

Maintaining a Green Fab through the Strategic Use of an Environmental Management System

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ABSTRACT

The use of an Environmental Management System (EMS) in a compound semiconductor manufacturing setting helps to drive environmental improvement. Skyworks Solutions' Newbury Park fab has successfully used its EMS to maintain a Green Fab through strategic environmental initiatives.

INTRODUCTION

A common environmental initiative adopted by manufacturing facilities is certification to the ISO 14001 Environmental Management Standard. The standard offers a strategic approach to addressing environmental concerns within a manufacturing organization. Semiconductor fabs that have an ISO 14001 certified Environmental Management System (EMS) are often found to have improved organizational integration of environmental considerations from senior management to the line operations technician [1].

The strategic use of an Environmental Management System in a semiconductor manufacturing setting helps ensure environmental compliance, resource conservation and improves the bottom line through improved efficiencies and associated cost savings. Direct cost savings are realized through efficiency improvements resulting in reduced resource costs (energy, water, chemical) and reduced waste output. Indirect savings can also be realized through reduced regulatory liability and an improved corporate image that can capitalize on the Green Fab as a market differentiating factor. An efficient Green Fab can often be thought of as improving the corporation's triple bottom line; improved operational costs, reduced environmental footprint and sustainable business practices.

DEFINING A GREEN FAB

A Green Fab requires the use of manufacturing systems, practices and technologies that improve the environmental outcomes of the production process. The improved

environmental outcomes can take the form of improved process efficiencies, reduced resource costs, reduced regulatory liabilities and improved corporate image. A Green Fab strives to set up processes that use the minimum required amount of resources, minimize environmental impact, are highly efficient and reduce waste generation. All of this can be achieved while maintaining optimal production outputs.

Simply put a Green Fab is a manufacturing facility that is run in a sustainable and resource efficient manner.

ENVIRONMENTAL MANAGEMENT SYSTEM

An ISO 14001 certified Environmental Management System is based upon a methodology known as Plan-Do-Check-Act (PDCA). The framework consists of the following elements:

Corporate Policy - An environmental policy that defines the organization and that often includes core elements for supporting regulatory compliance, pollution prevention, resource conservation and reduction of the environmental footprint from manufacturing.

Defined Aspects & Impacts – A system requirement for a fab operation to construct a comprehensive matrix of process activities (Aspects) that interact with the environment. These activities can in turn cause positive or detrimental changes (Impacts) on the environment that are managed through the EMS. This includes the consideration of environmental regulatory requirements that are applicable to fab operations and the final product.

Objectives & Targets – The fab organization must set up specific environmental improvement objectives with data supported target improvements. This process is key to driving continuous environmental improvement.

Implementation & Operation – Each part of the fab organizational structure must have operational controls to

ensure that environmental concerns are addressed. Standard Operating Procedures (SOPs) and work instructions in all areas should have specific, well communicated instructions on work tasks with environmental implications. Roles and responsibilities are defined through this process and training programs are developed so that all levels of the organization are addressing environmental concerns. All employees adhere to the EMS by following their job specific policies, work instructions and SOPs. Environmental business requirements are embedded in documentation at all levels of the organization.

System Checks – Metrics on all activities within the EMS are checked on a continuous basis and include; resource use, critical environmental systems data, evaluation of compliance and internal system audits.

Corrective & Preventive Actions – Any environmental issues that arise within the fab organization are managed through a corrective & preventive action system that addresses; root cause, ownership, estimated closure date and also serves to document the task in order to avoid reoccurrence.

Management Review – Sets a structure for fab operations senior management to review all aspects of the EMS on a regular basis and to ensure the allocation of appropriate resources. This component of the system provides management the means with which to support green manufacturing.

MAINTAINING A GREEN FAB

All environmental improvement initiatives at Skyworks Solutions are driven or monitored through the Environmental Management System. The elements of the ISO 14001 certified Environmental Management System have been used to drive Green Fab practices, track efficiencies and to maintain a competitive edge. Initiatives have included improvements in chemical efficiencies, natural resource conservation and hazardous waste reduction.

Skyworks Solutions' corporate environmental policy statement outlines the plan to maintain a Green Fab with top down support for regulatory compliance, pollution prevention, resource conservation and reduction of the environmental footprint from manufacturing.

The core components of the Environmental Management System assist in driving strategic improvements supported by the overall policy. Key Aspects for a Green Fab include chemical use, energy use, waste generation, air emissions and wastewater discharge. All

Impacts from these Aspects are monitored and controlled through the EMS.

The control systems which manage potential releases to the environment are standard fab facilities infrastructure including wet scrubbing and thermal oxidation of air emissions, pH control and treatment of wastewater

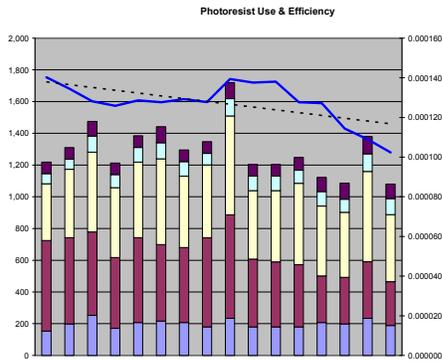


The control systems which manage potential releases to the environment are standard fab facilities infrastructure including wet scrubbing and thermal oxidation of air emissions, pH control and treatment of wastewater discharges and the safe collection and disposal of hazardous wastes. All of these control systems are monitored via documented procedures within the EMS with data recorded through prescribed documentation for internal metrics and external regulatory reporting. Any deviation from the specific parameters of these control systems triggers immediate corrective action through the EMS and requires a long term action plan to prevent reoccurrence.

