VALUTEK

INNOVATIVE SOLUTIONS FOR CRITICAL ENVIRONMENTS

CRITICAL ENVIRONMENT CONSUMABLES GUIDE

v 1.0

Valutek – keeping it clean since 1988

Valutek has been servicing the cleanroom and controlled environment needs for thousands of customers in the pharmaceutical, electronic, and biomedical industries since 1988. Our one-source shopping model eliminates the need to coordinate multiple manufacturers, invoices, and contacts – one call does it all. We offer our customers best-in-class products and superior customer service. We don't just meet your demands – we consistently beat them, and have fostered a culture of continuous improvement. Valutek has built our reputation on quality, performance, dedication, and knowledge, providing our customers with a trusted business partner you can count on for years to come.

Table of Contents

INTRODUCTION

This guide uses the Federal Standard 209e cleanroom classifications of Class 1 through Class 100,000 because it is still the most prevalent standard in use. Be aware that some firms are starting to use metric or ISO Classes. To further confuse the topic, some firms continue with the original Class 1 – 100,000 standards for their old sites, and have adopted the more global standards at their newer sites. See "Cleanroom Classification" in the glossary for a cross-reference between ISO, Metric and Federal Standard classifications.

CLEANROOM GLOVES & FINGER COTS

Selecting the most appropriate glove and wiper is the single most important cleanroom consumable selection. The operators' hands are in effect their "tools" to perform critical tasks in a controlled environment. Most gloves are used for hand protection in common industrial / medical applications. The industrial glove is designed to protect the operators' hands from heat, abrasion and chemicals. The medical glove is designed to prevent gross cross-contamination (blood borne pathogens, virus, and bacteria) between the patient and caregiver. Cleanroom gloves are designed to prevent gross cross-contamination (like medical), and also sub-micron contamination at the particle and extractable level.

Finger cots are worn in less critical production environments where there is a need to protect components from oils and salts on the fingers. Some finger cots can also provide ESD protection. Please note that with the advancement of cleanroom gloves, finger cots are becoming a functional obsolete product. Finger cots are most commonly used in military specification tasks that were written when the finger cot was the best option available. Finger cots only provide fingertip protection from product contamination. Operator prefer them over gloves for comfort. Technical teams prefer operators in gloves, to prevent the palm contaminant source hazard that finger cots represent.

CLEANROOM GLOVES

There are many types and styles of gloves on the market today. The most common substrate materials are: Nitrile (Acrylo-nitrile-butadiene), Latex (natural rubber), and PVC (Polyvinyl chloride). Latex is a natural, organic material. Nitrile & PVC are synthetic. Neoprene, and Chloroprene are

blends best suited for chemical handling, versus clean part handling.

The primary purpose of wearing gloves in a controlled environment is to minimize submicron particle contamination of the product or process from the operator's hands. When used in conjunction with coveralls or a frock, operator-generated contamination is significantly reduced. Chemical handling cleanroom gloves are worn over the standard thin wall cleanroom glove to protect the hands from harsh chemicals used in various manufacturing processes.

Critical environment gloves are engineered, manufactured, and packaged for the sole purpose for usage in a controlled environment. The manufacturer will post a product specification for particles and extractables, lot test data will be available to provide documentation that material is in specification conformance. Product will be vacuum packaged bag, in a bag, in a carton liner. The gloves are all neatly stacked with the cuff to one end, to allow the operator to don the glove by only touching the cuff. Less than 2% of all powder-free gloves are engineered for use in a cleanroom. The rigorous post-processing of a controlled environment glove often exceeds the cost of the blank, powder-free glove.

Powder-free Boxed GLOVES

Because the overwhelming majority (over 98%) of thin-wall, powder-free gloves are used in medical / lab / industrial applications, operators of controlled environments often unknowingly end up with an inappropriate glove. Powder-free lab / industrial / medical grade boxed gloves are not suitable for a controlled environment for these reasons:

1. Uncoated chipboard dispenser boxes shed particles, and contaminant the powder-free gloves. They are powder-free, not particulate free.
2. Dispenser box packaging forces operator to contaminate glove when donning.
3. Additives and fillers are used which reduce ESD compatibility (surface resistivity), and negatively impact glove cleanliness.
4. No post processing to reduce NVR contaminants on glove surface.

The best assurance to avoid getting a non-conforming glove is to insist that the actual glove manufacturer provide written documentation verifying the gloves suitability of usage.

Thin wall / unsupported vs. Thick wall / supported glove

The thickness of all dipped gloves is expressed in terms of the gloves Mil thickness at the palm. All dipped gloves thickness is measured at the fingertip, palm, and cuff. On average, the fingertip thickness is 25-35% thicker than the cuff thickness. Much like the wax candle dipping process, the fingertip is like the base of the candle. It dwells longer in the substrate tank, making it thicker. Not all glove manufacturer's uniformly site the palm thickness as their specification. Ensure that you compare glove thickness on a palm vs palm basis.

Thick wall / supported gloves are typically thicker than 10-15 mils at the palm. The glove is called supported, because it has a natural shape of its own. It does not conform to the operators hand, it has a supported shape on its own. Thin wall / unsupported glove are less than 9 mils at the palm. They are called unsupported, because the glove has not shape of its own. An unsupported glove takes the shape of the operator's hand.

The trend in controlled environment nitrile gloves is to make them as thin as possible. Some ultra-thin gloves now are as little as 2-5 – 3 mil @ the palm. The ultra-thin glove offers unsurpassed operator comfort, and lower cost.

Glove Substrate Materials / History

In the industry's infancy (1960-1980), Cleanroom gloves were PVC because it is a non-powdered manufacturing processes. At the time, thin wall Nitrile technology did not exist, and all latex gloves were powdered. PVC gloves developed by firms in the Ohio area of the USA, where latex / polymer dipping technologies were all developed. In spite of the relative cleanliness, and low cost, operators found the lack of dexterity / comfort in PVC no longer acceptable.

As the market grew, operator demand for a more form fitting glove led to the adoption of Latex / Natural Rubber in the 1990's. Latex had some major fit advantages, but the latex dipping process contaminates the glove. Initially, latex cleanroom gloves were dipped in the USA. As the global market demand for thin wall gloves grew, manufacturing all moved to SE Asia, near the equator, and the rubber tree plantations. Eliminating the transit cost of the raw latex offered the glove dippers the opportunity to make a glove at lower cost.

The formers are dipped in a calcium carbonate slurry, prior to the latex dipping. The powder coating on the former helps prevent pinholes, and minimize the glove thickness variation. The most effective method to remove the powder is a chlorination process on both sides of the glove. Although the chlorine process effectively removes the dipping powder, it leaves behind trace levels of chlorine residue embeds in the latex substrate. This residual chlorine gas reduces the latex shelf life, and out-gasses contaminants. Natural rubber also has significant lot-to-lot variation, and creates allergenic reactions for some wearers.

As the market matured, controlled environment facilities became more focused on contamination for the new millennium. By 2010, the market shift Nitrile was in full swing. On account of ongoing global latex shortages, the cost of a latex glove exceeds the cost of Nitrile.

Glove Substrate Material Summary

	Vinyl	Latex	Nitrile
Static Dissipative	+++	-	+++
Protein Allergies	None	---	None
Chemical Resistance	++	++	+++
Strength/Durability	++	++	+++
Modulus	-	++	++
Tactile Sensitivity	-	++	++

PVC Polyvinyl Chloride

Polyvinyl chloride is a petro-chemical derivative. It offers consistent lot-to-lot performance characteristics. PVC gloves are clean, inexpensive and static dissipative. However, vinyl gloves retain heat, have poor moisture vapor transmission, and are uncomfortable due to the rigid nature of vinyl. Although the glove is clean, unlike Nitrile / Latex, it does not go through an intensive heat, or vulcanization process to case harden the surface. Therefore, PVC gloves are suitable for dry applications, and NOT suitable for chemical handling. The PVC substrate is porous and will absorb contact chemicals.

PVC gloves are ESD safe, relatively clean (in dry / non-chemical applications), and did not require post-process washing. The former (ceramic hand) is dipped in the PVC resin without first needing to be dipped in a coagulant material (calcium carbonate slurry). PVC is a petro-chemical based resin. It is inorganic. It is consistent lot to lot. It has an indefinite shelf life. Because it is clean dipped, and not required post-processing, PVC offers the best value.

Natural Rubber Latex

Natural rubber latex is tree sap. Because it is a natural material, it suffers from lot-to-lot variation do to the age of the tree, fertilizer used, recent rainfall, and compounding technique. It was for many years the workhorse glove substrate. During the 1980 – 2000 time frame, it had the best cost/performance ratio of any material available. Latex is durable and is easy to manufacture. However, latex has no inherent static dissipative (ESD) characteristics. A percentage of the population has an allergy to the proteins found in natural latex. The typical operator allergic reaction is a rash indicated by large, red splotches on the skin. For these people, nitrile or vinyl gloves are a good alternative. Latex offers chemical resistance to acids, but none to solvents. In an era when most cleanrooms use highly concentrated IPA solutions for cleaning, that is problematic. Latex is much higher in particle counts, and NVR than both Nitrile and PVC. On account of recent global latex material shortages, it is also the most expensive glove material. As a result of Latex high cost and relative poor performance, the majority of cleanroom glove users have shifted away.

Nitrile

Nitrile, like PVC is a petro-chemical derivative. Acrylo-nitrile-butadiene is the proper name for a synthetic rubber compound referred to as "Nitrile." This material is a man-made substance that exhibits many of the characteristics of natural rubber as well as many advantages. Because it is synthetic, it is a more consistent product than natural latex. It offers similar comfort and dexterity to latex but it contains no proteins that can cause allergic reactions commonly found in natural latex gloves. Nitrile is also stronger, offers very good puncture resistance, and exhibits a broader range of chemical resistance than that of natural latex, particularly with solvents. Nitrile has very good static dissipative characteristics that are not found in natural latex rubber. In recent years (2010 – 2014), nitrile formulations have improved permitting the glove to be thinner; this improves operate comfort and reduces cost per glove.

Chloroprene

Chloroprene, like PVC and Nitrile, is a petro-chemical derivative synthetic rubber. It is used primary in thick walled glove applications for chemical resistance. These chemical handling gloves are typically worn over the thin wall glove. They are based at the chemical handling area, and just worn for the intensive chemical handling processes. Over time, most facilities have successfully automated much of their hazardous chemical handling, which reduces the operator chemical exposure. As a result the chemical handling Chloroprene substrate presence in our industry is very small.

Glove Manufacturing Process

There are several processing steps to manufacturing cleanroom compatible gloves. The major steps are

1. Raw material preparation
2. Glove blank dipping and online chlorination (inside glove)
3. Offline chlorination (outside glove)
4. Ultrapure water washing, and drying (remove NVR from glove surface)
5. Finished product testing, lot # approval, retention samples archived
6. Double bag vacuum packaging, in carton with polybag liner

Video summary available online: "How It's Made: Cleanroom Gloves"

Raw material preparation:

Collection

Latex: Rubber trees are "tapped" in order to collect natural rubber latex. Tapping means to remove a small amount of bark from the tree on a 45-degree angle. This allows the natural rubber material to drip out of the tree. These trees are commercially planted and harvested in order to maximize the quantity and quality of the product.

Nitrile / PVC: Petro-chemical ingredients are procured

Concentration

The natural rubber is purified and processed. Natural rubber latex is then aged, analyzed, and tested to ensure quality.

Nitrile / PVC: Petro-chemical ingredients are blended

Compounding

Compounding optimizes the performance characteristics of the glove as well as enhances the ability to process the material.

Nitrile / PVC: Not Applicable

Glove blank dipping / online chlorination:

Dipping

Formers are ceramic hand-like molds (formers) that are used to produce gloves. These formers are first washed to remove any particles on the former that could potentially become embedded inclusions in the finished glove. Next the former is dipped into a coagulant material (calcium carbonate) that causes the latex / nitrile to deposit a consistent / uniform, thickness and more stable film on the former. The thickness of a glove is determined by many factors, the foremost of which are how much time the former dwells in the dip tank, and the concentration of the latex in the tank. After dipping, gloves are processed through a drying oven that gels the substrate and "sets" the glove.

Rinsing

The next step is rinsing or leaching. The process dissolves and extracts water-soluble impurities from the gloves including natural rubber proteins and ionic residues. The cleanliness of the water in the rinsing tanks will impact to what degree the ionic contaminants are removed.

Vulcanizing

The gloves then enter an oven that dries them at low temperature and then vulcanizes or cures them at a higher temperature.

Online Chlorination

Chlorination reduces the tack level by washing the gloves in a solution of chlorine gas while the gloves are still on the formers. Chlorination also further reduces natural rubber protein levels as well as particulate and ionic residuals.

Offline Chlorination (double chlorination)

After the gloves are stripped from the former, they are inverted to reverse the inside to become the outside of the finished glove. Since the outside of the glove was not chlorinated online, because it was in direct contact with the former, it needs to be chlorinated offline remove gross contaminants. Gloves that are single chlorinated are not suitable for stringent applications, because the outside of the glove has not been cleaned of the gross contaminates of the manufacturing process. All powder-free boxed gloves are typically single chlorinated.

Post-processing / Ultrapure water washing and drying

After chlorination, the gloves are processed through multiple deionized water rinse cycles to further reduce residual contaminants on the gloves. In this process, excess particulate, extractable ions and nonvolatile residues are removed. The gloves are then dried in HEPA filtered dryers prior to packaging. This part of the process is undertaken in a cleanroom environment.

Packaging

The gloves are then cleanroom packaged in a controlled environment to ensure cleanliness. All gloves are precisely flat packaged with the cuffs all to one end in two stacks of 50 each. These 100 gloves are then

GLOVE ATTRIBUTES

Sterile Gloves

Sterile cleanroom gloves are used in many pharmaceutical and medical device applications. These gloves may require the same cleanliness level as standard cleanroom gloves as well as the sterility of surgical type gloves. Sterile cleanroom gloves are also packaged uniquely. Sterile cleanroom gloves are pair packed and then gamma irradiated to ensure sterility. Pair packed means that one right-handed glove and one left-handed glove are packaged together in a clean, sterile wallet. There are typically 200 pairs per case.

Electrostatic Charge

Movement of the body generates electrostatic charges when operators move about the cleanroom. In many instances, this electrical charge can damage or disrupt the manufacturing process. Electrostatic charges built up in the body are passed through the operator’s hand and glove when the product is touched. Latex gloves hold static charges while nitrile and vinyl gloves will dissipate static charge by transferring it to ground.

Powder

Since all rubber is naturally tacky, a powder is used as a mold release agent to allow the gloves to be removed from the formers during manufacturing. Powdered gloves are easier to done and remove. Industrial gloves are powdered, while cleanroom gloves are washed to prevent the powder from contaminating the cleanroom.

