Lecture - 2

Introduction Wafer Manufacturing Process and Clean room Protocols

Hi, welcome to this particular module, last time in the last module, what we have seen? We have seen, indicated circuits and within integrated circuits, we are saying monolithic indicator circuit, hybrid circuits thin and thick film technology-based i sees right? Now, what's the reason of understanding the indicator circuits, when the when the title says the electronic model for industrial applications using operational amplifiers, the reason is that, when you are talking about operational amplifier? You have to fabricate operational amplifier and, that option if I can fabricated with the technique or technology, called micro fabrication now when you talk about micro fabrication then, we have to understand on what substrate you are going to fabricate the device. Right? So, what are the substrates? The substrate can be silicon, substrate can be glass, substrates can be one silicon glass, and that is polymers. Right? So, in, in, in the case of op amps or 95% of the ices silicon is used as a

substrate now, when silicon is used as a substrate we should know, how this silicon is manufactured. Right? And once we know how silicon is manufactured, then only we will know that on the silicon substrate, how you are going to process different steps such that you can end up with having an entire operational amplifier, which is consisting of thousands of transistor in itself. Right? So, with that particular goal let us see this model quickly, where we will see, how the silicon is manufactured, and well I also talked about cleanroom. So, I have a video for you, how the cleanroom looks like and because, the point is when you fabricate a device it is within cleanroom, when you fabricate an op-amp or any other it's Right? Indicate a circus, it is within the cleanroom environment .so, what exactly cleanroom it's and what are the procedure to work in a clean room. Right? So, two we use the end of this module; let us see the first light and when you see the first slide,

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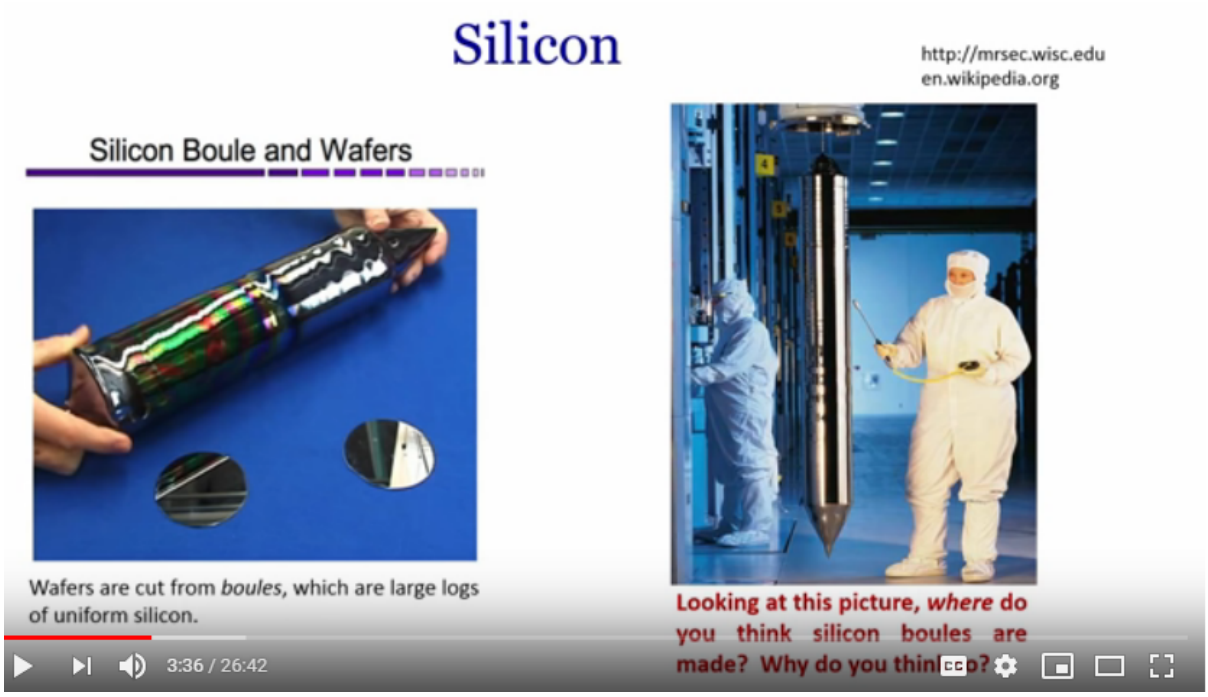

What is it? What exactly the silicon is? so, if you see silicon, silicon balls and wafers we have a silicon ball through which you slice the silicon ball to form the wafers, and then like last module we ave seen that looking at this picture, where what do you think? we think that the, the, the, the silicon ball is manufactured in a clean room and this is a clean, clean room governing procedure, where a person has to gown so, that there is a minimal contamination on to the actual ball, actually the contamination, should be as low as possible and that is depending on the class of the cleanroom that we discuss in the last module.

