



High-Performance Power and Hall-Effect Sensor ICs



TUR Continuing Education Conference - 4/14/10
TUR Project Management and Control at Allegro MicroSystems
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Overview

- Allegro Background
- Allegro TUR program
 - Implementation
 - Project Management, Tracking, and Control
 - Results
- Allegro TUR Program Affect on ISO-14001 Program
- Summary
- Questions



Allegro Background

- Allegro MicroSystems, Inc. is a leader in developing, manufacturing and marketing high-performance power and Hall-effect sensor integrated circuits. Allegro's innovative solutions serve high-growth applications within the automotive, communications, computer/office automation, consumer and industrial markets.
- Allegro is headquartered in Worcester, Massachusetts (USA) with design and applications centers located in North and South America, Asia, and Europe.
- Allegro has wafer fabrication facilities in Worcester, MA and Bloomington, MN, and an assembly plant in Manila, Philippines.
- Further information about Allegro can be found at www.allegromicro.com.



Allegro Background

- By the nature of the business, operation of a wafer fab is chemical and energy intensive.
 - Much of the process is performed in a class 100 designed clean room, which operates at class 10 or better.
 - Potential contamination includes
 - Unwanted material that adversely affects the physical or electrical characteristics of a semiconductor wafer.
 - Types: Particles, Metallic Ions, Chemical and Bacteria.
 - Sources: Air, People, Clean room, Equipment, and Processes.
 - The clean rooms must be closely monitored and controlled to maintain the desired cleanliness, temperature and humidity.
 - Certain process and support equipment use a significant amount of electricity.
 - The peak electrical usage for the facility was 39 million KWH in 2005 at a cost of \$3.9 million.
 - The peak chemical usage was 855 tons in 1995.
 - The significant use of chemicals and energy provides significant opportunities for TUR and resource conservation.



Allegro TUR Program Implementation

- Implementation of TURA in 1989 required that Allegro develop a TUR Plan, report annually to the MassDEP, and make a good faith effort to reduce it's use of toxic chemicals.
 - The TUR team was formed, consisting of representatives from production, process engineering, finance, facilities, DI building, EHS, and a chemist, with the following responsibilities:
 - Develop/maintain project list.
 - Hold meetings every one to two months to review progress and to discuss new projects.
 - Send notice to employees every two years requesting their input.
 - Update plan every two years.



Allegro TUR Program Implementation

■ Employee Suggestion Program

- Have received many suggestions for TUR and resource conservation projects through the use of this program
- Utilized for any suggestions
- Available to all hourly employees
- Awards for suggestions
 - If suggestion not accepted, still receive coffee and donuts in cafeteria
 - If suggestion accepted minimum award is movie tickets
 - Awards can be as high as \$7500 per suggestion



Project Management, Tracking, and Control

Allegro MicroSystems
Worcester, Ma

Figure 15
Summary of Options Implementations

- The tool we have used to track and control projects has evolved over the years.
- The original form was from the TUR plan and very basic.

Options		Schedule	Done/Initials
Option 1	Third DI Bed or Reverse Osmosis	Evaluate 1-95 Implement 1-97	
Option 2	Evaluate the use of FST's	Evaluate 7-95 Implement 1-98	
Option 3	Optimize acid strengths	Evaluate 10-95 Implement 7-98	
Option 4	Longer bath life	Evaluate 4-95 Implement 7-96	
Option 5	Backcoat/Photo Clean to T.O.	Evaluate 1-95 Implement 7-96	
Option 6	Thin Film/Wet Diffusion to Acid Scrubber	Evaluate 7-95 Implement 10-95	

Evergreen document, other option can be added.

