gallons/Yr.	68,000 Gallons/Yr.	39,000 Gals./Yr.
Disposal Cost	$25,000/Yr.	$18,000/Yr.	$12,500/Yr.
Labor	$31,200/Yr.	$26,000/Yr.	$20,800/Yr.
Timing	Sept. 2000	March 2001	Mar. 2001

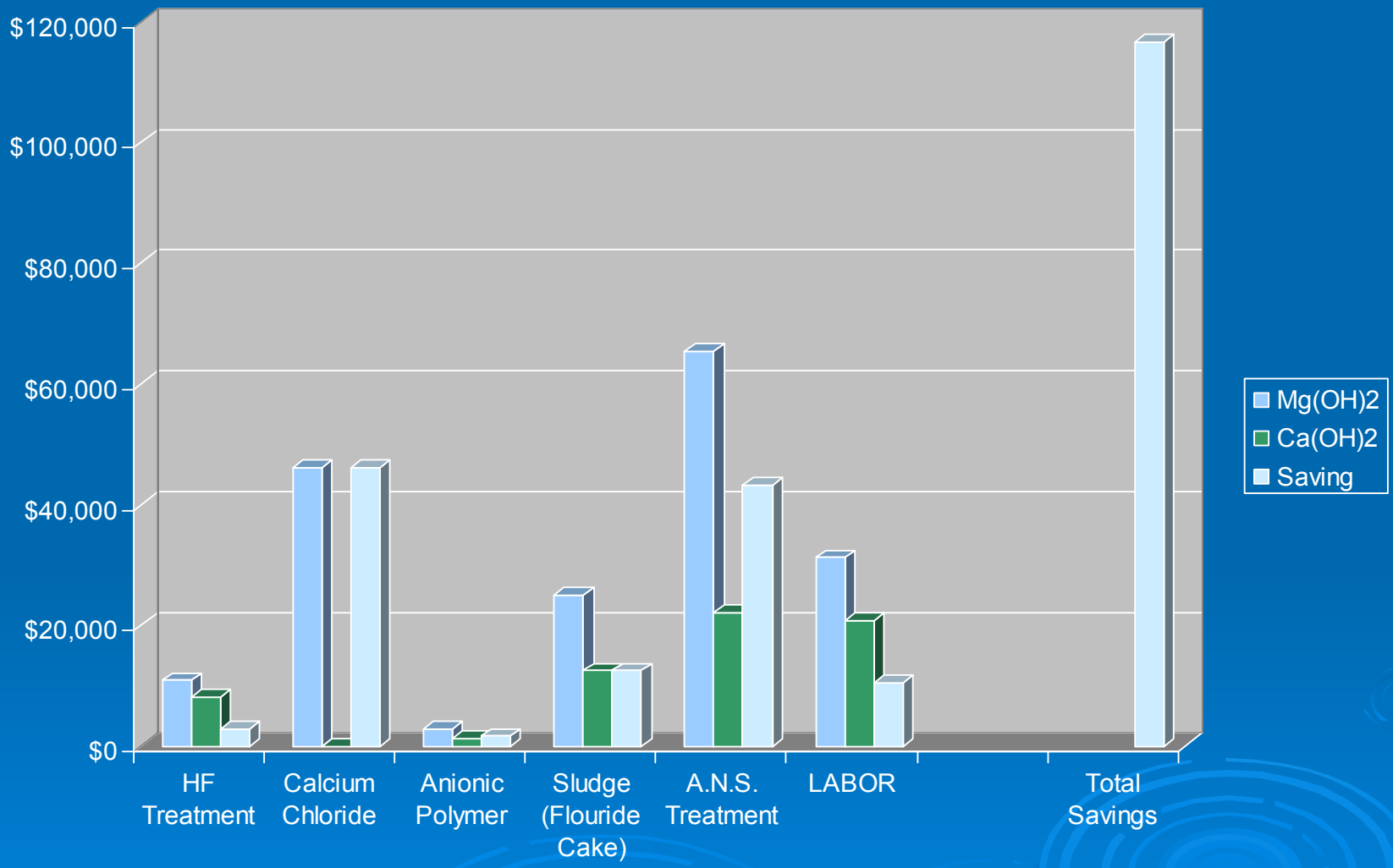
Analog Devices:
HF and Acid Waste Treatment Retrofit
– Summary --

- An opportunity to save costs was recognized and pursued:
  - Total savings ~ $117,000 per year
- Significantly reduced chemical costs
  - Eliminated one chemical, calcium chloride
  - Savings on Chemical Cost ~ $94,000 per year
- Reduced sludge generation by 65%
  - Reduced disposal cost
- Less labor and maintenance

Analog Devices:
HF and Acid Waste Treatment Retrofit



TOTAL SAVINGS



Success Story:
LSI Logic

Success Story: LSI Logic

- 300 acre site at Gresham, Oregon purchased in 1995
- November 1998 - Fab production start
- Received Oregon Green Permit and EPA National Performance Track Award
- Invested approximately $20 M in pollution abatement and treatment systems
- 2002 Semiconductor International Top Fab Award

Success Story: LSI Logic

- Reduced the amount of chemicals used in manufacturing chips by ~70% in 4 years
  - Conversion from wet to dry processing
  - Use of dilute chemistries
  - Material substitution (oxide slurry)
  - Process modification

Success Story: LSI Logic

- Conversion from wet to dry processing in etch cleaning operations
  - Dry processing uses ozone to replace HF and H_2SO_4
  - Eliminated DI water required for rinsing
  - Resulted in an annual chemical reduction of 2,000 gallons and water savings of 8,500,000 gallons

Success Story: LSI Logic

- Use of dilute chemistry at diffusion process
  - Determined that a dilute chemical bath could produce the same cleaning results as the original process recipe.
  - Reduced the volume of NH_4OH, H_2O_2, and HCl usage by 8,200 gallons per year

Success Story: LSI Logic

- Material substitution
  - Chemical Mechanical Processing department evaluated a new oxide slurry for use in the process
  - New slurry increased the processing rate by 5%
  - Reduced overall chemical consumption by 14,500 gallons per year

Success Story: LSI Logic

- Process modification
  - Reduction in wafer qualification
    - Developed a database to capture troubleshooting data that was previously gathered by the use of test wafers
    - Database effectively reduced use of test wafers
    - Total annual reduction: 2,200 gallons of CMP slurry, NH_4OH, H_2O_2, and H_2SO_4

Success Story: LSI Logic

- Process modification
  - Eliminated BOE
    - Previously used in a single tool for a single process step
    - To increase throughput of tool, step was removed from manufacturing process, eliminating the use of BOE
    - Process was replaced with an inert Argon sputter etch step
    - Reduced ~5,500 gallons of BOE per year

Success Story: LSI Logic

- Process modification
  - Cleaning frequency on susceptor sources was reduced by 67% without impact on product quality
    - Reduced HF consumption by 24,300 gallons per year, and water consumption by 125,000 gallons per year.

Summary

- Semiconductor facilities continue to find ways to reduce wastes, not only for environmental reasons, but for good business practice in general
- Semiconductor industry assessment report to be completed

End