

WHITEPAPER STUDY

SEMICONDUCTOR INDUSTRY LEADER ADDRESSES THE COST & ENVIRONMENTAL CONCERNS OF DISPOSABLE WASTE

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This paper describes a study undertaken by a major semiconductor manufacturer in the U.S. which examined processes for significant reduction of disposable waste, highlighting the selection of an alternative solution and the benefits incurred.

KEY WORDS: CONTAMINATION CONTROL, POLYMERIC FLOORING, ENVIRONMENTAL CONCERNS, PARTICLE COUNTS, COST CONCERNS, CLEANROOM

INTRODUCTION

A major semiconductor manufacturer in the Southwest U.S. was interested in continuing to reduce their particulate counts within their critical spaces while addressing the environmental and cost concerns of their current contamination control practices.

BACKGROUND

The manufacturer prides itself on being a good corporate citizen and has a long-standing commitment to responsible, sustainable manufacturing:

"We remain committed to our long-term environmental sustainability programs of conserving natural resources, reducing greenhouse gas (GHG) emissions, and mitigating climate change.

As a semiconductor company that manufactures billions of chips per year, we believe that it is important to drive efficiencies in our fabrication process. Multi-year sustainability goals guide our work and we strive to efficiently manufacture chips to reduce energy use, GHG emissions, water use, and the generation of landfill waste."

Because of this commitment to the environment, an analysis of a wide variety of disposable/consumable products used throughout the organization was conducted. The investigation concluded that single-use peel-off contamination control mats were an obvious issue and the company set out to seek alternative methods.

CURRENT CONTAMINATION CONTROL

Adhesive or "tacky" mats consist of layers (normally 30-60 per mat) of plastic polyethylene sheets or film, each coated with an acrylic adhesive. When walked across, the mat is “tacky” or "sticky", causing dirt and debris from the soles of shoes to “stick” as they come in contact with the surface. These mats are intended to be disposable. Depending on each facility’s protocol, once the top layer has become saturated or after a defined amount of time (i.e. per shift), it is peeled from the stack attached to the floor and discarded.

Within the manufacturer’s busy fabs (Class 10 to Class 1000 cleanrooms), peel-off mats were being used as the predominant method for controlling contamination at floor level. The facility reported disposing of thousands of peeled adhesive mats monthly – each mat producing an approximate 8” ball (Figure 1) of dirty adhesive and film that cannot be recycled and will fill dumpsters and landfill areas. The cost to dispose of the adhesive peel-off mats, including all related packaging, was reported to be $0.39 per peel.

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Figure I: Contaminated plastic waste ball from peeled adhesive mats

PEDESTRIAN TRAFFIC

At least 100 individuals pass through the entrances to the fab on a daily basis. However, the utilization of peel-off mats proved ineffective in maintaining complete control, leading to adhesive transfer and contamination within the critical environment [3]. Human error played a significant role in contamination incidents, as operators could bypass the peel-off mats and access the controlled space without adequately decontaminating their shoes. Additionally, the peel-off mats were susceptible to lifting from the subfloor, posing a potential health and safety tripping hazard.

WHEELED TRAFFIC

The peel-off mats installed in the material airlocks lacked sufficient size to accommodate a complete wheel rotation. As a result, wheeled traffic entering the fab would carry dust and dirt from the external environment into the critical controlled space. This contamination was then picked up by people walking and spread further, causing great risk to production. Peel-off mats frequently wrapped around the wheels of the carts and pallet jacks or would be torn up by the weight of the traffic, causing downtime and additional expense/waste.

AN OPPORTUNITY FOR IMPROVEMENT

Dycem polymeric flooring consists of an optically smooth surface manufactured from a non-toxic, plasticized material. The material has a high natural tack and surface energy that can retain particulate contamination (viable and non-viable) that comes into contact with its surface. Additionally, electrostatic forces bind particles to the surface until such a time when they can be removed through cleaning (typically as part of the regular wet cleaning schedule). The mat remains effective even when dirty and is intended to be a long-term solution [2].

Dycem was invited to present their polymeric flooring solutions (CleanZone and WorkZone) to the manufacturer's environmental committee as an alternative for stopping shoe and wheel-borne contamination from reaching the cleanrooms.

Dycem's Contamination Control Specialists worked with the multi-stakeholder committee to identify areas within the facility where Dycem polymeric flooring could be used in the replacement of peel-off mats.

Dycem's proposal covered the main traffic areas of 13 gowning rooms and material airlocks with large areas of CleanZone and WorkZone polymeric flooring. These areas provided 10 times the square foot coverage offered by the peel-off mats previously in place.

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THE RESULT

Following the installation of Dycem polymeric flooring, it was observed that the polymeric flooring had several short-term benefits over the peel-off mats. Over time these benefits continued to be realized as summarized below.

COST

The manufacturer was spending an estimated $102,000 per year on peel-off tacky mat usage and disposal (Figure 2A). This cost included the reported figure of $0.39 disposal cost per mat.