TURA Team/ 6-17-94
Revised _____



Project Management, Tracking, and Control

- Changed to use of Summary of Options Implementations table from TUR Plan for project list
- Microsoft Word based
- Status options
 - Open
 - Closed (not implemented)
 - Complete
 - Ongoing
 - On hold

Options Evaluation

Summary of Options Implementations: Semiconductor Moves

Option #	Description	TURA Technique	Evaluation Date	Implementation Date	Status
94-01	Hard-Piped Sulfuric Acid Stripping System to recycle Sulfuric Acid	Process Recycle	Sept-95	-----	closed
94-02	Spray Washing System instead of Bath Washing System	Process Modification	Jul-95	Mar-97	complete
94-04	Optimize the Number of Wash Dumps in Bath Washing Systems	N/A	----	----	on hold
94-07	Optimize Acid Etch Strengths	Process Modification	Oct-95	Feb-97	complete
94-08	Dry Etch Operations to Replace Wet Etch Operations	Process Modification	Sept-96	Aug-97	Implementing
94-09	Utilize High-Efficiency Tube Cleaners	Process Modernization	Aug-96	Mar-97	complete
94-10	Optimize Bath Life	Operations and Maintenance	Apr-95	Mar-98	complete
94-11	Reduce Bath Dragout	Process Modification	Dec-95	----	closed
94-14	Backcoat and Chemical Mix Exhaust to the Thermal Oxidizer	Process Modification	May-96	----	Backcoat connected 12/00
94-15	Thin Film Cleaning/Trans. Diffusion Acid Baths to Acid Scrubber	Process Modification	May-95	----	Trans Diffusion eliminated
94-16	Maskmaking to Acid Scrubber	Process Modification	Jan-95	----	closed
94-17	Vapor Analysis and Vapor Rate Testing	N/A	Jun-96	----	closed
94-18	Increased Bath Life of Sulfuric Acid using Recirculation	Process Modification	Apr-97	Aug-97	closed
94-24	Sale of Waste Acids	Process Recycle	----	Sep-97	closed



Project Management, Tracking, and Control

TUR Project List

TUR Summary of Options Considered

Production Unit 1: Semiconductor Manufacturing
 Production Unit 2: High Purity Water Manufacturing

Option #	Description	Production Unit	TURA Technique	Evaluation Date	Implementation Date	Status	Capital Cost or Expense	Annual Savings	Annual Toxics or Resource Reduction	Comments
94-01	Hard-Piped Sulfuric Acid Stripping System to recycle Sulfuric Acid	1	Process Recycle	Sep-95	----	Closed				
94-02	Spray Wash vs Bath Wash System	1	Process Modification	July-95	Mar-97	Complete	\$2.3 million	unknown	unknown	Part of 6" equipment cost
94-04	Optimize the Number of Wash Dumps in Bath Washing Systems	1	N/A	----	----	Closed	\$0	\$5,225	2397#	
94-07	Optimize Acid Etch Strengths	1	Process Modification	Oct-95	Feb-97	Complete				
94-08	Dry Etch Operations to Replace Wet Etch Operations	1	Process Modification	Sep-96	Aug-97	Complete				
94-09	Utilize High-Efficiency Tube Cleaners	1	Process Modernization	Aug-96	Mar-97	Complete	\$280,000	unknown	unknown	
94-10	Optimize Bath Life	1	Operations and Maintenance	Apr-95	Mar-98	Complete	\$10,000	\$548	1095#	
94-11	Reduce Bath Dragout	1	Process Modification	Dec-95	----	Closed				
94-14	Backcoat and Chemical Mix Exhaust to the Thermal Oxidizer	1	Process Modification	May-96	Dec-00					
94-15	Thin Film Cleaning/Trans. Diffusion Acid Baths to Acid Scrubber	1	Process Modification	May-95	----					
94-16	Maskmaking to Acid Scrubber	1	Process Modification	Jan-95	----	Closed				
94-17	Vapor Analysis and Vapor Rate Testing	1	N/A	Jun-96	----	Closed				
94-18	Increased Bath Life of Sulfuric Acid using Recirculation	1	Process Modification	Apr-97	Aug-97	Closed				
94-24	Sale of Waste Acids	1	Process Recycle	----	Sep-97	Closed				
95-05	Transition From 4" to 6" Water Processes	1	Input Substitution	Aug-96	Aug-06	Complete				
96-01	Eliminate the Use of Nitric Acid in Diffusion Etching Process	1	Input Substitution	Sep-95	Feb-97	Complete	\$130,000	\$209,264	78376#	
96-02	Reduce Acid Use in Mask Making	1	Process Modification	Mar-96	Mar-96	Complete				