Modulus

“Modulus” is the measure of how stiff or how supple a glove is. High modulus gloves are stiff, tight, and they fight your hand while you are wearing them. Vinyl gloves tend to be high modulus. Low modulus gloves are more comfortable because as you wear them they warm and rubber conforms to your hand. Latex and nitrile gloves are low modulus gloves.

Color

The color of natural latex and nitrile is translucent milky white. Latex gloves turn light brown as a result of the chlorination process. Powder-free Nitrile gloves have a bright white color. The post processing flattens the color, also making the glove surface smoother. Additives can be introduced to latex and nitrile gloves to produce a variety of colors.

Texture

Texture is an important glove feature. The texturing allows water to channel away in wet environments, thereby improving grip. Textured gloves can have a micro finish or an aggressive finish. However, textured gloves can cause particulate problems because the tiny ridges can rub off while being worn. The raw material and surface oxidation largely determine grippiness (tack level). You will usually find that gloves are either smooth or textured on the fingertips, palm or the whole glove. Smooth finish, low tack gloves offer the lowest particle counts and NVR. A textured glove will hold particles. Getting the balance between a glove that is clean, and not too slippery is a challenge that requires ongoing operator training.

Glove Configuration

Gloves are constructed as ambidextrous or hand specific. Ambidextrous gloves will fit on either hand while hand specific gloves can only be worn on the appropriate side. Hand specific gloves tend to be more comfortable because they are made with an opposing thumb that minimizes hand fatigue. Most gloves on the market today are ambidextrous because they are less expensive to manufacture. Sterile gloves still tend to be hand specific due to the nature of their use.

Sizing

Gloves sizes are not consistent from a manufacturer-to-manufacturer due to the size intolerance in ASTM specifications. This tolerance can be as much as 10mm. Ambidextrous gloves are typically sized XS, S, M, L, and XL. Hand specific gloves are typically sized from 5.5 to 10.0. The number on a hand specific glove refers to the glove diameter at the palm.

Length

Cleanroom gloves come in two basic lengths; 10” / 240mm and 12” / 300mm. This measurement is from the tip of the middle finger to the cuff. The 10” / 240 mm glove is for routine use in Class 1000 to Class 10,000 environments. The 12” / 300mm length is typically used in conjunction with coveralls in Class 100 and cleaner environments. Garment sleeves bellow as you move and this action causes air to move past the cuff leading to contamination problems. The 12” glove is long enough to allow the sleeve to be tucked into the glove, thus eliminating this problem.

Cuffs

Most gloves have a beaded cuff that makes the glove stronger, allows the glove to be pulled up easier, and helps the glove stay up.

Packaging

Ambidextrous cleanroom gloves are typically double poly bagged 100 per pack, 10 packs per case in an inner liner to ensure cleanliness. Hand specific gloves are packaged with 50 lefts on one side of the bag and 50 rights on the other side.

Industrial / Medical / Lab gloves are typically packed in a dispenser box (cardboard) with 10 of the boxes per case.

Tactile Sensitivity

The ability to precisely feel items with your hands and fingertips while wearing gloves is referred to as “tactile sensitivity.” A thin walled the glove tends to provide more tactile sensitivity than a thicker glove. This is an important issue in product environments.

Barrier Integrity

The quality to a glove is inherently revealed by its barrier integrity. Barrier integrity specifically refers to the number of pinholes in a lot of gloves. A relative unit of measure referred to as Acceptable Quality Limit (AQL) communicates barrier integrity. This unit of measure is not absolute. A lower AQL represents a higher quality glove. A higher AQL means that there are more holes in that particular lot of gloves.

CLEANROOM FINGER COTS

The usage of finger cots in critical environments declines each year. As a result, manufacturers with dipping technology are not investing in new product development. Facilities that still rely on finger cots should qualify an alternate Nitrile glove, to ensure business resiliency in the event on fewer available sourcing options.

Herein is a brief summary.

Finger costs are manufactured the same way as gloves. The following are particular issues associated with finger cots that make them different from gloves:

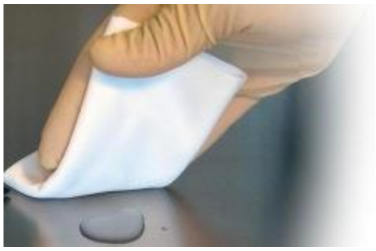
Sizing: small, medium, large, x-large

Packaging: 5 or 10 gross (144 each) per pack, 5 or 10 packs per case.

Finger cots are also available in a static dissipative black latex material. This is ideal for handling sensitive electronic components.

CLEANROOM WIPERS

Wipers are used to remove contamination from all areas of the cleanroom and are also used for wiping and cleaning products. Wipers are very important to fab operations because if they spread more contamination than collect, yield will decrease. Therefore, the design and construction is very important. Products that are to be used in critical areas are typically cleanroom laundered to ensure their cleanliness.



Wipers are a high-visibility item in the cleanroom because they are used to clean everything in the facility. A few examples include:

- Wiping operators' gloves on a frequent basis
- Wiping cart wheels as they enter the fab
- Wiping the inner protective bags that contain production supplies
- Cleaning work surfaces
- Cleaning production equipment
- Final wipe of product

Wipers are designed to effectively pick up wet and dry contaminants and hold the contaminants for disposal. Wipers are typically used with an appropriate solvent or cleaning solution in order to effectively clean the surface. This can happen by wetting an individual wiper with a spray bottle, pouring the appropriate amount of fluid directly into the bag of wipers, or by using a pre-saturated wipe. The following is a basic guide for which types of wipers should be used in each class of cleanroom:

Cleanroom Class	Wiper Type
1-10	Sealed edge polyester knits
100-1,000	Synthetic knits
1,000-10,000	Poly cellulose blends
>10,000	Cotton, foam, or composites

Important attributes of wipers include materials of construction, edge treatment, size, amount and type of inherent contamination, durability, absorbency and packaging.

WIPER MATERIALS OF CONSTRUCTION

Wiper fabrics are made from synthetics, natural materials, or a blend of the two. Synthetic materials such as polyester and nylon are typically used for cleanrooms class 1000 and cleaner. Blended wipers are acceptable for cleanrooms class 1000 and higher. Natural fabric wipers tend to be used for specialty or high heat applications.

Wiper Properties by Material

	Polyester	Nylon	Poly/ Cellulose	Cotton	Foam
Cleanliness	+ + + + +	+ + + +	+ + +	+ +	+ +
Durability	+ +	+ + + +	+	+ + + +	-
Absorbs Water	-	-	+ + +	+ + + +	+ + +
Absorbs Solvents	+ + +	+ + +	+ + +	+ + + +	+ + +
Chemical Resistance	+ + +	+ + +	+ + +	+ + +	+ + +
Heat Resistance	-	+	-	+ + +	-
Cost	High	High	Low	Med	Med

Polyester

Knitted polyester wipers consist of 100% continuous filament interlocked knit synthetic polyester. Lighter weight wipers are usually single knit polyester. If an exposed thread from a single knit wiper is dislodged, a run the can occur which will spread particulate. Heavier wipers are double knit, which is a more robust fabric that will not come apart. Variations in knitted polyester wipers include double or multiple layer wipers, tubular wipers, and hemmed wipers. Synthetic nylon is very strong and abrasion resistant. Polyester will readily absorb solvents, but will not absorb water or aqueous based solutions.

Hydro entangled polyester wipers are 100% polyester that is created by spraying high-pressure water onto a bed of polyester to form a lightweight, non-woven fabric. These wipers have similar characteristics to knitted polyester wipers, but are much lighter and less costly.

Nylon
100% continuous filament knit synthetic nylon is very strong and abrasion resistant. Constructed in similar fashions to polyester, the advantage of nylon is in its heat resistance and strength.

Poly cellulose blend
This general-purpose fabric is a blend of cellulose and polyester fibers that combine the highly absorbent properties of a natural fiber with the cleanliness and strength of a synthetic. These wipers are composed of polyester and cellulose fibers that are mixed together to form a slurry that is then sprayed onto a web conveyor sheet to create a non-woven fabric.

Cotton
Woven cotton wipers can be used on high-temperature surfaces that would likely melt synthetic or blended wipers. Formed from long staple cotton fiber, these wipers are strong and durable as well as very absorbent in aqueous solutions.

Foam
Foam wipers are constructed of synthetically grown open cell polyurethane foam. These wipers are typically resistant to solvents and are very absorbent and have a high capacity to carry liquids.

Composite
Composite wipers typically have an internal cellulose layer that is bonded to two outer layers of 100% polypropylene. This wiper is highly absorbent as well as clean due to its ploy outer layer.

WIPER ATTRIBUTES

Edge Treatment
The perimeter of the wiper can be a great source of contamination if it is not properly finished. For example, polyester wipers made from the same fabric can have drastically different levels of contamination based on the way it edges are cut and finished. The predominant ways that wipers are cut are heat-sealed, laser cut, hot wire cut, and knife cut.

Heat-sealed
Heat-sealed is used for synthetic wipers and is accomplished by forming a flat edge on the wiper that eliminates any stray threads from being exposed. This is the cleanest of all edge treatments.

Laser Cut
One advantage of a laser cut wiper is particulate retention because the laser used heat that seals the edge of the wiper. Another advantages cost and precision because the laser can quickly and accurately cut the fabric.

Wire Cut
This method utilizes a hot wire and is similar to the way a poly bag is heat-sealed. The border is not as clean as a laser cut or heat sealed edge, but in many cases the lower-cost of this type of wiper is desirable.

Knife Cut
In this case, a steel blade is used to cut the fabric. This method can leave a lot of fibers on the wiper, and can lead to particulate contamination generation as the wiper is used.

Size
The standard sizes for most wipers are 4”x4”, 9”x9” and 12”x12”. Many wipers are available in other sizes depending on the way the manufacturer offers the product. Custom sizes are also available is the quantity warrants.

Inherent Contamination
The materials from which wiper are made typically have inherent, or natural, types and levels on contamination. For wipers, we are concerned about particles, fibers, ions, and non-volatile residue (NVR). Contamination levels are measured using standardized procedures published by such institution as ASTM and IEST.

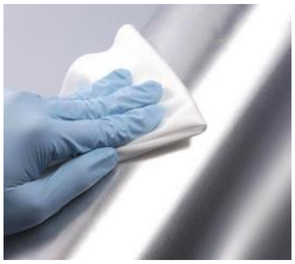
Particles
Lower particle counts on products brought into the cleanroom are desirable to reduce contamination of critical surfaces as well as the general cleanroom environment.

Fibers
Fibers are large particles found on wipers that are undesirable in the cleanroom. Many processes that can withstand some small particle contamination are much more sensitive to large particles and fibers.

Ions
Ionic contamination can cause failure by changing the electrical properties of the material or to the corrosion of metalized layers.

Nonvolatile residue (NVR)
The nonvolatile residues extracted from wipers and swabs can be highly detrimental to cleanroom manufacturing.

Durability
Wipers must have an acceptable level of durability for the application that they are being used for. If the proper wiper is not chosen, unacceptable levels of contamination will be generated because the fabric will break down or melt.



Absorbency
The absorbency of the wiper is a very important feature to ensure proper wet and dry wiping. For example, if a polyester wiper is used

with water you simply spread the contamination instead of collecting it for disposal.

Packaging

Wipers for use in a cleanroom environment will be cut, laundered, processed and packaged in a highly controlled facility. This ensures that no contamination will be introduced into the cleanroom on the package or the product.

PRE-WETTED WIPERS

Pre wetted wipers offer the convenience and time savings of not having to pre-mix and measure chemicals for use with wipers. This type of wiper is packaged in a solvent safe container in which a predetermined amount of solvent has already been added. He operator simply opens the container and pulls out a wiper that is ready to be used.

DISPOSABLE CLEANROOM APPAREL

Clean environments, by their nature, require separation of the product and operating personnel. Protective apparel provides that barrier. Sometimes it is important to contain contamination generated by operating personnel and keep it away from the process and the product. Conversely, when working in facilities where the process or product creates a dangerous or harmful working environment, protection of the operator is an additional concern, in addition to assuring that the operator does not contaminant the product and / or process.

REUSABLE VS. DISPOSABLE

While reusable garments are standard for most cleanrooms, there are instances where disposable apparel is the most appropriate choice. These instances include:

1. When laundered garments are not available, that is cleanrooms not located within the laundries delivery service area.
2. When reusable garments could be contaminated by toxic and/or hazardous substances (i.e. nuclear, chemotheraphy). Laundries will not process due to possible garment cross contamination, and the exposure risk to their laundry employees.
3. In small facilities where laundered garments are not cost effective. Laundries have minimum service charges that typically make sites with fewer than 10 operators cost prohibitive for a laundry garment service.
4. For visitors. Paying a weekly laundry fee for a garment that will be seldom used is not cost effective.
5. For new hires until their uniform sets are available.
6. In less critical environments, i.e. Class 10,000 and above
7. In emergency situations
8. Where conditions exist that would likely stain, damage or destroy reusable garments. The re-usable laundry will penalize your facility for damaging a garment before its service life is completed.

DISPOSABLE APPAREL CONSTRUCTION & SUBSTRATE OPTIONS

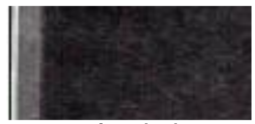
Seam Construction

Seam construction is an important consideration in apparel worn in clean environments. Other than simply joining two pieces of material, the primary purpose of seams on cleanroom garments is primarily to minimize or eliminate passage of particles either into or out of the garment. There are a few primary seam designs. They are:

Serged seams
Two pieces of material are joined with an interlocking stitching technique that provides general protection.

Felled seams
Two pieces of material are joined and interlocked then sewn together with double needle stitching.

Bound seams
A tightly sewn seam is reinforced with a third layer of similar material to provide extra protection.



For industrial grade products, elastic cuffs are common. Most elastic is seamed using a quick and inexpensive technique. “Tunnelized” elastic is technically better than an industrial seam, but not as good as a serged seam.

Substrate Material Options
There are several different types of materials currently used in the construction of disposable cleanroom apparel. Materials are chosen based on cost effectiveness, availability, and performance. While the following list of materials is not all encompassing, it does represent the vast majority of textiles used today.

Spunbond polypropylene
Used extensively for bouffant caps, shoe covers and some frocks and coveralls. It is also used in conjunction with other materials as a component of some high tech laminate fabrics. Due to the low cost of this material, it is ideal for disposable products. The barrier capability is relatively low and is therefore used in applications where only gross containment is needed.