The implementation of Dycem polymeric flooring saw the elimination of virtually all peel-off mats within the facility. This resulted in a return on in investment in year 2. Over the 5 year lifespan of the Dycem polymeric flooring this amounted to more that $330,000 of savings (Figure 2B).

	Peel-off 2'x3' mat	
Material cost per peel		$0.80
Peels per shift	5	$4.00
Shifts per day	2	$8.00
Days per week	5	$40.00
Annual material cost per mat		$2,080.00
# mats installed	33	
Total annual material cost		**$68,640.00**
Disposal cost per peel		$0.39
# peels disposed per mat	50	
Annual disposal cost per mat		$1,014.00
# mats installed	33	
Total annual disposal cost		**$33,462.00**
Total annual spend year 1		**$102,102.00**

Figure 2A: Annual 2'x3' peel-off mat cost

The calculation above shows in one building alone, the company was spending $69,000 per year in purchase costs and $33,000 in disposal costs for the peel-off mats

	Peel-off 2'x3' mat		Dycem 6.5'x10' mat	
Material cost per		$0.80		n/a
Peels per shift	5	$4.00	0	n/a
Shifts per day	2	$8.00	2	n/a
Days per week	5	$40.00	5	n/a
Annual material cost per mat		$2,080.00		$5,525.00
# mats installed	33		33	
Total annual		**$68,640.00**		**$182,325.00**
Disposal cost per		$0.39		n/a
# peels disposed	50			n/a
Annual disposal cost per mat		$1,014.00		n/a
# mats installed	33		33	
Total annual disposal cost		**$33,462.00**		**$0.00**
Total annual spend year 1		**$102,102.00**		**$182,325.00**
Replacement & disposal cost year 2		**$102,102.00**		**$0.00**
Replacement & disposal cost year 3		**$102,102.00**		**$0.00**
Replacement & disposal cost year 4		**$102,102.00**		**$0.00**
Replacement & disposal cost year 5		**$102,102.00**		**$0.00**
Total 5 year material & disposal cost		**$510,510.00**		**$182,325.00**

Figure 2B: Peel-off mat & Dycem 5 year cost comparison

The calculation above shows a total savings of $325,000+ over 5 years from implementing Dycem polymeric flooring

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EFFICACY

Expanding the contamination control zones from 2′ x 3′ (peel-off mats) to 10′ x 6′ (Dycem Polymeric Flooring) led to an immediate and significant decrease in foot and wheel-borne contamination at all cleanroom entrances—a tenfold increase in surface area. These particle counts remained low after 5 years of the Dycem polymeric flooring being installed. These reductions in particulate reflect the findings of several published independent studies that have proven Dycem as more effective in removing foot and wheel-borne contamination [3].

CLEANING

The maintenance team routinely cleaned the gowning room floors at the beginning of each shift. Given the expansive coverage of CleanZone and WorkZone, capable of withstanding the substantial foot traffic during a shift change without becoming saturated in particulate contamination, it was concluded that a single cleaning per shift sufficed. Cleaning the Dycem polymeric flooring involved using the facility's approved detergent, a sponge mop, and a floor squeegee.

ENVIRONMENTAL IMPACT

The manufacturer was peeling and disposing of approximately 85,800 sheets of non-recyclable plastic a year. This waste has the potential to fill approximately 75 industrial dumpsters per year with plastic waste that, if not incinerated will go directly to landfill (Figure 3). One study compared the carbon impact of using Dycem vs peel-off mats at a US manufacturer and found that over a 5 year period there would be an approximate 300,000 KG reduction in CO2 emissions [1].

Peel off mats per dumpster: Calculated	
Volume of Peel-Off Mat Waste Ball ft^3	0.155
Volume of Industrial Dumpster ft^3	252
Sphere Density Packing %	0.71
# of used peel-off mats disposed of in one dumpster load	**1154.32**
Waste created: An example	
Total # of peels per shift	5
Shifts per day	2
Days per week	5
Total # of peels per mat	2600
Total # of peel off mats	33
Total # of balls of waste	85800
Total # of dumpster loads created	74.33
Total number of dumpster loads created over 5 years	**371.65**

Figure 3: Environmental impact calculation

Assumptions:
Volume of a sphere is $V=4/3\ \pi r^3$
Volume of a cube is V=LxWxH
One layer of peel-off mat creates an 8" ball/sphere
A standard industrial dumpster measure 6'L x 6'W x 7'H
Sphere Density packing theory by Kepler states maximum volume density of up to .74048 [4}

The calculation example above illustrates that the manufacturer saved 371 industrial dumpster loads of plastic waste from going to the landfill over 5 years by switching to Dycem.

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SUMMARY

The transition to a process improvement in contamination control yielded significant benefits, aligning with the manufacturer's criteria for cost and waste reduction. In essence, the effectiveness, cost efficiency, ease of maintenance, and positive environmental impact of Dycem flooring have been convincingly demonstrated.

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