Project Management, Tracking, and Control

- Expanded project list again, adding
 - Project owner
 - Estimated implementation date in addition to actual implementation date
- Set up the capability to be able to sort by information within each column



Project Management, Tracking, and Control

- Columns included in current project list
 - Project number (year/number within year)
 - Project description
 - Production unit
 - Project type (TUR versus resource conservation)
 - TURA technique
 - Owner
 - Evaluation date
 - Estimated implementation date
 - Actual implementation date
 - Status
 - Capital cost or expense
 - Annual dollar savings
 - Annual toxics or resource reduction
 - Comments



Project Management, Tracking, and Control

Option # (year/ sequence)	Description	Production Unit	Project Type	TURA Technique	Owner	Evaluation Date	Estimated Implementation Date	Actual Implementation Date	Status	Capital Cost or Expense	Annual Savings	Annual Toxics or Resource Reduction	Comments
08-10	Change Metal 2 Track Develop Process	1	TUR	Change Production Unit Design	Denham		TBD	Nov-08	Complete	\$0	\$44,400	17140#	This change went into effect 11/19/08, and reduced the usage of MF-320 developer.
09-03	Eliminate Use of Argon During Gate Oxidation and HCl During Poly Deposition	1	TUR	Process Modification	Amons	Jan-09	Nov-09		Open	\$0	\$ 60,000	Argon	Gate Oxidation change went into effect 6/18/09. Poly Deposition change should be complete by Nov.
09-04	Reduce Amount of 3513 Photo Resist Dispensed Without Causing Resist Spikes	1	TUR	Process Modification	Denham	Mar-09	Sept-09	Aug-09	Complete	\$0	\$ 96,000	Photo Resist	Trials have been run to reduce the amount of 3513 photo resist dispensed from 4.0 to 3.0 ml per wafer without causing resist spikes. Made adjustments on one photoresist pump per month and monitored results. Complete as of 8/18/09.
09-05	Eliminate TiW Bath and TiW Sputter Target	1	TUR	Process Modification	Denham	Mar-09	Jul-09	Aug-09	Complete	\$0	TBD	TiW, 180 gal H2O2	ECN issued 6/18/09 to replace TiW layer with oxide layer under the metal, and eliminate TiW bath which is only used for metal etch rate testing. Working on final details for implementation of bath elimination.
94-12	Reuse Sulfuric Acid in Waste Water Treatment System	2	TUR	Input Substitution	Feraco	Nov-96	Not Applicable	---	Closed	na	na	na	Not implemented
94-19	Install pH probe to Deionizer Regenerations	2	TUR	Process Modernization	Feraco	Sep-96	Not Applicable	Nov-96	Complete	\$ 1,000	\$ 135	816#	Insures proper pH of regenerant chemicals.
94-20	Reverse Osmosis	2	TUR	Process Modification	Feraco	Jan-95	Not Applicable	Jan-97	Complete	\$ 480,000	\$ 110,000	176700#	Install RO system that will reduce the frequency of the ion exchange regenerations



Project Management, Tracking, and Control

■ Recent change

- Our most recent change was to post a copy of the project list on the Allegro intranet so that the latest version can be viewed at any time by
 - project owners
 - other interested employees

■ To be implemented

- Will use the list to periodically revisit projects that are listed as closed

■ Energy is Fun Committee

- We have an Energy is Fun Committee that meets every 2 or 3 weeks, helping to maintain a focus on resource conservation projects.