Polyethylene
Used for she covers, bouffant caps, and aprons. This material is a good short-term barrier to most fluids. Latex is commonly introduced to improve these characteristics. As a result, polyethylene is a poor moisture vapor transmitter and is therefore hot when used as a garment. Polyethylene particulates somewhat and can be cut very easily

Spunbond olefin
Commonly known by its DuPont trade name, Tyvek. Spunbond olefin has a smooth side, and a rough side. Take caution to ensure that the smooth side is the outside surface on your garments. This material is has high tensile strength, however it is not suitable barrier against blood bornesolutions, and solvents. Due to this material’s popularity in the industrial market, non-cleanroom capable Tyvek often ends up in cleanroom environments. Tyvek suitable for a cleanroom will be packaged in polybags, with the smooth side out, and bound seam construction.

Microporous / Polypropylene laminate

The most appropriate laminate substrate for a critical environment is a microporous material. The inner material is a comfortable (albeit high shedding) uncoated polypropylene. The outside is a chemically pure urethane. This material lamination provides a garment that is strong, relatively low cost, provide excellent particle retention, and have good moisture vapor transmission that keeps the garment cool to wear.

Other Laminate materials

In order to accommodate the requirement to block particle penetration as well as keep a garment comfortable to wear, a variety of proprietary fabrics have been developed. These materials are strong, relatively low cost, provide excellent particle retention, and have good moisture vapor transmission that keeps the garment cool to wear. They are typically constructed of three or four layers of different materials and do a good job of bridging the gap between disposable and reusable materials.

Vinyl

Aprons and sleeves are typically make from vinyl due to its chemical resistance characteristics.

Packaging

The way a product is packaged can have an impact on its cleanliness. Packaging also impacts product cost. Some common methods of packaging include:

Cardboard box only

For products where cleanliness is not important. The rigors of shipping and handling create friction between the raw garment and the uncoated chipboard. This allows allowing corrugated fibers, dust, and debris to contaminate the product. You will find that some shoe covers, bouffant caps, and industrial coveralls come bulk packaged in this way. Cardboard boxes without a polybag liner should NEVER be used in a controlled environment.

Cardboard box with inner liner

Your facility should specify that all disposable apparel be packaged in polybag liners inside the carton box. This allows the product to be removed, or detached from the corrugated carton outside the cleanroom. Since a relatively clean bag separates the product from the dirty box, the product arrives at the cleanroom relatively clean. Many times, there will be two poly liners for contamination control. Since cardboard is not allowed in the cleanroom, the inner bag containing the product can be removed and then carried into the change area.

Individual packaging

The cleanest way to handle products. Each individual piece is double bagged; all pieces are then placed in a poly liner and packed in a cardboard box. Most common for sterile garments.

Collar Types

Frocks, smocks, lab coats and coveralls are typically available with a choice of collar types that include military, fold down and knit.

Military

A style of collar that minimizes areas for contamination to collect. Also known as a mandarin collar.

Fold down

This style is similar to a normal shirt or jacket collar. Used primarily on lab coats, this collar can easily harbor particles.

Knit

Collars of this style are not usually compatible with cleanroom protocol. Industrial styles may incorporate this style.

Sleeve Construction

The way sleeves are attached to garments greatly affect comfort as well as particle generation. The two main types include "raglan" and "set in" sleeves:

Raglan sleeves

Much more comfortable and provide greater range of motion. The added benefit is lower particle generation, since the cuff remains at the wrist without moving up the arm.

Set in sleeves

Typical of what you will find on "street clothes." This style is usually found only on garments for industrial use.

Clean and Sterile Garment Processing

Disposable garments for use in clean environments may require laundering in order to minimize the particulate introduced into the environment. Tyvek and laminate materials can be "clean processed" to meet this need.

Pharmaceutical, biotech and life science environments sometimes require garments to be sterilized to minimize the bio burden in these areas. Gamma irradiation and ethylene oxide (EtO) gas sterilization are the most commonly used methods today.

APRONS

Aprons are used to cover routinely worn garments and clothing to protect the worker from harmful chemicals or splashes. Most aprons are made from a single piece of material and protect only the chest, waist, and thigh areas of the operator. Coat aprons are open in the back and have full-length sleeves and long length fronts and are used in the wafer-fab areas of semiconductor companies to protect from acids. Other aprons have a neck loop and rear toes are used for protection against a variety of chemicals. They usually are measured by size (S, M, L, XL) or by length and width measurements.

BEARDCOVERS

Beardcovers are used to protect a cleanroom, food cosmetic or FDA regulated production area from the shedding of facial hair from beards, moustaches and sideburns. They usually attach to the face via ear loops, elastic bands, or ties. Materials of construction include foam and spunbond polypropylene. Beardcovers come in sizes regular and large and are usually packed in sub case quantities of ten or one hundred

BOOTCOVERS

Bootcovers are used where shoecovers are inadequate and a greater level of containment of shoe born contamination is needed. These limited use, high top bootcovers are normally 18”-20” high and have uppers made from a cleanroom compatible fabric and either a fabric sole or a non-skid polyethylene sole for durability and better traction. They can have a variety of features such as instep straps hell straps, zippers, etc. Normally, they have an elastic top and attach to the coverall with a snap system to prevent them from sliding down the calf. They are worn over street shoes, or facility shoes and should be compatible with the type of floor in the cleanroom

BOUFFANT CAPS

Bouffant caps are used to protect the environment from the shedding of hair, and are typically constructed of lightweight spunbond polypropylene (SBPP) fabric. Caps are worn alone or under a reusable or Tyvek hood for added particle protection.

Some caps are constructed of non-porous and very low shedding Tyvek fabric. These caps are not very good for moisture vapor transmission and therefore are somewhat hot to wear. They are also significantly more expensive than disposable polypropylene bouffant caps, (10-20 times more per cap) but they can be worn numerous times and are cleaner than spunbond polypropylene.

An elastic band is used to hold the cap on the head. The caps are available in two primary sizes of 21” and 24” diameters (size of circular fabric swatch in diameter prior to applying elastic band) and in the routine colors of white and blue. Other sizes and colors are available.

Bouffant caps are bulk packaged in cardboard boxes, but the cleanroom routinely uses bouffants packaged in poly bags that line the box.

COVERALLS

Coveralls provide full body containment when paired with shoe or boot covers, gloves, a hood and a face veil or mask. Coveralls are available in a wide variety of materials and packaging to meet the need of any type of controlled environment. The front closure is usually a zipper made from nylon or other plastic material. Coveralls for the cleanroom will have a military collar and no pockets.

Coveralls – Polypropylene

These coveralls are made from different fabric weights of spunbond polypropylene fibers and are primarily for industrial use. They are low cost and usually have open cuffs and ankles, or elastic cuff and ankle. There are also styles that have hoods and boots attached. They are not designed for stringent cleanroom applications below class 100,000 environments and are usually worn to protect the wearer's clothing from low-level contamination. Since polypropylene fabric is quite porous, they provide very little chemical protection unless they are worn with some form of barrier laminate material like polyethylene or Tyvek.

Coveralls – Spun bound olefin or Mircoporous Laminate

For class 100 and better cleanrooms, these coveralls are designed as limited use, disposable garments and they provide great barrier protection to chemicals and contamination. The fabric is also somewhat micro porous and offers moisture vapor transmission or breathability, which makes it cool and comfortable to wear in comparison to reusable garments. It is constructed for either industrial or cleanroom applications and is available with other garment styles to make a garment set appropriate for many applications. Suitable for cleanroom use at Class 10 to Class 100,000 applications, the fabric and it's construction of seams and closures, along with secondary processing (laundry or sterilization) will make it suitable for sterile or cleanroom applications.

FACEMASKS AND FACE VEILS

Masks and veils are designed to minimize the level of contamination generated from the face area of an operator. This contamination can originate as skin flakes, spittle mucous, hair follicles, and cosmetics. Since the head area is usually in close proximity to the product, contamination from this area must be virtually eliminated. A nosepiece is usually included to maximize comfort and fit. There are several different styles, materials of construction and attachment methods for facemasks and face veils.

Facemasks

Duckbill

This style of a facemask resembles a closed duckbill and allows for some air space between the users nose and mouth and the front edge of the facemask. The major advantage is that this air space reduces the temperature of the air being breathed in and is therefore more comfortable to the user. This style also keeps the air pressure between the mask and the mouth and nose lower and allows the user to inhale and exhale with less resistance. This type of mask usually uses a single elastic band for attachment to the head.

Ear Loop

Ear loop facemasks utilize either elastic polyester or polyurethane loops which are placed over the ears for attachment to the head. The benefit of these types of masks is they are easier to put on and easier to take off than traditional four-tie style masks. They feature the same type of pleated, multi layer facial that is used in a surgical mask.

Elastic Band

Same as an ear loop mask except that is attached to the head by a single elastic band that stretches to go around the back of the head to provide a secure fit. Some masks even utilize a double elastic band that gives a good seal at both the top of mask and at the lower bottom half of the mask.

Foam

This mask is made from a thin, single piece of die-cut polyurethane foam with integral ear loops.

Face Veils

Face veils are made from a lightweight synthetic, non-woven fabric that utilizes either snaps or an elastic headband to secure it to a reusable garment hood or to attach it to the wearer's head. Customers who are using a three-piece system of hoods, bootcovers and coveralls wear face veils.

Face Shields

These are usually a two-piece system that is used to protect the user's face from being splashed with hazardous chemicals. The headgear is adjustable and make of lightweight plastic or metal. The shield is a replaceable piece of polycarbonate plastic that is optically clear and first onto the headgear. The shield can very from 9" in length depending upon the protection needed. Normally, some type of disposable facemask or respirator, along with some protective eyewear is worn under the face shield system for added protection. You will find these being worn in any area where hazardous chemicals are being mixed, poured or handled.

FROCKS

Frocks – Pro Shield

This is a frock that is made from Kappler's ProShield fabric.

Pro-Shield is a laminated fabric made from spunbonded polypropylene and a laminated layer of microporous polyethylene sheeting that is ultrasonically welded to form a single fabric. A frock is a long sleeved coat with elastic sleeve openings, a military style collar and snaps down the front, or a zipper. It is comparative to a Tyvek frock in performance.

Frocks – Reusable

This is a frock that is made from launderable fabric. The fabrics are usually polyester, or a polyester and carbon filament ESD fabric. It features either snap cuffs or elastic cuffs, a military or mandarin high-collar, and either a zipper or snaps down the front. It is long sleeved and usually comes down to the knee area in length.

Frocks – Tyvek

This frock is made from DuPont's Tyvek material which is a spunbonded polyolefin material that is moisture and chemical resistant. It is a lightweight fabric that is low linting and made to be worn and disposed of after several donnings. The frock is designed like those above, and Tyvek can be processed for the cleanroom, or for sterile applications as well as standard style for industrial applications. Frocks typically have elastic wrists, snaps down the front, a high collar and no pockets.

HOODS

When a bouffant cap worn alone does not provide adequate contamination protection from the head area, hoods are used in conjunction with coveralls and a face covering. Limited use, disposable hoods can be constructed of proprietary laminate materials or Tyvek. The hood is either open-faced or eyes only style and is available with snaps for snap in face veils. The product is sold bulk packaged or individually packaged. These hoods tuck into the collars of coveralls.

LABCOATS

Labcoats are usually used in a non-cleanroom environment where assembly operations are performed or where minimal contamination control procedures are in place. Labcoats usually have a fold down collar, open sleeves, snap closure, are mid-thigh in length and typically have one breast pocket and two waist pockets. Labcoats can be made from spunbond polypropylene, laminate materials or Tyvek.

SHOECOVERS

Shoecovers protect the cleanroom from shoe borne contamination and are usually made from spunbond polypropylene (SBPP). They are often worn alone over shoes in class 10,000 and higher cleanrooms are worn under reusable boot covers in class 100 and lower cleanrooms. The seam is either turned in or left on the outside of the shoecover and this is referred to as “seam in” or “seam out”. Shoecovers are low cut with an elastic top and are usually offered in two sizes: regular (14” – 15”) and extra-large (16”-18”). This measurement corresponds to the length of the sole when stretched completely open. They are bulk packaged in a cardboard box with a poly bag liner.

SHOECOVERS VERSUS DEDICATED SHOES

The optimum contamination control strategy is to prevent, versus merely cover-up the footborne particles that can get embedded in your operators street shoe soles. Additionally, any Shoecover provides less traction than a clean shoe. The anti-skid properties versus a shoe that never leaves your controlled environment. Numerous “best in class” facilities have adopted factory shoes to provide improved operator safety, and

Nonskid SBPP shoecovers

Used where accidents can happen due to slick or wet floors. These shoecovers have a layer of tacky adhesive on the sole that promotes added friction and grip on most floor surfaces. This tacky adhesive is usually a mixture of latex and adhesive compound. The tacky adhesive can be white or clear and typically has a pattern like that of a tire tread, wave or swirl.

Conductive shoecovers

Used in electronics assembly facilities. They are very similar to regular shoecovers except that they have the added feature of a conductive strip of material sewn onto the sole that is tucked into the wearer's sock. This contact to the skin allows any charge that the wearer may have on their body to be transmitted through the conductive fabric, down to the sole of the shoecover, and grounded onto the conductive floor material. This grounding prevents damaging static discharge from occurring during movement that could cause a harmful ESD phenomenon. It is important to have a properly grounded floor tile or mat in order for a conductive shoecover to perform effectively.

Polylatex or polyethylene (PE)

Used for their waterproof characteristics. These shoecovers are made from polyethylene film that has a latex additive. It is typically blue in color and can be smooth or textured on the surface. They are fairly durable, but they can rip on sharp edges or floor grates. They are priced slightly higher than spunbonded polypropylene shoecovers.

Tyvek shoecovers

Durable and can be worn several times before disposing. This material is liquid repellent and does not fracture, particulate or rip easily. It is also expensive and could cost 10 times more than a regular SBPP or polylatex shoecover.

SLEEVECOVERS

Sleeve covers are used to protect the workers wrists and forearms from being harmed by hazardous solutions or chemicals. In other instances the sleeves are there to protect the product from the worker's arms and possible product contamination. These are limited use or disposable sleeve covers that have elastic at both ends and are usually about 17" – 20" in length. They can be standard, cleaned or sterilized. In sterile bench applications the workers will frequently wear a sterile sleeve cover to make sure that a sterile field is maintained at the workbench. Vinyl sleeve covers are made from a 6-8 mil thick vinyl material with elastic at both ends. They will discolor over time, especially after repeated chemical contact or autoclaving. They can be clear white or light blue in color.

ADHESIVE MATS

A contamination control entry surface will be found at the door to almost every cleanroom or electronics assembly area. The purpose of this mat is to minimize the amount of contamination that enters the controlled environment by way of shoes, cart wheels, and other sources.