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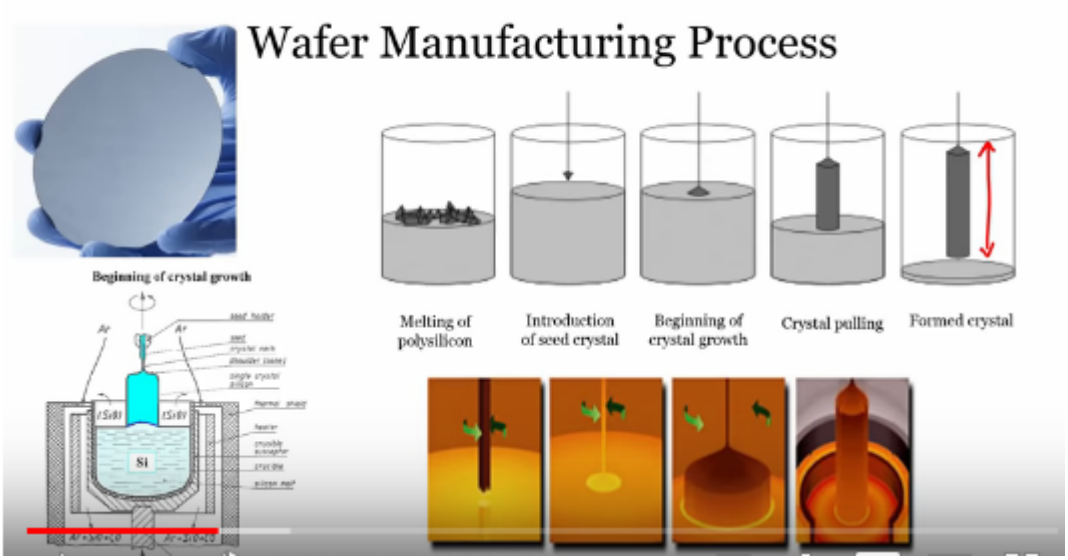

Now, when you want to understand how exactly you get this silicon wafer. Right? Then you need to understand what the procedure is? The procedure to get this silicon wafer is you start with melting of poly silicon, introduce yourself crystal, begin the rotating of crystal and then pull the crystal slowly and you will see a formation of a bowel Right? And the same thing is shown here, there is a YouTube video, please go to it, please watch the YouTube video, and you will understand the procedure of getting the silicon ball from the polled poly silicon. Now, when you talk about the crucible? the crucible consists of across ball shaft, there is a silicon melt, across the ball a heater, thermal, shield and then you have a single crystal silicon seed, where you dip in the molten silicon, and then you pull it up, when you pull it up you will see there is an shoulder neck, there is a solder neck, crystal neck, there's a shoulder and deformation of the silicon ball. So, this, this is a known process, there are two processes, one is called Zhukov sky technique and second man is called float zone technique. Right? There are two techniques to form the silicon anyway