■ Important consideration

- Most people are very busy in their jobs, and TUR and resource conservation are likely not high on their list of priorities.
 - This means that you need to follow up with them on the status of their projects.
 - Having meetings every other month helps to remind them what they need to do and when they said they would do it.

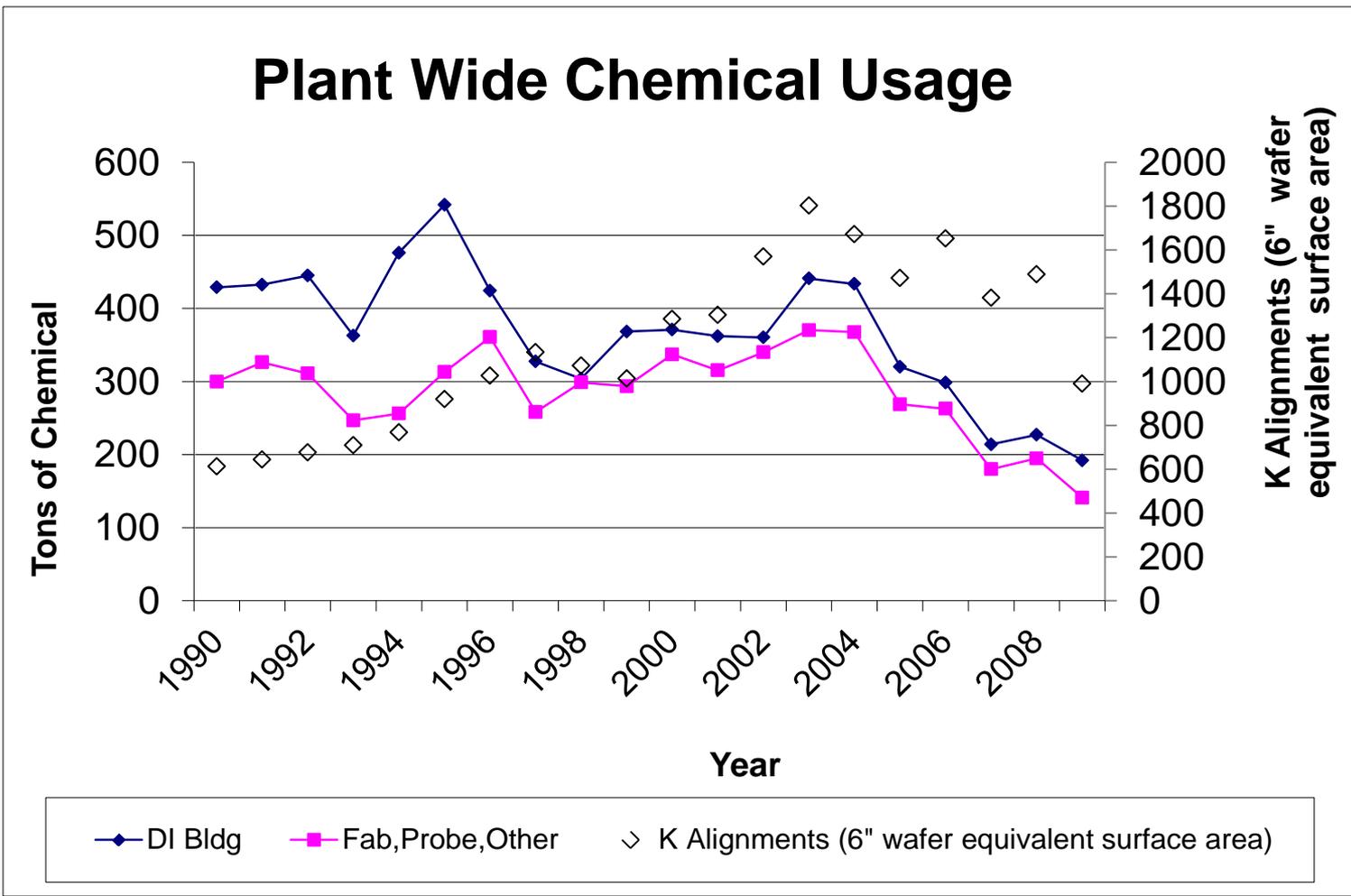


TUR Program Results

- Through the use of this system of project management, tracking, and control, Allegro has been able to achieve the following savings from TUR projects