These surfaces are commonly known as “sticky” or “tacky” mats and are either semi-permanent or disposable. While each type has advantages and disadvantages, disposable maps are by far the most prevalent in the industry today. Semi-permanent mats tend to cover a large area and usually provide wall-to-wall protection, while disposable maps are by far the most prevalent in the industry today. Semi-permanent mats tend to cover a large area and usually provide wall-to-wall protection, while disposable masks are available in standard sizing configurations from 18” by 36” by 60”. Both semi-permanent and disposable mats are available in the custom sizes.

DISPOSABLE MATS

Disposable mats are made from a stack of sheets of polyethylene film, with a specially treated pressure sensitive adhesive on the exposed surface. This adhesive film is strong enough to remove dust and dirt from the bottom of a sole, yet mild enough not to cause the shoe cover to stick to the mat. There are typically 30 or 60 sheets per mat. Operators or carts entering a cleanroom or clean zone walk or roll on the film to remove contamination on shoe heels, soles and wheels.

When a sheet becomes loaded with contamination, it is peeled off exposing a new clean sheet for use. Sheets that need to be disposed of are easily identifiable by the visible dirt and debris on the surface. Each mat is adhered to the floor or a frame with double-sided adhesive tape or a full bottom sheet of double-faced adhesive film. The top of each mat is protected with a clear release sheet until it is ready for use.

The sheets have corner tabs that are consecutively numbered to shoe the number of remaining sheets, thus providing the economy of only one sheet being removed at a time. Dirty sheets are loosened for removal by pulling up on the corner tab that has no adhesive. The mat is skid resistant and is not damaged by footwear or wheels.

Disposable mats are usually packaged 4, 6, or 8 mats per case. Each mat contains 30, 40, or 60 sheets per mat. Therefore, a standard case would contain between 120 sheets and 480 sheets. Even though there is a great difference in the number of sheets per mat, the relative height difference is very small because each sheet is so thin.

Disposable mats are also available with a biocide that is added to each sheet. Important in a life science or biotech account, this anti-microbial agent kills much of the bacteria that can enter a space on shoe soles or cart wheels.

Variations from the standard disposable mat include:

1. Beveled edges
2. White, gray or blue sheets
3. Clear sheets over a base color of white, gray, or blue
4. Custom colors and sizes are available
5. Company logos may be inserted to display through the mats made of clear sheets over a colored base sheet

DISPOSABLE MAT FRAMES

Frames are used to provide a uniform and effective base for adhering mats securely, yet permitting easy removal of the last sheet. This eliminates problems caused by left over adhesive sticking to the floor after the mats are removed. Disposable mat frames can also be used to enhance appearance.

Disposable mat frames are very similar to picture frames in that they consist of a sloping edge base into which the tacky mat is placed. Frames also allow carts to roll over the mat easier due to the beveled edge of the frame.

SEMI-PERMANENT MATS

Semi-permanent mats minimize contamination in the same basic manner as disposable mats. The biggest difference is that instead of simply removing the dirty sheet from a disposable mat, semi-permanent or renewable mats need to be mopped and cleaned on a regular basis and this can be a burden on a fab's janitorial crew. One advantage of a renewable mat is that it can be sized to cover a very large area.

Renewable mats are made from a tacky vinyl compound that will withstand heavy carts and foot traffic. Installation is usually very simple and is accomplished by laying the mat in place and securing with the pre-installed adhesive strips.

These mats are typically cleaned by mopping with either water-soluble or solvent-based chemicals. While there is no ongoing cost to replace the mat, there can be a significant cost in cleaning materials and man-hours to renew the mats.

CLEANROOM CLEANING PRODUCTS

Cleanroom cleaning products are used to initially clean the facility and then maintain cleanliness during ongoing operations. This housekeeping exercise is designed to minimize particulate contamination on work surfaces, wall, floors, curtains and equipment. A maintenance crew usually performs facility cleaning and in many instances this function is outsourced. The level of cleaning required depends on what is being manufactured, how clean the environment needs to be, and the frequency required to maintain that level of cleanliness. Most fabs are cleaned every shift to maintain an acceptable grade of cleanliness with more intense cleaning efforts performed on a daily and weekly basis.

Cleaning products are specifically designed and constructed from appropriate materials so as to not generate additional contamination. Products covered in this section include:

- Mops
- Hardware
- Sponges
- Cleaning Chemicals

MOPS

Mops are used in a cleanroom to remove contaminants from floors, walls, mats and curtains. In general, a mopping system consists of the mop head, an adapter to hold the mop head, and a handle. Several different styles of mop heads and materials of construction are available.

Styles

Floor mops are used for cleaning floors and mats and are designed to clean large surface areas quickly and efficiently.

Roller mops look similar to a paint roller and are used for general purpose cleaning on all surfaces.

Flat head mops are typically used for removing surface contamination from flat surfaces. They usually have a pivoting head and a disposable slipcover. They are particularly useful for cleaning vertical surfaces.

Materials of Construction

Polyvinyl alcohol (PVA) has an absorbency of 600% of its own volume and a drying time of 10-20 seconds. PVA is ideal for cleaning applications where a dry, residue-free surface is essential. Not compatible with Isopropyl Alcohol (IPA).

Latex rayon blend mops are hardwearing and will retain their absorbency and efficiency over multiple uses. They are resistant to strong disinfectants and can be autoclaved. This is a good choice for light industrial customers making a move into controlled environment – Class 10,000 or similar.

Polyester is typically laser cut to minimize particulate. Some polyester mops are sewn and looped to provide the cleanest possible design. Woven polyester efficiently wicks away moisture. An internal foam substructure at the top of the mop provides for dual-cleaning action for high-traffic areas. Polyester does not have the same absorbency as PVA. This feature makes it a good choice for pharmaceutical and medical device facilities where disinfectants need a prolonged contact time. Polyester holds up to strong disinfectants and is autoclavable.

HARDWARE

Mop buckets, wringers, handles, extensions and squeegees are used in conjunction with mops in order to capture surface born contamination and remove it effectively.

Mop buckets are constructed of stainless steel or polypropylene and come in various shapes and sizes depending on the cleaning solution and some systems have 2 or 3 different buckets to allow for dirty waste to be collected separately.

Mop wringers are constructed of stainless steel or polypropylene and are specifically designed to minimize particle entrapment. Many wringers are designed with no gears or lubricated parts so they can be autoclaved.

Mop handles and extensions are available in various configurations to enable maintenance staff to easily clean all areas of the facility. Constructed of stainless steel, fiberglass and a variety of plastics, these accessories provide strong, dependable connections to the mop. Electro polished stainless steel will guard against rust.

Squeegees are available in several sizes are used for cleaning and removing fluid from windows, floors and walls.

SPONGES

Sponges are used for general cleaning and maintenance. Materials of construction are similar to those of mops. Special designs are available and include a polyester cover over a foam interior. Sponges are used for hand wiping and cleaning products as well as facilities.

CHEMICALS

As mentioned in the Pre-wetted wiper section, particles / contaminants will cling to the object that they are on because of the physics of surface tension. Introducing a liquid (i.e. chemical) reduces the surface tension, so that the contaminants will float from the object that they originally were adhered to.

Different chemicals are used for various cleaning jobs inside a controlled environment facility. Your cleaning chemistry solution will be influenced by the nature of your cleanroom activities.

Life Science sector facilities (Biotech, Pharma, MDM) are regulated by the FDA. Chemicals used in these type facilities are focused to kill and remove viable contamination (virus, bacteria, fungus). The chemistry solution is typically rotated on a predetermined schedule. Effective chemical cleaning typically involves fully wetting the area, and permitting an air dry.

Advanced Material sector facilities (Semiconductor, Optics, Lasers, etc) make their chemistry selection based on not solely killing viable contaminants. These facilities seek to remove all particles, regardless as to whether they are viable, or non-viable.

The common denominator chemical used in both sectors for critical cleaning is an Isopropyl alcohol / Ultrapure water chemistry solution. IPA / H20 in a 70 / 30 solution is used in the many critical environment because:

1. 70% IPA is adequate to kill most viable contaminants
2. 30% Ultrapure Water gives enough dwell time to clean, before the chemistry evaporates.

CLEANROOM DOCUMENTATION

Cleanroom stationery and paper products are a very important consideration in controlled environments. Any production environment will contain various equipment manuals, procedural manuals, forms, and job orders, as well as a variety of products on which to take notes or document daily trends.   This group of supplies is commonly referred to as “cleanroom documentation”.

Regular paper that we use in the office is made of cellulose (wood pulp and fibers). The problem is that his paper particulates heavily when used and is a substantial source of contamination. Cleanroom paper is made from low particulate filler and fibers that are coated with latex.

Notebooks, binders, tabs and labels are specially designed to ensure that particulate contamination is not trapped in or on them. These products are made from materials polypropylene, latex and Mylar.

Products covered in this section:

- Notebooks
- Binders
- Tabs
- Paper
- Preprinted Forms
- File Folders
- Labels
- Manuals
- Pens
- Thermal Printer Rolls

CLEANROOM NOTEBOOKS

Cleanroom spiral notebooks are used to record events and results of daily operations. Notebooks must remain in the cleanroom once introduced, and are not to be taken in and out at will. Notebooks are manufactured to cleanroom standards from materials with unique properties to keep particle burden to a minimum in the cleanroom. Each notebook is cleaned and double shrink-wrapped. To maintain the integrity of the notebook it should only be unwrapped or opened in a clean environment

Cover stock is 0.023” high-density polypropylene. Cleanroom notebooks typically have a clean front cover and a clear or blue back cover. Since the front covers are clear, the first page is the title page. The title page can be a custom design or the customer’s logo. The customer should supply camera-ready artwork for the title or logo page

The three standard sizes are 8.5” x 11”, 5.5” x8.5” and 3”x5”. On occasion there will be a request for 11” x 17” spiral notebooks. Each book has 50 sheets (100 pages) of print format in college rule, ¼” grid, 1/10” grid or engineering log. Additional custom formats include blank sheets, isometric graph, or daily planner.

Rarely are ink colors utilized other than process blue (medium blue), reflex blue (dark blue) or black. Inks are low sodium and low metallic soy based to keep particle contamination to a minimum.

BINDERS

Binders are widely used for organization of forms and for archival purposes within the cleanroom. The standard binder is made of 0.055” clear high-density polypropylene with 1” capacity slide lock rings. As with so many other products, binders are available in a variety of configurations. For capital equipment operation manuals, the size can range up to 5” with powder coated angle “D” rings. Note that most binders are not cleaned, and they are shipped in a cardboard carton. Therefore, they should be cleaned by wiping with IPA before they are brought into the cleanroom.

TABS

Tabs, also known as chapter dividers are produced in 1/3 cut (3 to a set, with 3 protruding tabs) and 1/5 cut (5 to a set, with 5 protruding tabs). The material is 0.023” high-density clear poly, the same as cover stock used on spiral bound notebooks. The outboard corners are rounded to eliminate tearing of the shrink-wrap and operator gloves. Holes are drilled in either a 3-hole or 5-hole pattern for insertion into cleanroom binders. Each set of tabs are cleaned and double shrink-wrapped. A variety of colors are available.

PAPER

Cleanroom paper is used for such items as spiral notebooks, custom printed forms, laser labels and flat stock. Made from a special formulation that is impregnated and coated with special polymers, it is available in such 22.5#, 22.5# and 30# in colors of white, blue, green, pink and yellow. There are 250 sheets per pack and 10 packs per carton. The typical sheet as received has a nominal particle count of 38 particles. Cleanroom paper is also available in 11x17 in white and blue with 1250 sheets per case.

Copiers and printers will jam with some cleanroom paper and not others. Weight and composition of the paper differ from manufacturer to manufacturer. If the customer experiences difficulty, sampling will help determine the proper choice of paper.

PREPRINTED FORMS

Custom printed forms come in all shapes and sizes. Many end users ten to photocopy forms on cleanroom paper, although there is no qualified copy machine. Additionally, customers are typically not equipped to clean the forms prior to introduction into the cleanroom. Many customers assume there is a cost savings by copying their own forms, but the opposite is actually the case. After printing, forms are cleaned and double shrink-wrapped to maintain cleanliness right up to the point of use.

A unique custom printed item is a cleanroom multi part form. This item is generally used as an equipment downtime ticket, sequentially numbered. Multi part forms are coated with a chemistry that takes about 20 minutes to achieve maximum resolution. These forms are significantly cleaner than commercially available NCR forms, however they are not as clean as individual sheets of cleanroom paper.

FILE FOLDERS

Files folders are made of 0.012” polypropylene and are used in the cleanroom for organization of forms and manufacturing data. Folders are available 1/3 cut in various colors, and in 100 set minimums. As with the binders, file folders are not cleaned prior to shipping and should be thoroughly wiped down before use.

LABELS

Labels come in a variety of sizes, print, and materials of construction. The standard material for label face stock is typically a biaxial polypropylene or Tyvek, and a removal adhesive is on a clear Mylar liner. Cleanroom compatible labels always come on a plastic core and are shipped double shrink-wrapped. Except for large labels, there are usually 1000 labels per roll. Labels are available blank, thermal direct, thermal transfer, printed, coated for resistance to IPA, die or butt cut. Multi-color printing, as well as sequential numbering and bar coding are readily available.

Sheet printed labels for use with laser printers and ink jet printers are also common. Laser printers have a working temperature of 400°F. Synthetic labels have a plastic state of about 265°F, so label materials were developed so that they could be used in laser printers. The face stock is cleanroom paper. Standard packaging is 100 sheets per pack and double shrink-wrapped. Sheet labels should be cleaned before they are taken into the cleanroom.

MANUALS

Manuals are supplied by capital equipment manufacturers for operating and maintenance of processing equipment housed in critical environments. These manuals remain in the cleanroom for instructive and reference purposes. Manuals are a combination of many individual items already discussed, including cleanroom paper, binders, and tabs.

Artwork for manuals is supplied by the customer either hard copy or disk. For disk artwork, a proof copy is generated on standard bond to be approved by the customer before commencing production. The customer also supplies multicolor covers and spines that are laminated before insertion into the front and spine clear view overlays. After final cleaning of the assembled manual, it is double shrink wrapped in a Class 100 environment and shipped to the customer.

PENS

Pens for use in cleanrooms are available in medium point, colors Black, Blue or Red ink. The cap and trim of the pens indicate the ink color. The chemistry of the ink is as low as possible in sodium and trace metals for pens used in semiconductor cleanrooms. Pens are packaged 25 per bag, 4 bags to a pack. A custom imprint on the barrel is available from some manufacturers.