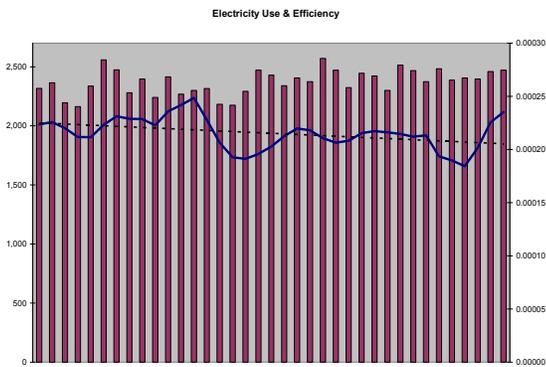
Beyond basic control of environmental Impacts, site metrics within the EMS help to track trends and set objectives and targets for environmental improvement. Metrics for resource consumption can often point out inefficiencies and opportunities for improvement. Examples of metrics used to drive resource efficiency improvements can be best shown by reviewing chemical efficiencies.

The photoresist trend shown below was used at Skyworks Solutions to monitor both gross and normalized

photoresist use per month. This data was used to drive and confirm improved photoresist efficiency objectives and targets. A 50% decrease in total photoresist applied per wafer was able to be targeted and achieved [2] with associated efficiency improvements in the normalized use of photoresist.



Beyond efficiency improvements the EMS can be used as a tool to drive environmental improvements with no direct cost savings. It was noted through the Environmental Improvement Team (EIT) at Skyworks Solutions that the continued use of a chromic acid dip process had a detrimental environmental potential that outweighed its benefit from a process perspective. The EMS was used to maintain focus on transferring this process to one with significantly reduced environmental impacts. This was a lengthy project with a variety of potential barriers to change. The EMS was able to maintain visibility on the importance of implementing this environmentally beneficial change until the objective was successfully achieved.



Metrics can also be used to track the use of energy to ensure that significant inefficiencies do not arise from changes in fab processes or facilities infrastructure. The data tracks energy efficiency changes due to increased fab energy requirements or conservation improvements. Improvements can include management of fab air flow requirements to optimize the electricity required to maintain

a cleanroom. The metrics for additional high use resources in a semiconductor fab such as water were also effectively monitored using this methodology.

Hazardous waste output is another significant Impact that has been tracked and controlled through the EMS. This has multiple avenues for impacting the environmental footprint of a fab including waste management liability, increased cost and regulatory reporting. The EMS sets a structure for monitoring the types of hazardous waste generated and a way to set objectives that strive to produce the least amount of waste per unit production. The monitoring of solvent waste is of particular importance as it tends to be the largest hazardous waste stream generated by a fab and can be controlled by ensuring that the associated process operations are operating efficiently. Any significant losses in the process efficiency of chemical use will significantly increase chemical costs, increase hazardous waste output and heighten the external visibility of environmental impacts due to the comprehensive reporting requirements for hazardous waste generation.

Change control is an important part of the Environmental Management System used to maintain a Green Fab. The introduction of new chemistries, processes and manufacturing equipment must be tracked through the EMS to ensure that all environmental Aspects and their associated Impacts are addressed within the system. New chemical introduction must be reviewed and approved through the EMS to make certain that no chemistries with high levels of environmental concerns, including toxicity, are introduced into the manufacturing process; a standard tool is a chemical usage request form. An associated system is a manufacturing approval and installation procedure. This component of an EMS allows for all environmental considerations to be taken into account when bringing in a new process and supporting tool set. It allows the operations team to adequately define and address the environmental permitting needs and facilities treatment system costs. In the absence of this type of system, a fab will often over run on capital costs while bringing a new process online.

Management review of the EMS helps to maintain visibility at all levels of the organization and to assist in the allocation of resources to address environmental concerns. The management review can take many forms including; an Environmental Improvement Team (EIT) with management representatives from each operations' department, senior management fab operations reviews, daily fab operations review meetings and one on one communications with fab management.

CONCLUSIONS

The strategic use of an Environmental Management System is a beneficial tool to drive environmental improvement within wafer fab operations. It provides a framework in which all employees within the organization can assist in environmental improvement. Using an EMS to maintain a Green Fab helps drive the efficient use of all resources. Conversely, the natural drive of a business to control cost assists in ensuring efficiencies and highlights the value of an Environmental Management System.

ACKNOWLEDGEMENTS

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ACRONYMS

EIT: Environmental Improvement Team
EMS: Environmental Management System
ISO: International Organization for Standardization
PDCA: Plan-Do-Check-Act
SOP: Standard Operating Procedure