 - Total annualized savings of \$1.1 million per year (not adjusted for inflation).
 - Wafer fab (production unit #1)
 - Reduced annual usage by 172 tons/55% between 1996 and 2009.
 - DI building (production unit #2)
 - Reduced annual usage by 350 tons/65% between 1995 and 2009.



TUR Program Results





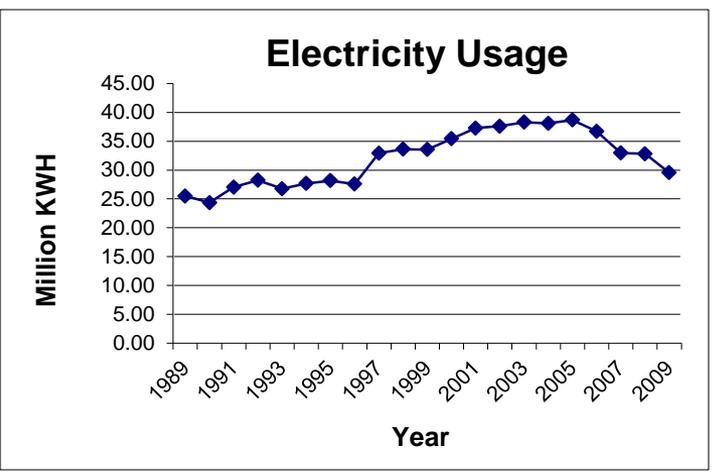
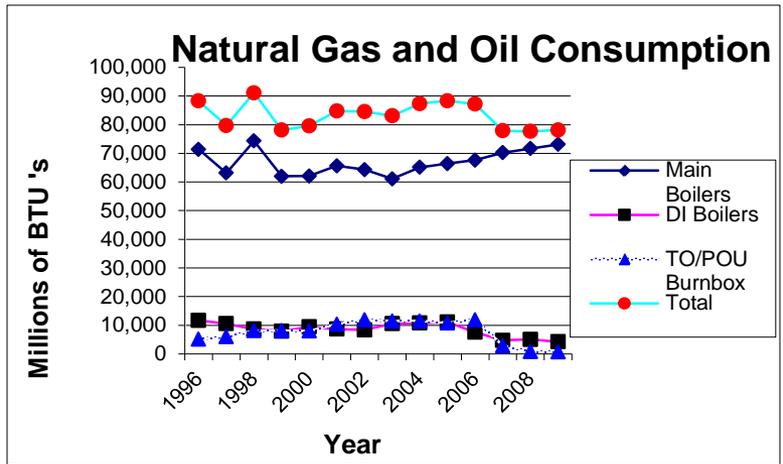
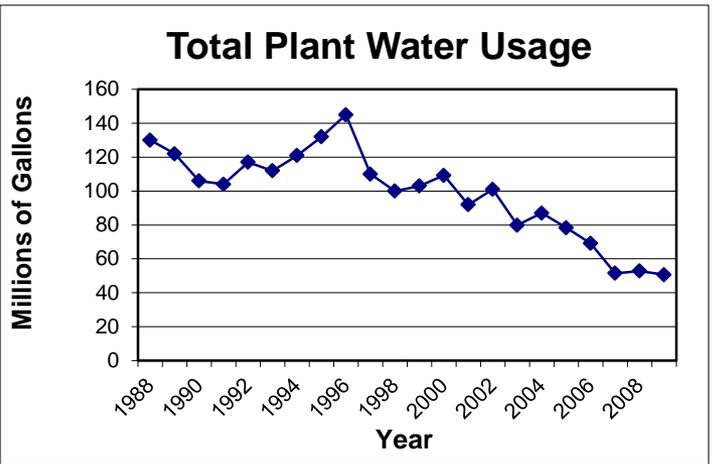
TUR Program Results