THERMAL PRINTER ROLLS

Thermal rolls are used in many steps in the manufacturing process to record data or significant events. Some customers use fax paper tape that may be easily torn. A cardboard or honeycomb core is the first tip that fax paper is being used instead of biaxial polypropylene film on a solid plastic core. The poly film cannot be torn or ripped, thus reducing the particle burden in the cleanroom. Width of thermal rolls is defined in millimeters and the most common sizes are 57mm, 80mm, 110mm, and 216mm. Each roll is individually cleaned and then double shrink-wrapped prior to shipment.

CLEANROOM ACCESSORIES

CLEANROOM BENCHES AND TABLES

Benches and tables are used in all areas of manufacturing and assembly operations. Gowning benches are used to sit on while donning cleanroom attire. Tables are used for inspection, assembly, packaging, etc. Many people use the words “benches” and “tables” interchangeably. The commonalties of these products are their design and materials of construction. Most of these products are custom built and can have substantial lead times. Tables and benches can be fully assembled when shipped or can be ordered “knocked down” for assembly at their final destination.

Laminate Benches and Tables

Laminate benches and tables have powder coated steel frames with four legs and a laminate top. Powder coating is a painting method that is more durable, sheds fewer particles, and is more corrosion resistant than traditional enamel paint finishes. The work surface is typically a pressboard substructure over which a plastic laminate is placed. These products are suitable for use in Class 100 cleanrooms or higher. Some options include:

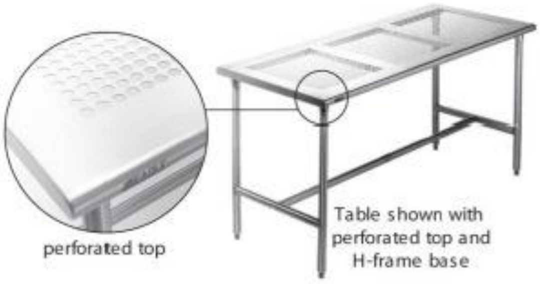
- Style of legs (H frame, C frame)
- Style of supports (2-, 3-, or 4-sided)
- Leg rests
- Gauge of steel
- Weight bearing capacities
- Drawers
- Electrical outlet strips
- Shelves

ESD Laminate Benches and Tables

The ESD laminate is essentially the same as regular laminate. The exceptions are that a static dissipative laminate material and grounding system are employed to discharge static electricity. The work surface is grounded through a conductive wire that runs through the legs or frame of the bench to an earth ground somewhere in the facility.

Stainless Steel Benches and Tables

Stainless steel tables and benches are typically used in areas where particulate contamination control is an absolute necessity. Stainless steel is typically either buffed or electro polished to ensure a good surface finish that will not trap particles. Electro polishing is an electro chemical method that gives the smoothest and cleanest finish.



The work surface can be solid, rod top, or perforated (1/4" or 3/8" diameter). In a laminar flow fab environment, perforated tops allow for cleaner work surfaces. Due to the cost of material, extra labor, and shipping weight, stainless steel tables and benches are much more expensive than their laminate cousins.

Laminar Flow Benches

These stand-alone benches, sometimes referred to as laminar flow hoods, are used to create a clean, laminar air workstation. They can be used inside a cleanroom or in a standard work area. They have their own HEPA filter system that filters the air to sub-micron particle levels. These filters are located in the bench top (vertical airflow) or bench back (horizontal airflow). Normally, there are pre-filters and final filters for maximum filtration. These benches are equipped with a motor blower that moves the air at rapid speeds up to 100-120 cfm through the filters for efficiency and a laminar flow stream. The makeup air is either drawn from the room, or there is a ducting system that draws air from outside the building.

These workstations usually have built-in electrical lighting controls. They can come in a variety of lengths, heights, widths and depths.

PASS THROUGH MODULES

Pass through modules are boxes that are built into a cleanroom wall that allow movement of goods from the inside of the cleanroom to the outside (or vice versa) without disturbing the cleanroom operation or positive pressure air balance. Typically, an electrical interlock prevents both doors from being opened at the same time. The pass thin modules can be of various sizes and constructed from acrylic, stainless steel or other and can be fitted with shelves.

CLEANROOM SHELVING AND CARTS

Shelving and carts are very common items found in almost every facility. Shelving is used for storage and carts are used for transporting material. Plastics and chrome-plated steel will be found in the class 1000 and higher cleanrooms, while stainless steel products are typical in class 1000 and lower cleanrooms.

Carts

Plastic Carts

Carts used in assembly areas and class 1000 and higher cleanrooms are usually basic plastic rolling carts that have 2-3 shelves. Some carts are made from metal posts with casters and plastic shelves. They come in various sizes (height, width, length) and they normally have a handle to push or pull the cart with on one end.

Stainless Steel Carts

Carts used in class 1000 or lower cleanrooms are fabricated from stainless steel to minimize the particulate contamination. Stainless steel cart shelves can be either solid or made from stainless steel wire. Wire shelving is usually adjustable. The casters or wheel are specially designed for use in a cleanroom. They have a handle on one end or both ends for pulling and pushing the cart.

Shelves and Racks

Cleanroom Garment Racks

These racks are made from welded stainless steel wire. They can be floor mounted or wall mounted. They can be set up as a complete gown racking system with garment hangars and bin boxes that contain such things as shoe covers and bouffant caps. Hangars can be open looped or closed looped. There are a variety of styles and configurations available.

Wire Shelving

These are adjustable storage racks for use in cleanroom, gowning rooms, and regular storage areas. Wire shelves are used as opposed to solid shelves because the air passes through the wire more easily. This ensures that contamination does not collect as easily on the shelf. Class 1000 and higher cleanrooms will typically use plated steel shelving while class 100 and lower cleanrooms used stainless steel shelving. Options include:

- Dimension
- Material of construction
- Wheel options
- Storage bins

- Shelf dividers

CHEMICAL SAFETY STORAGE CABINETS

Chemical safety storage cabinets are specifically designed to store flammables, solvents, or acids. They are chosen by selection of hazardous chemical group, size dimensions, storage volume capacity, door style, door closure type, etc.

CLEANROOM SEATING

Seating for critical applications include those for cleanroom, ESD, and assembly and test applications. They come in a variety of different styles and sizes (height adjustment range, seat width, and seat back dimensions). Chairs and stools are available in desk height (30') or bench height (36"). They can have 4 or 5 legs and are available with no foot rings, adjustable height foot rings, or fixed height foot rings. They can come with glides or casters and the caster can be standard rubber, ESD safe or cleanroom suitable. Some casters are available with a braking mechanism that prevents a chair from rolling when a person is seated in the chair.

Chairs

Chairs can have vinyl covered cushioned seats and seat backs which are of standard grade, cleanroom grade, static dissipative grade, or cleanroom static dissipative grade. They can also be covered with a synthetic or woolen fabric that is ESD safe. The base of the chair can be painted, chromed or polished from aluminum or steel. The control mechanisms are hydraulic or a threaded internal screw mechanism on less expensive models. There can be controls for forward tilt and back height adjustment.

The cleanroom chairs have a filtration system built into the underside of the seat cushion and the seat back, which filters the air exhausting from the compression of the cushion as you sit on it. In cleanroom chairs, you normally have a high-grade vinyl that is finished off with some method of covering or concealing the seams. The chair base is usually polished aluminum or steel and in some lower grades is just a chrome-plated metal. They are available with or without foot rings.

The ESD chairs have either a static dissipative vinyl cushioning or a conductive fabric covering. There is normally a ground cord that runs through the base that is attached to ground chain for a path to ground and uses a conductive caster or glide to make continuous contact. They are available with our without foot rings.

Stools

Stools are typically used in areas where operators are in and out of stool frequently because they are easier to get in and out of then a chair. The materials of construction and features are the same as cleanroom chair.

CLEANROOM VACUUMS

Cleanroom vacuums are used to clean up dust, dirt, and debris inside the cleanroom. They come in various styles, sizes and capacities. There are backpack units that fit onto the workers back for mobile spot cleaning, and floor units ranging from 2 gallons to 30 gallons capacity. These units handle dry or moist materials. Cleanroom vacuums must have body components and a motor manifold that prevent particle shedding. There is a HEPA or ULPA filter on the vacuum exhaust, a filter on the intake air side of the motor, and gross particulate pre-filter. Accessories include:

- wands
- brushes
- squeegees
- special bags or plastic liners

CLEANROOM DESICCATOR CABINETS

Desiccator cabinets are used to keep moisture and contamination from sensitive electronic components. They are constructed of acrylic or glass and steel and they can be large or small, single or multiple chambers and they are typically fitted with shelves. The door is sealed with a gasket to keep the contents from being exposed to ambient moisture or particles. They can also be designed to be static safe or conductive to eliminate ESD damage. A nitrogen source is attached so that the chambers can be flushed and purged with the inert gas to eliminate oxidation of sensitive electronics.

CLEANROOM STORAGE LOCKERS

Storage lockers are usually enamel coated steel lockers that are placed inside change rooms and in storage areas. They are often used to store the street clothes, shoes and lunches of operational personnel. The lockers come either assembled or unassembled. Options include:

- Color
- Size
- Number of lockers per assembly

CLEANROOM PACKAGING

Cleanroom packaging, in the form of bags, tubing, and film, is used to protect a product from becoming contaminated from the surrounding environment. Cleanroom tubing and film is thinly extruded polyethylene or nylon. Cleanroom bags are nothing more than tubing or film that has been heat-sealed to form a pouch. Typically, all parts and components used in the cleanroom are double bagged.

Since the function of cleanroom packaging is to protect the product from the environment, it is very important that the raw material from which packaging is made is very clean. Also, the environment in which the film is converted to bags needs to be properly classified so as no to introduce contamination during production.

There are many different types of film and bags used in our industry. Low-density polyethylene (LDPE) virgin resin is the primary material of construction for cleanroom film. This material is available in many different thicknesses, widths, and lengths, and can be processed to meet special applications.

LDPE CLEANROOM BAGS

These bags are used to package everything from cleaned laundry garments to parts and finished product. The best bags are cleaned using an automated, web-vacuum ionization system that removes particles from extruded film prior to sealing and cutting the roll-stock into bags. The bags themselves are usually double or triple bagged for to ensure that they are clean when they are used.

LDPE INDUSTRIAL BAGS

These bags are extruded from LDPE resin and made into a variety of sizes and mil thickness. They are inexpensive because they are made from recycled material and are not processed in a cleanroom. They are used to package industrial parts and other various other non-critical applications. They can be purchased in open top or zip lock styles. Some bags are available with writing spots on them for product identification.

LDPE ANTI-STATIC BAGS

These bags are usually known as “pink poly” bags. They are used to handle ESD sensitive parts. They are relatively inexpensive and come in various sizes and mil thickness and are offered with a flat top of a zip lock top.

STATIC SHIELDING BAGS

These multi-layered bags are silvery in color because they contain a thin layer of aluminum or nickel in the middle. The metal layer acts as a complete “faraday cage” for protecting components from any source of static electricity discharge. The inner layer is usually an anti-static polyethylene and the outer layer is usually a tough polyester to protect the bag from punctures. These bags can be made with an open top or a zip lock top. Used routinely by manufacturers that are shipping ESD sensitive parts, components and loaded circuit boards.

NYLON CLEANROOM BAGS

Nylon bags are unique because they are extruded from nylon resin that is stronger and has a higher temperature range than polyethylene. Usually an additive is mixed with the nylon to render the bags anti-static or static dissipative. Nylon is much stronger and abrasion resistant than polyethylene. It is often used as the inner bag for stainless steel parts and components that have sharp edges that would cut through a polyethylene bag.

REFERENCES / RESOURCES

GSFCC.org

Global Society for Contamination Control

Controlled Environment Wiki

Critical-tips.com

Critical Environment Best Practice Video Blog

IEST.org

Institute for Environmental Sciences & Technology

ESDA.org

Electro Static Discharge Association

Wallace, J., (2001) *Semiconductor Desk Reference*, Texas Engineering Extension Service.

CLEANROOM GLOSSARY

Absorption
To take up a substance into or throughout a material or fabric by physical or chemical means. For example, protective clothing may act more like a sponge and absorb certain liquids rather than act active barrier. When evaluating wipers, a higher absorbent capacity and rate are preferred. Absorption is often tested with both Ultrapure water, and an IPA solvent.

Acid
An acid is a substance that dissociates in solution to produce hydrogen (H^+) ions and they have a pH value of 0 for strong acids to less than 7 for mild acids. (A pH of 7 is neutral.)

Air Particle Count (APC)
A test method to determine the density and size of a specific airborne particle.

Ambient temperature
The temperature of the environment (air) around a suite, object or individual.

Analog
A term to describe a value which can be continuously variable over a defined range, rather than having only a fixed number of distinct permitted states.

Analog integrated circuit
A type of integrated circuit in which the signals are continuous and can take on any value within a range, instead of just one of two possible values (digital). Analog chips are often used for applications like multimedia and communications. Testing of analog chips must be done on a test designed to be able to handle analog signals.

Analysis
Analysis is a term for the separation of the desired ion species in an ion implanter. It is based on the ion mass, charge and energy (voltage with which it is accelerated). The separation is done by the magnetic field in the analyzer.

Aqueous solution
An aqueous solution is which water is used as the solvent. An aqueous solution of potassium permanganate ($KMnO_4$) is such a solution.

ASTM
American Society for Testing and Materials – Guidelines for safety and standardization of manufactured goods. Organized into 140 committees. Co F23 is made up of individuals representing both producers and users of protective clothing. The group develops test methods and voluntary standards assessing the performance of protective clothing against occupational hazards.

ASTM F1001
Standard chemical test battery used to compare material resistance across like chemicals. Currently consists of 15 liquids and 6 gases with each chemical representing a different family of chemicals.

ASTM F1052
Standard practice for pressure testing of “Level A” totally encapsulating chemical protective suits. Test if suit has “air leaks” which could possibly allow entry of hazardous substances.

ASTM F739
Standard test method for resistance of protective clothing materials to permeation. Fives consistent and repeatable method to determine if material “X” provides sufficient barrier to chemical “Y”.

Atmospheric pressure
The pressure the earth’s atmosphere at sea level. The pressure is equal to 14.7 pounds per square inch or the equivalent to 760 mm of mercury.

Atmospheric pressure chemical vapor deposition (APCVD)
This is a diffusion process that uses heated process gases at atmosphere pressure to deposit films onto silicon

Atom
Small building block of matter. All materials and elements are composed of atoms.

Atomic force microscope (AFM)
A microscope that works by bringing a fine needle right up to the surface of a semiconductor and tracing the topography of the material. AFM’s are an alternative to scanning electron microscopes as a means of measuring and monitoring the widths and heights of critical geometries (critical dimensions – CDs) on a circuit.