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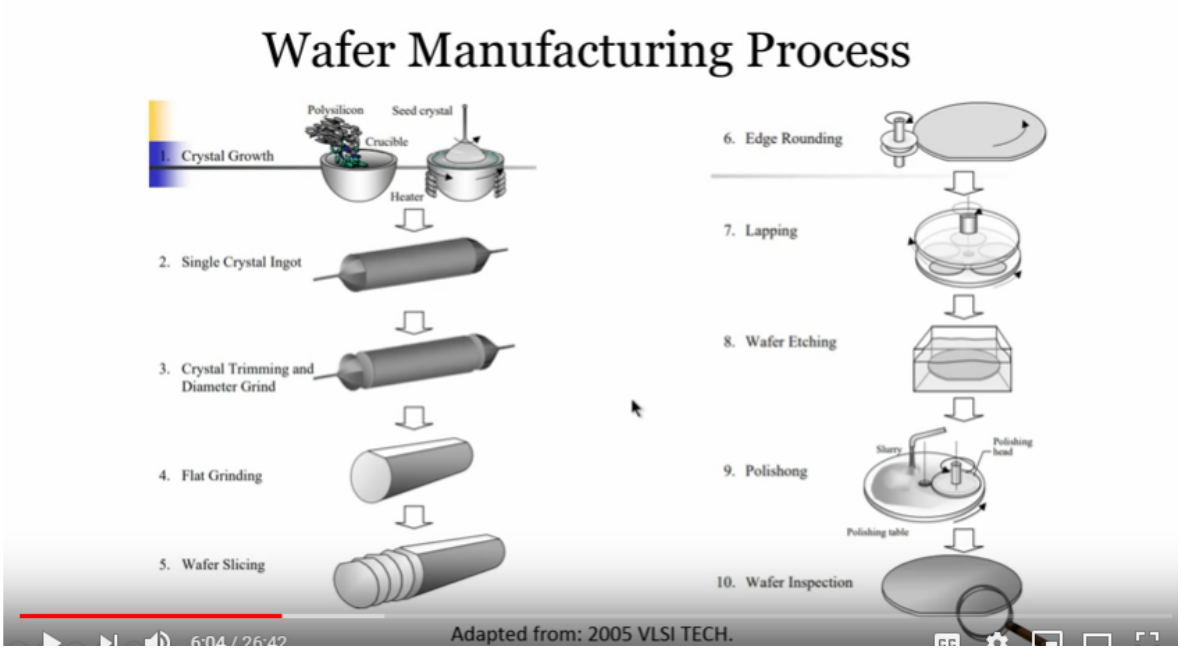

There we are not too much interested in understanding those techniques, we should just know, how the things are done because, we are interested in understanding the silicon wafer. Right? Because, silicon wafer is a substrate on which we are going to fabricate, several hundred thousands of transistors. Now, but the same procedure is shown here, that you have poly silicon in the crucible, you heat it up and then you pull put the silicon cell or load the see crystal pull it up in the rotating question, what you'll get you'll get a single crystalline con and then you, you do the trimming of the edges and once that is done you have to do a flat grinding, now this is very important step this flat grinding. Why we require this flat grinding? I'll tell you, this flattening is important to form the primary flat. What is called primary flat? So, in a silicon wafer, you will have primary flat, and you will have secondary flat, primary flat and secondary flat. Okay? In some silicon wafer you will only see one single flat which is family friend. So, what's the role of primary flat, we will see quickly I will also show you the singer the silicon wafers. So, once you have the flat grinding, you slice the wafer then do the edge rounding lapping, wafer edging, polishing, because finally we want to have a polished surface, finally you have to do the wafer inspection ,this is the main way for manufacturing process.

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but when you so, if you see this further, you can see that these are in gods and when we want to slice the single wafer from the ingot, you had to use a diamond coated wire and it is the procedure is shown here, and then the lapping machine, the schematic, is shown here, this lapping, and polishing, is used to polish the surface of the wafer.

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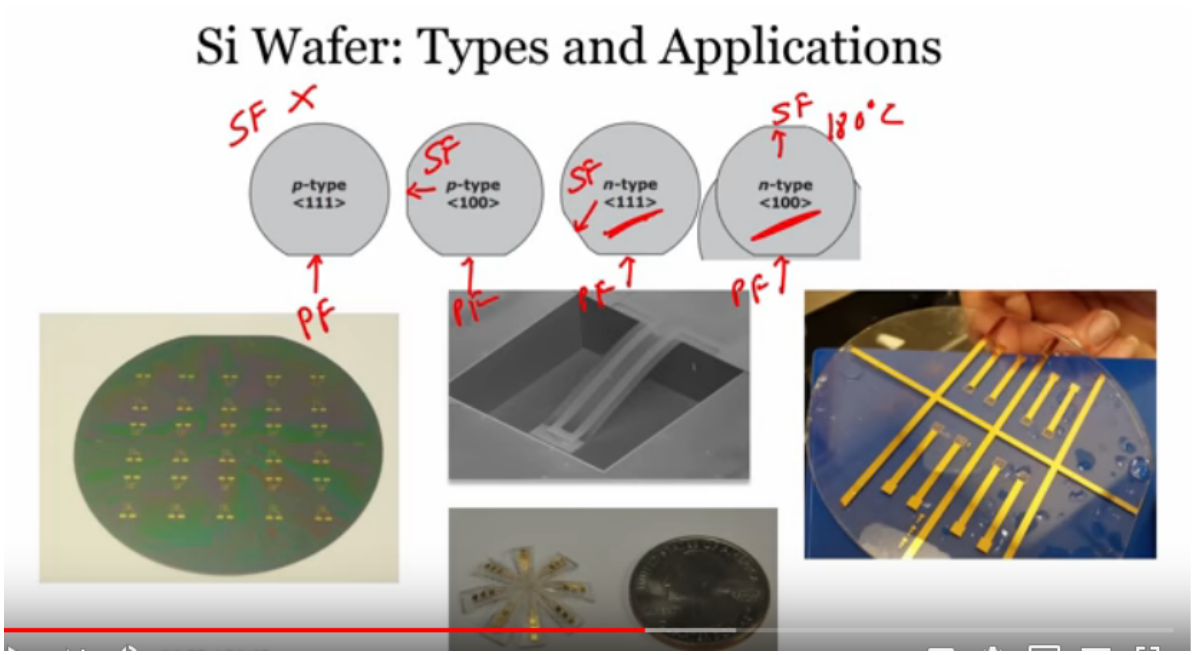