■ Resource Conservation Projects

- Resource conservation projects were being performed all along, but became more of a focus as resource costs began to rise significantly.
- Total annual savings of \$1.2 million per year (projects since 2003, excluding inflation)
 - Water
 - Reduced annual usage by 94 million gallons/64% between 1996 and 2009
 - Electricity
 - Reduced annual usage by 21% between the peak in 2005 and 2009
 - Natural gas
 - Reduced annual usage by 14% between the peak in 1998 and 2009



TUR Program Results





TUR Program Affect on ISO-14001 Program

- Allegro's Worcester facility received it's registration to ISO-14001 in 2/06.
- We have since passed the 2007, 2008, 2009, and 2010 recertification audits with no nonconformities.
- To meet one of the several requirements of our ISO-14001 certification, we have determined the significant aspects of our operations
 - They include the use of certain chemicals, city water, natural gas, oil, and electricity, as well as waste generation

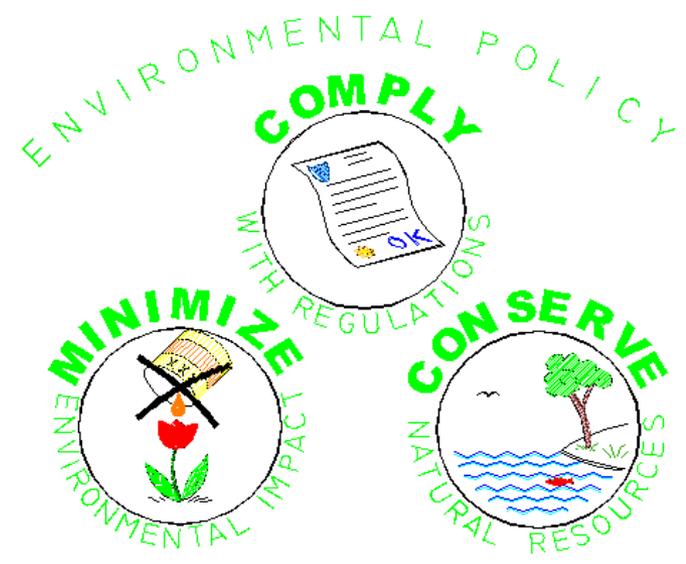


TUR Program Affect on ISO-14001 Program

- ISO-14001 goals have been set to reduce the impact of these aspects, and implementation of these goals ties nicely with the TUR program that was already in effect.
- Allegro's environmental policy
 - E=MC2
 - Environmental = minimize environmental impacts, comply with regulations, and conserve natural resources.
- If we did not have an active TUR and resource conservation program, it would have been more difficult to develop and achieve goals that are related to our significant aspects and environmental policy.



TUR Program Affect on ISO-14001 Program



ENVIRONMENTAL = MINIMIZE * COMPLY * CONSERVE

$$E = M C^2$$





Summary

- By the nature of the business, operation of a wafer fab is chemical and energy intensive.
- A TUR team was formed at Allegro to meet the requirements of TURA
- Management, tracking, and control of projects has evolved over the years and has become more effective.
- Resource conservation projects were added to the TUR project list in 2008 and became more of a focus in 2009 with the new Energy is Fun Committee.
- Effective implementation of TUR and resource conservation projects has allowed Allegro meet the requirements of TURA and to save money.
 - Total annual savings of \$1.1 million per year have been achieved from implementation of TUR projects.
 - Total annual savings of \$1.2 million per year have been achieved from implementation of resource conservation projects .
- Allegro received it's registration to ISO-14001 in 2/06.
 - If we did not have an active and effective TUR and resource conservation program, it would have been much more difficult to develop and achieve goals that are related to our significant aspects and environmental policy.



Questions?