Atomic mass
The number of protons and neutrons in the nucleus of given atom measured in atomic mass unit (amu).

Back end manufacturing
The portion of semiconductor manufacturing that happens after the wafer has left the cleanroom. This includes testing the chips at wafer level, repairing the chips if necessary, dicing the wafers and putting the individual chips into packages. In short, back end manufacturing is test and assembly. There is a growing trend among semiconductor manufacturers to outsource the assembly, and often the testing too, to independent assembly houses.

Back grind
Thinning the wafers just before dicing them up in the packaging process by grinding away at the reverse side of the wafer on a grinding wheel. Wafers must be a certain minimum thickness during processing or they will break too easily. If the chips are too thick they become difficult to package.

Bar
A unit of pressure in the British measurement system. One bar equals 101,325 Pascals and one atmosphere equals 1.013 bars of pressure.

Base (chemical)
A base is a substance that dissociates in solution to produce hydroxide (OH^-) ions.

Bias
A mask or reticle where the relative dimensions of the transparent and opaque regions are different from the pattern to be transferred is said to have bias.

BiCMOS
The family of solid-state devices using both bipolar and CMOS structures on the same substrate.

Binning
Classifying chips by their performance (usually speed) – the analogy is to physically drop things into different bins. This happens at the final test. Once the chops have been packaged, they are tested one more time to see if they work and how well they perform.

Bipolar
The family of solid-state devices whose operation depends on the conduction of two polarities of charge carriers.

Body Box Test
This is a test to determine how particle shed a garment has. During the body box test, a subject is placed in a Class 10 room and performs a series of activities during a 10 minute test period. The activities include arm extensions for 3 minutes, walking for 3 minutes and doing 5 deep knee bends in 1 minute. These activities are separated by 1 minute intervals of standing still. The data is reported as the average number of particles .5 micron and larger counted per minute during the 10 minute test period.

Boiling Point
The temperature at which a liquid turns to gas in standard atmospheric pressure. For example, the boiling point of water at sea level is 100°C, 212°F.

Bond (atomic)
A chemical connection between atoms in which electrons are share. Commonly called covalent bonds.

Bootie
A sock-like extension of the suit leg designed to protect the wearer's feet. Allows the wearer to use his own boots while ensuring the chemical protection provided by the primary suit material.

Bound seam
A clean-finished binding that encapsulates the raw edges of two plies of fabric. All layers are sewn through with a chain stitch.

Boule
More commonly called Ingot or log. A doped, cylindrical, single-crystal form of solid silicon produced by the Czochralski method which is sliced into wafers.

Breakthrough time
The time that elapses between the time the challenge chemical first contacts the test specimen (e.g. suit fabric) and the time at which the chemical is detected on the collection side of the permeation cell. Basically, how long dies the suit material “X” holds out challenge chemical “Y”? This is determined by permeation testing. Also referred to as “Chemical Detection Time”.

Bulk gases
Bulk gases refer to gases that are stored on site in large quantities and piped to the fab area as required.

Butyl
Synthetic or man-made rubber. Invented during the 1950’s for use in everything from car tires to chemical warfare suits. Considered a durable fabric, it has good barrier to a limited number of chemicals.

Challenge agent
The chemical or mixture to which a material is exposed. Also called “attacking chemical”.

Capacitor
An electronic component composed of two conductive surfaces separated by a dielectric. It can be used to store an electrical charge.

Cassette
Cassettes are plastic containers used to transport or store wafers in the fab.

Cellulose
A major component of wood, cotton, and other plant materials. The constituent atoms are carbon (C), hydrogen (H_2), and oxygen (O_2). They combine in a particular fashion to give a chain-like form, often a single molecule containing more than 100,000 of these various atoms.

Charge (crystal growth)
Molten polysilicon and dopants (generally boron or phosphorus) of which a single crystal is grown.

Chemical Mechanical Planarization (CMP)
Chemical mechanical planarization is a surface planarization process that combines physical polishing with chemical etching. The wafer is rotated in contact with a

rotating polishing head in the presence of a polishing compound and a chemical etchant.

Chemical Mechanical Polishing (CMP)

Polishing the top surface of a wafer aided by a slurry containing abrasive grit suspended in reactive chemical agents. As the name implies, the polishing action is partly mechanical and partly chemical.

Chemical Vapor Deposition (CVD)

Deposition of thin films (usually dielectrics or insulators) on silicon wafers by placing the wafers in a mixture of gases that react at the surface of the wafers.

Class 10

When referring to a clean environment, Class 10 means that there are no more than 10 particles that are 0.05 mm per cubic foot of air.

Cleanroom

The facility in which semiconductor manufacturers process their wafers. Dust and particles that might fall on the wafers during processing and result is not working are kept out of the cleanroom by filtering the air and managing the airflow. Humans are required to wear specially designed cleanroom apparel over their street clothes, and must put on gloves and face masks.

Cleanroom Classification

ISO Class	English	Metric
ISO 14644-1	Fed Std 209E	
1		
2		
3	1	M 1.5
4	10	M 2.5
5	100	M 3.5
6	1000	M 4.5
7	10000	M 5.5
8	100000	M 6.6
9		

Cm2

Square centimeter. Measure of area about equal to the size of a standard shirt button.

Complimentary metal oxide semiconductor (CMOS)
The family of solid-state devices using both n-channel and p-channel MOS devices on the same substrate.

Composite (Films/Materials)
Refers to materials constructed with two or more layers of dissimilar (different) materials. Generally exhibit broad chemical resistance. Adding more layers increases the barrier protection of chemical protective clothing.

Conductive
The measure of a material's ability to conduct or carry electrical current.

Contamination
Any material, substance, or energy that is unwanted or adversely affects the process or product

Contaminant
An undesired substance in the semiconductor material or process.

Contamination Control Best Practices
Any material, substance, or energy that is unwanted or adversely affects the process or product

Control variables
Process or equipment parameters (pressure, temperature, time, etc.) that affect the final product.

Critical dimensions (CD)
The size of the smallest line, spacing or feature overlap critical to device or circuit yield performance.

Cross contamination
Cross contamination occurs when the same implanter or furnace is used with different ion species or dopants.

Crystal
Material in which all the positions of all the atoms follow a precise pattern which is repeated throughout the material.

Czochralski (CZ) method
The crystal formation is done by dipping a seed into the melt and slowly pulling the crystal from the molten polysilicon. This method is widely used for growing silicon crystals.

Damascene process
A way of making metal lines which involves depositing an insulator (oxide), etching a trench in the oxide, depositing metal everywhere and then polishing back with CMP so there is just metal left in the trench. This is the opposite of the traditional

sequence that has metal being deposited first, the metal being patterned through etching, and the oxide being deposited to try to fill the gaps between the metal.

Degradation
Refers to the loss of integrity of a material when attacked by a chemical. When a glove is dipped into a chemical, does it change color, wrinkle, fall apart, or show other signs of attack? Test are usually based on weight gain over a period of time, in other words, has material absorbed chemical? Does not indicate if gases passed through material (permeation).

Deep ultraviolet (DUV)
Deep Ultraviolet exposure sources at 248 nm.

Dice
Semiconductor chips. Plural of die.

Dicing
Cutting up the wafer into individual chips. This is usually done with a circular saw called a dicing saw.

Die
The term for a single semiconductor chip. Strictly speaking, the plural of die is dice, though engineers have a tendency to use the term die both in singular and the plural.

Die attach
Attaching a die to its mount in its package. This is often done with a metal-based glue-like silver epoxy for good conduction of heat way from the chip. Chips get hot when they are running in normal operation, so packages must be designed to help dissipate the heat.

Dielectric
See insulator.

Digital
A type of circuit in which the signals can have only one of the two possible states (an “I” or an “O”). This is in contrast to analog circuits in which the signals are continuous and can take on any value within a range.

Discrete circuits
Circuits made up of discrete devices mounted and interconnected on an insulting surface such as a printed circuit board.

Displacement
The process of physically displacing an undesired gas form the purge volume.

Doffing
Taking off a cleanroom glove or suit.

Donning
Putting on a cleanroom glove or suit.

Dopant
Tiny amounts of impurities can change the electronic properties of the silicon, affecting greatly how it conducts electric current. Selected impurities called dopants are deliberately introduced into the silicon to create devices such as transistors.

Doping Cleanroom
The introduction of desired impurities into a semiconductor substrate modify the electrical characteristics is known as doping. There are two types of dopants, p-type and n-type.

Dry etching
Another name for plasma etching.

E-beam lithography
E-beam lithography uses a focused beam of electrons to form an image on the resist surface without using a mas in a manner similar to forming an image on the screen of the cathode ray tube (CRT).

Elastomeric
“Rubber” based materials; e.g. Butyl, Neoprene, and Viton. Typically durable but have limited chemical resistance.

Electrolyte
Electrolytes are solutes that dissolve in water to give an electrically conductive solution.

Electrostatic discharge (ESD)
The transfer of electrostatic charge (static electricity) between objects due to their electrical potential difference. Electrostatic discharge (ESD) can damage or destroy semiconductor devices.

Elongation
Stretching without breaking. One of the physical properties used to compare fabrics and gloves. For example, a cleanroom nitrile glove should be able to be elongated 650% prior to it bursting.

Encapsulation
Encasing the die in plastic as part of the packaging process. This is done after the die has been attached to its lead by clamping a mold around the die and injecting molten plastic into the cavity of the mold

Endothermic (Reactions)
A process or chemical reaction that is characterized by the absorption of heat.

Energy contamination
During ion implantation, energy contamination occurs when the ion beam contains ions traveling at two or more different energy levels.

Environmental test
Complete device test performed at elevated and lowered temperatures. May include application of environmental stress by repetitive thermal cycling between specified temperature extremes

Epitaxial (epj)
A typically thin, single-crystal silicon film that is grown on a wafer. The epi film takes on the same crystal structure as the substrate.

Epitaxy
The deposition of a thin film of silicon on a silicon wafer, in such a way that the deposited layer forms a single continuous crystal with the underlying wafer. This method is used to create a high quality, low doped surface in which to make transistors and other devices on top of a highly doped substrate with a low electrical resistance.

Etching
Etching is the process of removing unwanted material from the wafer surface by physical or chemical means or a combination of the two.

Evaporation
The changing of a liquid to a gaseous state. See also: Boiling Point, Sublimation, and Vapor Pressure.

Exothermal (Reactions)
A process or chemical reaction that is characterized by release of heat, for example, combustion reactions.

Extreme Ultraviolet (EUV)
A new process to lithography that permits smaller feature sets.

F.E.P.
Fluorinated ethylenepropylene – type of material commonly known as Teflon® – used in clear form as an overlay for chemical suit visors, to provide extra chemical protection. (Also known as Fluoroethylene Polymer).

FAB
Short for wafer fabrication facility - a semiconductor factory. Often used to refer to a semiconductor cleanroom. In a broader sense, non-semiconductor, high technology firms will refer to their manufacturing area as the FAB.

Field
Since a photolithographic stepper cannot accurately deal with imaging the microscopic circuit features over all of a wafer at one time, it exposes an area it can easily manage. This is called a field. The stepper will keep moving the wafer and

exposing a new area the size of a field till the whole wafer is done (about 80 fields on an 8-inch wafer).

Film (products/fabrics)
Usually refers to materials composed of multiple layers. Such products generally are less durable, but present a wider range of chemical holdout than elastomeric fabrics.

Final test
A series of electrical and mechanical quality and reliability tests of the packaged device that vary according to device specifications or customer requirements. The last tests before shipment.

Flame resistant
Material that inherently resists ignition (burning), melting or other degradation when exposed to heat or flame.

Flame retardant
Material that is typically treated to extinguish itself upon ignition from a flame source.

Flash point
The specific temperature above which solvent vapors will ignite in the presence of an open flame.

Flexural Fatigue Test
Physical test used to measure the durability of a suit material. NFPA test consists of twisting a fabric many times.

Flow rate
The rate at which a quantity of fluid or gas passes a given point, expressed as volume over time (ft3/min, cm2/min).

Footprint
The area a machine takes up in the cleanroom. This is important because cleanroom space is expensive, and so minimizing the footprint of a machine is a good thing to do. There are two numbers that semiconductor manufacturers are interested in – the footprint and the linear frontage number (length of the front of the machine). The linear frontage number w many machines will fit into a bay since the machines are all lined up side by side.

Fourier transform infrared spectroscopy (FTIR)
A powerful analytical tool. In this method, infrared spectra of a sample are collected at all frequencies of the frequency range allowed by the equipment at the same time. The data are then analyzed by computer to give infrared spectra in the form of absorption vs frequency. These spectra are then used as fingerprints to identify different species.

Front-end manufacturing
This refers to wafer processing that takes place in the cleanroom, as opposed to processing that happens after the wafer has been essentially finished. Once the

wafer is done with its cleanroom processing, it moves into the back end manufacturing which involves test and assembly (packaging). There is potential for confusion with this terminology because semiconductor engineers also divide the front end manufacturing into two parts, called front end processing and back end processing. Front end processing is the device formation part, and the back end processing (in the wafer fab) is the part in which all the interconnect wires of the integrated circuit are laid down and defined.

Furnace
A long glass (quartz) tube that can be heated to high temperatures. Furnaces are used for giving wafers heat treatments, oxidizing them, or reacting gases in the vicinity of the wafers to result in the deposition of thin films on the wafers (CVD). Furnaces used to be horizontal (long direction parallel to the floor) but current generation ones built for eight inch wafers are mostly vertical (tubes standing upright).

Gas
One of the three physical states (gas/solid/liquid) in which a chemical or substance can appear. This state is characterized by very low density. The gas phase of a substance is dependent on temperature and pressure. Many chemicals appear commercially in liquid and gas state, and require different levels of protection accordingly.

Gas cabinet
An enclosure where the high pressure compressed gas cylinders are stored. This containment enclosure (cabinet) contains the valves, gauges and safety devices needed to handle and store the compressed gases.

Gate
The control element of MOSFET. Also, a digital decision making device, for example, AND gate, OR gate and NOR gate.

Glass
Within the semiconductor industry usually refers to amorphous silicon dioxide (SiO_2) film.

Hazardous chemical
Any substance that can cause physical harm.

Helmke Drum Test
A test for measuring air particle shedding of cleanroom gloves, wipers, and garments used for cleanroom applications. For example, a garment is tumbled for 10 minutes at 10 revolutions per minute in a stainless steel drum having an enclosed volume of 1 cubic foot to determine the average rate of release of particles 0.3 microns and larger. An air particle counter (APC) is used to sample the air at the rate of one cubic foot per minute during the ten minute test period. The particle counts are then summarized per standard test method.

High k e dielectric
An insulator which will not conduct electricity but which when sandwiched between metal plates will easily allow these plates to talk to each other via electric fields (this is called a capacitor structure). While high k dielectrics are good for capacitors, the opposite is true of the insulators used to separate metal lines, for which low k dielectrics are desirable.

High-Density Plasma (HDP)
Plasma that contains a high concentration of reactive elements. High-density plasmas are used in advanced plasma etchers and CVD machines.

High-Density Plasma CVD (HDPCVD)
A chemical vapor deposition technique in which a concentrated plasma is created. This suppresses the bulging at outside corners that standard CVD films tend to show. HDPCVD is thus a good solution to the problem of getting insulating films to fill in between narrowly spaced metal lines (the gap fill problem). Gap fill is becoming more and more of an issue as semiconductor manufacturers scale down circuit dimensions.

High-Density Plasma Etcher
An advanced etcher that uses high-density plasma. This results in a better capability for etching small geometries with straight vertical walls (especially difficult for small deep holes) and good selectivity (etching only the layer to be patterned and not attacking the layer beneath.)

Hook and loop
Fastening technique for storm flap closures. Common trade name is Velcro

Humidity Control
The percentage of H20 in the ambient air. Typically, Controlled Environments set humidity in the 35-50% range. Higher H20 content in the ambient air reduces static electricity.

Hydrophilic
Literally meaning water loving. Compounds that have polar groups showing charge separations will attract water molecules that are also polar. A wafer coated with an oxide layer when dipped in water will not shed all of its water (in other words, it will be wetted) because of the hydrophilic nature of silicon dioxide.

Hydrophobic
A surface repelling water molecules. Water will not stay on a clean silicon wafer surface because of its hydrophobic nature.

Immiscible liquids
Liquids that do not mix with each other, but maintain a clear boundary separating them. Organic and inorganic liquids normally show this type of behavior.

In situ measurements
Are measurements of process parameters such as film thickness or resistivity made in the process chamber during processing.

Inches of water (or cm of water)
A measure of pressure.

Inert
An inert gas is a gas, such as nitrogen (N_2), that does not react readily with other gases or materials. An example is nitrogen (N_2).

Infrared spectroscopy (FTIS)
An infrared beam is passed through silicon and from the absorption of part of the beam, the concentrations are determined. The method uses mathematical manipulation of data employing Fourier transform.

Ingot
A large doped, cylindrical, single silicon crystal which is the result of the crystal growth process and from which wafers are but (also called “boule” or “rod”).

Inking
The process of marking bad dice on a wafer with dots of ink so that these dice will be discarded without the expense of putting them in packages.

Integrated circuit
A complete electronic circuit with transistors and wires connecting these transistors on a semiconductor chip.

Inter Bay Automation
Automated transport of wafers throughout the entire fab, between the machine bays. One way of doing this is with an overhead monorail system.

Interconnect
Wires patterned in integrated circuits to connect different devices together.

Intra Bay Automation
Automated transport of wafers within a bay of machines. There are a number of products that are used for this, as machine interfaces are not yet standardized. Mobile robots that run on rails, or are free standing, can be used. Another option is to extend a brand off a central inter bay overhead

Ion
An ion is an atom or molecule that carries an electrical charge due to the gain or loss of electrons. A negative ion has an excess of one or more electrons. A positive ion, on the other hand, is missing one or more electrons.

Ion beam lithography
Ion beam lithography has two modes of operation, focused ion beam and showered ion beam. Focused ion beam lithography uses a focused beam of ions to form an

image without the use of a mask. Showered beam lithography passes a collimated ion beam through a proximity mask to expose a layer of resist.

Ion implantation
The process by which dopants are introduced in exact quantities into silicon. A stream of charged particles (called ions) or phosphorus, arsenic, or boron is created and then directed at a silicon wafer at a precisely controlled velocity (energy). In this way both the concentration and depth of the dopant can be controlled.

Ionization
A process to reduce static electricity in a controlled environment.

Insulator
A material that will not allow an electric current to flow through it. In everyday life, we cover electric wires and plugs with rubber or plastic, which are insulators, so that we do not get electric shocks. In semiconductor chips, commonly used insulators are silicon dioxide (glass) and silicon nitride (silicon+nitrogen). Semiconductor engineers more often refer to these materials as dielectrics.

Joule
SI unit used to measure the amount of work performed or the amount of energy expended.

Killer defects
Killer defects are defects that are directly involved in the degradation of device performance.

Lattice
A lattice is a purely geometric concept and can be defines as an infinite one, two or three dimensional arrangement of points, each of which has identical surroundings.

Lead
A name for the metal prongs which stick out of a chip package, allowing electrical connection between the chip inside the package and the outside world.

Lead frame
A spider-like frame of wires that the chip will be connected to. The lead frame is bent to form the metal pins that run out of the semiconductor package. This allows the packaged chip to be plugged into its electrical socket so that it can function.

Liquid
A substance that, unlike a solid, flows readily, but unlike a gas, does not tend to expand indefinitely. Important to know state of chemicals – gas, liquid, or solid – when determining type of protective clothing necessary.

Liquid Particle Count (LPC)
A test method to determine the density and size of a specific particles in a liquid sample.

Logic Chip
A chip that does computations, makes decisions, or makes things happen. Chips can be loosely defined as either logic chips or memory chips.

Low k dielectric
A type of insulator that isolates metal connections, preventing these from interfering with each other. Metals that are close together can affect each other’s signals through the electric fields that run between them.

Low pressure chemical vapor deposition (LPCVD)
A deposition process that uses a process gas at low pressure to deposit thin films on silicon wafers.

Mask
The slang expression photomask or reticle. The negative from which the device pattern is printed.

Mask (photolithography)
A glass plate with one surface coated by opaque material (typically chrome) providing the photographic pattern for an entire wafer.

Masking layer
A patterned layer associated with a semiconductor integrated circuit. A typical circuit will require between 12 and 25 masking layers for full definition.

Masa flow controller (MFC)
A device used to control, monitor and deliver precise gas flows. It consists of three parts a mass flow meter, a controller and a valve.

Mass spectrometer
A device that filters or selects ions depending upon their mass-to-charge ratio.

MDL
Minimum Detection Limit. See System Detection Limit.

Megasonic cleaning
A liquid medium based cleaning system which uses sonic energy in the frequency of 0.8 to 1 MHz The acoustic waves agitate the liquid around the particles helping to dislodge them from the wafer surface.

Memory Chip
A chip that retains information for logic chips to use.

Micron
One thousand microns make one millimeter. A human hair is about 100 microns thick. A transistor in an advanced semiconductor process might have an area of about 4 microns by 1.5 microns (though of course transistors vary greatly in size depending on their purpose.

MIL
Unit of length or thickness. 1/1000 (.001) of an inch.

Mullen Burst Test
A physical property test for material strength. Represents the force that would be applied when a bending elbow bursts through a shirt sleeve.

Millibar
A vacuum pressure measurement unit equal to 10^2 Pascals or 0.75 Torr.

Molecular beam epitaxy (MBE)
The epitaxial growth of material using ultra-clean molecular beams.

National Institute for Standards and Technology (NIST)
A U.S. government agency responsible for methodology standards. NIST was formerly known as National Bureau of Standards (NBS).

Neoprene
Natural rubber, non-synthetic. A durable elastomeric material with moderate chemical resistance.

NFPA
National Fire Protection Association.

NFPA 1991
Performance standard for vapor protective clothing.

NFPA 1993
Performance standard for disposable protective garments used in decontamination procedures.

NIOSH
(National Institute for Occupational Safety and Health) – A regulatory or respiratory protection; technical advisement for OSHA.

Non-conductive
A property of an object, substance or material which restricts or prevents the flow of electricity.

Non-volatile memory
Semiconductor memory that will not forget its data once the power is switched off. This is in contrast to volatile memory that loses information when there is no power supplied to the chip.

NFPA 1992
Performance standard for splash protective garments.

Nonvolatile memory
Nonvolatile memory does not lose its stored information when the equipment loses power. PROM EPROM and EEPROM are examples of nonvolatile memory.

Notch or flat
A particular indentation on a wafer used to identify its crystal orientation. Some flats identify the dopant type used as the wafer substrate.

Nucleus
The nucleus is the central core of an atom. It is made up of two types of particles, protons with a positive charge and neutrons with no charge. The nucleus contains almost the entire mass of the atom.

Ohm’s law
Electrical law which gives the relationship between voltage (V), current (I), and resistance (R): V = RI.

Organic compound
A chemical compound made up of carbon (C), hydrogen (H), and one or more other elements, such as oxygen (O) or nitrogen (N).

Orifice
A very small hole in which gases or liquids flow in controlled amounts.

Outgassing
When a system is undergoing vacuum (pumped down), contaminants and condensed gases may vaporize and act like a leak.

Oxidation
The oxidation process is used to insulate. Silicon can be oxidized to become silicon dioxide by raising it to high temperatures (about 900 degrees centigrade or above) in an oxygen environment. Silicon dioxide is an insulator, and so is used in semiconductor circuits to isolate different conducting regions.

Particulates
Bits of undesired material that are present on the wafer surface caused by any number of sources including wafer handling equipment and cleanroom personnel.

Part per billion (ppb)
A measurement counting the amount of doping or contaminations by volume per total volume. In this case X parts per billion parts.

Parts per million (ppm)
A measurement counting the amount of doping or contaminations by volume per total volume. In this case X parts per million parts.

Pascal
The standard metric unit for pressure of which one atmosphere is equal to 101,325 Pascals.

Pass Through
A bulkhead coupling system or chamber that allows materials to be passed between the cleanroom and a corridor without causing contamination.

Pellicle
A thin transparent membrane stretched over a metal frame that is mounted over a mask or reticle as a means of protection from dust and other contaminants.

Penetration
Visible physical entry of a chemical in liquid form through an opening such as a seam, zipper, or similar area. Not on a molecular level as with permeation.

Permeation rate
The rate at which permeation occurs. Commonly expressed a micrograms per square centimeter per minute (µg/m2/min).

Permeation
Refers to the passage of a chemical through a protective clothing material on a molecular level. Gases may be passing through the material leaving no detectable physical signs of damage to the clothing. Unlike degradation, testing for permeation involves elaborate gas detection instruments. It is the highest level of testing available for protective clothing fabrics.

Photolithography
The photographic process used to transfer circuit patterns onto a semiconductor wafer. This is done by projecting light through a patterned reticle, onto a silicon wafer covered with a photosensitive material (photoresist). A reticle is a glass plate with a layer of chrome on one side.

Photoresist
Sometimes referred to as resist. This is a photosensitive material that will dissolve in developer if it has been exposed to light. Patterns are transferred to a wafer by covering the wafer with photoresist, exposing a pattern in the photoresist and then using the patterned photoresist as a mask through which to implant dopants or etch the material.

Physical Vapor Deposition (PVD)
Deposition of thin films by physical means as opposed to chemical means. This is most often used for deposition of metals. The most common firm of PVD is sputtering, in which a metal target is exposed to a plasma gas like argon which is not chemically reactive. The excited gas atoms hit the target and knock off metal atoms that deposit onto a wafer place below, building up the desired metal film.

Piranha
Piranha is the name given to a cleaning solution made up of sulfuric acid (H_4SO_2) and hydrogen peroxide (H_2O_2). It was given the name piranha because when the two chemicals are mixed, the solution heats to about 120^{o}C and bubbles vigorously.

Planarization
Flattening the surface of the wafer. Both the devices and the metal wires used in the circuits have height. Several layers have to be built up, one on top of another, to make a complete circuit. It is difficult to create the lithography and etching layers if the surface of the wafer is not flat. Thus, every so often process steps must be added in to flatten the surface of the wafer. This is called planarization, and in modern advanced processes it is often down with chemical mechanical polishing (CMP).

Plasma
A highly excited gas. Plasmas are created by exposing gases at low pressure to an electric or electromagnetic field. In semiconductor processing, plasmas are used for etching and thin film deposition (the excited state of the gas makes it very reactive).

Plasma Ashing
A variant of plasma etching, used specifically for removal of photoresist. A plasma of oxygen ions is created and these ions react with the oxygen and carbon which make up photoresist to create water vapor and carbon dioxide. The photoresist is thus burned away or ashed, not so much because of high temperature, like in a fire, but because the oxygen is made particularly reactive when it becomes a charged ion in the plasma.

Plasma Enhanced Chemical Vapor Deposition (PECVD)
Chemical vapor deposition in which a plasma is created from the reactant gases. The ions in the plasma are in an excited state and so will easily react with the silicon wafer, without the need for elevated temperatures as in conventional (thermal) CVD.

Plasma Etching
Also called dry etching. This involves using plasma gas to etch a semiconductor layer. Plasma contains highly excited molecules (reactive ions) that easily react chemically. There is also a physical bombardment mechanism in that the ions are accelerated towards the wafer with an electric field. Plasma etching is usually anisotropic, which means that the etching takes place in only in one direction (line of sight). This is a key advantage over wet etching with chemicals.

Platform
The frame of the machine, including robotic handling apparatus, needed to feed wafers from their loading station into the individual process modules in which the processing will occur. Cluster tools are machines in which more than one process chamber is mounted on the platform, so that several wafers can be processed at a time (with identical or different processes).

Polarization
The process by which ordinary light (for example, from a light bulb) is confined to oscillate in a particular place. Filters or polarizers, made out of certain compounds, will allow only one component of light to transmit through and absorb the rest.

Polycrystalline
The structure of polycrystalline materials consists of many small crystals of varying size and orientation within the solid. Polycrystalline materials are not as ordered in structure as single crystal materials.

Polymer
A general term used to define chemical compounds such as polyethylene or polypropylene. Technically they are long chains of molecular bonded repeating structural units of the original molecules.

Polysilicon
Silicon that is deposited on wafers in a form that is crystalline, but is not one continuous crystal like the silicon wafers are. Polysilicon is used as a critical part of a transistor called the transistor gate. It is also sometimes used as a resistor, and as a wire for connecting things together (although it does not conduct electricity as well as the metal wires used in integrated circuits).

PPB
Parts Per Billion. A typical example of part per billion is one second in 110 days.

PPM
Parts Per Million. A typical example of part per million is one second in 11 days.

Pressure
A physical force on a surface expressed as force per unit area, for example, pounds per square inch (psi).

Pressure Testing
Standard test used is ASTM Method F1052. Tests for leaks that would compromise the vapor protection of a chemical suit.

Preventive maintenance (PM)
A periodic process of replacing, cleaning or calibrating components on process tools.

Primary Suit Material
The material that is used for the main body parts of a garment.

Prober
A machine for aligning contacting pins (probe cards) to the dice (chips) on a wafer, so that these chips can be electrically tested even before they are packaged and connected to standardized metal leads. This is termed wafer level probing.

Process uniformity
This is a measure of the consistency of the process from batch to batch or wafer to wafer.

PVC
Poly Vinyl Chloride. A durable thermoplastic material with a variety of uses from floor tiles to protective clothing fabric and face shields (visors). Good durability but has limited range of chemical protection. Typically used for protection against acids.

Puller
Equipment used in the Czochralski method to grow silicon ingots including the apparatus to dis seed crystal into the molten silicon (melt) and to lift the grown crystal away from the melt.

Qualification sample
A wafer that is used to monitor a process by placing it in the chamber with the production wafers. Product characteristics such as film thickness, resistivity, and uniformity are measured on the qualification sample to check characteristics of wafers processed with the sample.

Quartz
High purity, high melting point silicon dioxide glass which is typically used in high temperature applications.

Radiant heat
The energy given off (for example from a flash fire) in the form of infrared radiation, like that from a heat lamp.

Radio frequency (RF)
Electromagnetic radiation that is alternating current (AC) I the radio frequency range (audio frequencies low kHz to the microwave frequencies low GHz). For industrial use, 13.56 MHz is the band for frequencies set aside by the Federal Communications Commission for Industrial use.

Random access memory (RAM)
Memory is which each storage location can be addressed and its contents changed in random order repeatedly.

Rapid thermal processing (RTP)
A method of rapidly heating up a wafer by exposing it to bright lamps. Wafers can be raised from room temperature to up to 1100 degrees centigrade in seconds, and cooled in a similar length of time.

Read only memory (ROM)
A Random Access Memory in which the sored data pattern is available only for reading access in normal operating conditions. The contents cannot be overwritten with new information.

Reagent grade
The highest concentration of a chemical commercially available. Typically greater than 95% concentration.

Reduction stepper
A photolithography machine that reduces the image that is projected onto the wafer. The typical reduction factor is 5x, which makes the process easier for the reticle makers since they can make the features on the reticles five times larger than what is needed on the circuit.

Resist
A common term for photoresist.

Resist track
Sometimes called a track. A common name for a photoresist spin coater. The term “track” comes from the early designs in which wafers were transported to and from the spin stations on parallel rails called tracks. These days the more advanced spin coaters use robotic arms for movement of the wafers.

Resistivity
A property of a material that is a measure of the materials ability to resist the flow of electric current. The resistivity unit is ohm-centimeter.

Resistor
A component that opposes current flow.

Resolution
The smallest feature size that can be repeatedly produced on a wafer.

Reticle
Sometimes called a mask or a photomask. This is a glass plate with chrome on one side in which a pattern is etched. The pattern is transferred to the wafer by shining light through the reticle. A typical semiconductor circuit will need between 12 and 25 masking layers.

Salt
A salt and water are the products of a reaction between an acid and a base.

Scanning Electron Microscope (SEM)
A microscope that uses an electron beam to image very small features. SEMs have much higher resolutions than optical microscopes. SEMs are used in semiconductor manufacturing for measuring the widths of circuit geometries.

SCBA
Self-Contained Breathing Apparatus. Typically 1-2-air tanks worn on the back and connected to a full-face mask respirator.

Scientific notation
A method for describing very large and very small numbers through the use of powers of 10. As an example: 624,368 is expressed as 6.24368×10^5.

Scrubber
An inline chamber containing a liquid or solid absorption material that is placed in the exhaust of process furnaces to remove hazardous gasses.

SDL
System Detection Limit. Describes the sensitivity of the instruments used for detecting gases during permeation testing. This limit is determined prior to each permeation test by exposing the detection device to a minimum known quantity of the challenge chemical which will produce a measurable signal. SDL is expressed in parts per million.

Seam
Where two sections of a garment are joined. There are several types available; examples include felled, serged, bound, taped.

Seed crystal
Small crystal which is used as the starting material for growing larger crystals.

Semiconductor
An element or material used as the base material for solid state devices. Semiconductors have electrical characteristics which fall somewhere between conductors and insulators.

Serged seam
A seam where three threads are interlocked around the raw edges of two plies of material.

SI units
Complete unit system that includes, the meter, the kilogram, etc., and which is based on multiples of ten (also called international system).

Silicon
Pure silicon is used to make almost all the semiconductor chips currently sold on the market. Silicon is not the only semiconductor that can be used to make integrated circuits, but it does have many properties that make it much better for this purpose than the other known semiconductors. When silicon is combined with oxygen it becomes silicon dioxide.

Silicon Dioxide
Sometimes just called oxide in the semiconductor industry. Sand on the beach and the glass from which we make bottles is silicon dioxide. Silicon dioxide is an insulator, and is used in semiconductor circuits to isolate different conducting regions. Silicon dioxide can be grown from silicon by exposing it to oxygen at high temperatures, or it can be deposited using chemical vapor deposition.

SMIF (Standardized Mechanical Interface)
A wafer manufacturing concept in which wafers are kept in sealed pods when they are not being processed in machines. One of the original drivers for SMIF was the

thought that this would reduce particle contamination and possible render large-scale cleanrooms obsolete.

Solvent
The component of photoresist which allows the resist to be applied in liquid form. The solid component of the resist is suspended in the solvent.

Specific heat
A measurement of the amount of heat (energy) required to change the temperature of a given mass of material.

Spectrophotometer
An instrument used to measure film thickness. It operates by measuring the difference in phase of the light wave reflected from the top surface and bottom surface of a film coating.

Spin Coater
Also called a resist track or a tract. A machine for applying photoresist uniformly to a wafer by spinning the wafer during or after pouring on the photoresist. Spin coaters are also used for developing resist. In addition they can be used for coating wafers with other liquid films.

Spin Tool
Sometimes called a spin-rinse-dryer or SRD. This is a machine for etching or cleaning wafers in wet chemicals. It is constructed like a front loading laundry machine. A cassette holding its wafers is turned round and round as chemicals are dispensed over the wafers. Wafers are rinsed in de-ionized water, and dried by spinning at high speeds.

Splash Protection
Protection from physical contact with a liquid.

Spray tool
This is a machine for etching or cleaning wafers in wet chemicals. It works like a dishwasher in that chemicals are sprayed at the wafers. The cassettes holding the wafers are rotated while this is happening.

Sputter deposition (sputtering)
A metallization process in which a target is bombarded by plasma generated ions producing dislodged target material to be deposited on the wafer surface.

Sputtering
A form of physical vapor deposition (PVD) often used for deposition of metal films. Sputtering involves knocking metal atoms off a disc of pure metal with charged, energetic, chemically inactive atoms called ions (from a plasma). The metal atoms will re-deposit onto the wafer to build up the desired metal film.

Standard deviation
Is a statistical parameter that is a measure of variation in a frequency distribution.

Static electricity
Electrical charges generated by friction. Also referred to as a “tribo-event”.

Static random access memory (SRAM)
A random access memory that required no refresh cycle as long as an external source of energy is supplied to maintain its stored bit pattern.

Static process control (SPC)
A method that uses mathematical techniques of statistics to identify, document and characterize process and equipment variables from batch to batch and to maintain them within acceptable limits.

Statistical quality control (SQC)
A basic statistical concepts to monitor product specifications during manufacturing.

Steady state
Refers to flow rate in permeation testing. The point at which the challenge chemical has begun to permeate the fabric, and the rate of permeation flow is neither increasing, nor decreasing.

Stepper
A photolithography machine used to expose a pattern on a wafer by shining light through a reticle (a glass plate containing a pattern etched in chrome). Since it cannot accurately expose the entire wafer at once, a stepper exposes an area of a smaller size and keeps repeating this until the whole wafer is covered. This process is called step and repeat. An eight-inch wafer might need about 80 fields for full exposure.

Stockers
Automated storage units for wafers when they are not being processed.

Storm Flap
Splash guards constructed from the primary suit material which help keep liquids off the zipper, valves, boots or other components.

Strain
Strain is a unit used to tell how much a material stretches under load. Strain is defined mathematically as the change in the length divided by the original length.

Stress
Stress is the term that tells how much force per unit area that a load puts on a material.

Substrate
The base material. Commonly used to refer to the base material of a wiper (i.e. polyester, microfiber) or glove (i.e. nitrile, latex, PVC).

Surface Tension
The Physical theory around why particles tend to be attracted to a surface, versus airborne.

Surface Particle Counter
A device that counts the number of particles that fall on a surface. This is a newer approach, versus the traditional method of counting the number of particles airborne.

Taped seam
A very strong seam produced when a sewn seam is covered with a strip of compatible material. The strip is attached by heat sealing as with film laminated materials.

Target
The source of metal atoms and ions in PVD/sputtering processes. The target, composed of the metal or alloy to be deposited, is placed above the wafer and is then bombarded by ions generated form a plasma in the deposition chamber.

TES
Totally Encapsulating Suit – A full coverage suit where the head, arms, torso, and legs are fully protected. Not necessarily gas tight.

Temperature Control
Controlled environments typically set their temperature thermostats in the 68-72 degrees Fahrenheit. The cooler temperature:

1. Keeps Operators in full bunny suits comfortable, reduces possibility that garment system will be tampered with.
2. A cold facing thermostat reduces ambient temperature variation, which can adversely impact process and tool consistency.

Tester
A piece of electronic equipment designed to test chips to check if they work, and if so, how well (usually how fast) they work. Testers are usually specialized as either memory chip testers, digital logic chip testers, or analog chip testers, though some of the more sophisticated testers can deal with more than one of these groups.

Thermal Heat
Direct heat transfer from a source, non-radiant, as in a burning liquid splashed onto a chemical suit.

Thermistor
A temperature sensor made of semiconductor material in the form of a resistor. It has a negative temperature coefficient.

Thermoplastics
Heat welded or heat laminated fabrics such as PVC or CPE.

Third Party Testing
Testing not performed by any parties who might financially profit by test outcome. Ensures objective, fair test results.

Throughput
Refers to the number of wafers processed during a given time period.

Tongue Tear
A physical test that determines the force (non-shear) required tearing a fabric.

Topography
The surface condition of a wafer, usually refers to the irregular, bumpy surface containing is structures caused by the processing steps involved, such as patterning, and etching.

Total quality control (TQC)
A manufacturing philosophy, extensively used in the semiconductor industry that centers around the concept of customer satisfaction at every stage of manufacturing.

Toxic
Any chemical that is dangerous to human health. Toxicity levels are normally given in units such as parts per million (ppm) or parts per billion (ppt) implying that any human exposure to that chemical at a higher level will cause harm to the human body.

Toxicity
Level of poisonous effects from a chemical.

Track
Sometimes called resist track. A common name for a spin coater.

Transistor
A three-element semiconductor device capable of signal amplification and current switching.

Traveler
Document used to record all the information needed to track process steps and product production history.

Trench
An etched region on a silicon substrate which is used for (a) isolating one device from another and (b) fabricating storage capacitors.

Ultraviolet light (UV)
Light waves that have wavelengths in the range of 600 to 3800 Angstroms.

Uniformity
Uniformity, or more commonly non-uniformity, is a measure of how far a given parameter varies from the average value. Uniformity can be considered across one wafer, from wafer to wafer in the same batch or from batch to batch.

Vacuum
A condition where the pressure of a gas is less than atmospheric pressure.

Vapor pressure
The pressure created by a gas at any given temperature in equilibrium with its liquid state. The pressure build up (particularly in warm weather) in a car fuel tank is an example of vapor pressure.

Very large scale integration (VLSI)
Wafers with devices with critical dimensions of 0.35 – 0.5 microns. The number of components per chip are 10^5 – 10^6. VLSIs are used in memories, computers, and signal processors.

Viscous flow
A gas flow that behaves like a fluid, occurring at pressures greater than about $1x10^{-2}$ Torr. Each gas molecule is influenced by its neighboring molecule.

Viton
Trademark name for a series of flouroelastomers based on the copolymer of vinylidene fluoride and hexaflouropropylene. A common elastomeric with fair to good chemical holdout.

Volatile
A material that can be easily vaporized.

Volt
An SI unit used to measure electrical potential.

Wafer
Semiconductor processing is done on round disks of silicon called wafers. A current generation wafer is 8 inches in diameter, the thickness of a credit card, weighs about a third of a pound, and is polished to a mirror finish on one side. It is silvery gray in color.

Wafer boat
A container designed to hold 25 to over 100 wafer for batch processing.

Wafer flat or notch
Silicon wafers are marked with one or more flats or notches ground into them to identify (a) its crystallographic orientation, a (b) its conductivity type. Larger wafer (200 mm) do not have flats or notches.

Wet Cleaning
Cleaning of wafers by immersing them in chemicals such as acids. This can be done in sinks, spray tools (machines that work like dishwashers) or spin tools (machines that work like laundry machines).

Wet etching
Etching away of layers on a wafer by immersion in a chemical bath.

Wire bonding
The linking of a chip with the outside world. This involves connecting each of the contact pads (fabricated on the chip) with the metal leads of the package by joining one end of a gold (or aluminum) wire to the pad and the other end to the corresponding lead. The bonds are formed by applying heat, pressure and/or sonic vibration.

Word
The number of bits of information a particular microprocessor can process simultaneously. Usually a multiple of eight bits.

Yield
Yield is defined as the fraction formed amount of stress that a material can withstand without becoming permanently deformed.

70% of cleanroom contamination is operator based

Valutek can help eliminate contamination, enhance yield and reduce non-compliant product exposure

VALUTEK™

800-763-1250 Valutek.com

Valutek has serviced cleanroom and critical environment clients in the Life Sciences, Advanced Technologies and Emerging Industries marketplace since 1988.

Product expertise – Our NanoTek, MicroTek, and MacroTek high performance product lines are engineered to optimally meet / exceed your exact specifications.

Lowest price guaranteed – Should our pricing not offer the lowest total acquisition cost, Valutek will beat any regular published competitor price by 5%.

Multi-line discounts – Include both gloves and wipers on a bundled 90-day purchase order and receive a discount of 15% or more off your entire order.

Simplified ordering - Purchase anytime online with your company's customized My Valutek web portal, and enjoy effortless ordering tailored to your specific requirements.

We are passionate about what we do, and look forward to being your trusted cleanroom solution partner for critical contamination control products now and in the future.

CONTACT US

Albany ▪ Phoenix ▪ China ▪ Malaysia
www.valutek.com

Valutek Global Headquarters

1005 N 50th Street
Phoenix, AZ 85008

Main: 602.256.0540
Toll Free: 1.800.763.1250
FAX: 480.302.6015
E-Mail: info@valutek.com

Valutek CNSE\SUNY

257 Fuller Road
Albany, NY 12203

Valutek Asia Sdn Bhd

Butterworth, Penang
Malaysia

Valutek China

Wuhan City, Hubei Province
PRC 430022

VALUTEK