Now, you see very interesting thing. Right? I told you there are two flats, primary and secondary, the why we require primary flat? You see in all these cases there is a one single flat called primary plate. Right? With respect to primary fled ,there is a secondary flat ,in this case there is no secondary flat second flat is absent, in this case secondary flat is Right Over here, in this case here, in this case here. Right? So, if there is no prior a secondary flat, secondary flat, this is primary flat. Right? If there is no

secondary flat, the wafer is p-type 1, 1, 1, if there is a secondary flat at 90, degree with respect to primary flat the wafer is p-type 1, 0, 0, if the secondary flat it is at 45, degree with respect to primary flat it is n type 1, 1, 1, and finally when you have second leaflet, with respect to primary flat at 1, 0, 0, it is called sorry ,second leaflet with respect to fled at 180 degree, 180 degree with respect to primary flat then you are wafer is n-type ,1 ,0 ,0 what I mean is? that if you have a secondary flat with respect to primary effect at 180, you have 1, 0,0 45, a 1, 1, 1 this both are n types, if you have P type, the second if light would be at 90 degree, with respect to priority flat or there will be no second leaflet understood ,that is the importance of your primary flat. So, let us see, how silicon wafer looks like, now you can see I am wearing a glove, if you can focus here so, to hold the wafer yeah. So, I am wearing a glove right, because to hold a wafer we cannot use our bare hand that is wrong the, the contamination occurs in device because, of the contamination can it by humans. So, as long as we follow the process in a Fab Lab, the device would be correct, you will have less failures you are your throughput would be higher, your accuracy will be higher and the device will feel less. So, wearing a glove this is called tweezer, this tweezer is to hold the wafer all right we have to hold a wafer like this hmm. So, now let me show you some wafer I have brought with me so, that you can understand on what kind of substrate so this is a wafer holder by the way, this is a wafer holder. Right? On which we are holding the wafer ,now I am taking out the wafer let me wear my another glove because, I don't want to contaminate my wafer of course when I am bringing the wafer out of the cleanroom there is a contamination.

So, I had to clean the wafer, if I want to use it again, again this is not allowed when you are walking in a, in a Fab lab, in a class 10 class hundred environment. Right? So, once you take out the wafer it's gone, it's contaminated so, it's very difficult to understand or are to work following the rules because, a small mistake in your process, where I can kill thousands of chip all Right? So, you need to be careful, now this is a wafer holder like I said Right? And I am holding now a silicon wafer, hmm, a silicon wafer is in my hand and you can now, see that the there is a primary flat right over here, Right? And if you see then, you will see a second flat over here, yeah. That, that's enough thank you, a second leaflet over here. okay? So, secondary flat and a primary flat .Okay? So, now where is the second leaflet with this vector primary flat, the secondary flat is at 180, degree with respect to the primary flat, what does that mean? If the secondary flat is at 180, degree with respect to primary flat, it is n type 1, 0, 0 this is silicon wafer easy, that's why all the wafer has a primary flat okay? Decided now, if you see the backside of the silicon wafer, backside of silicon wafer looks rough compared to the front side, right? in a front side, you can see a glow, you can see like a mirror kind of surface polished one, but if you see the backside is difficult no see so, this is a thing side polished wafer in some cases we require double side polished refer so, when you have the wafer, when you have the why you require lapping and polishing? So, that the roughness of the wafer can be reduced and you can get a smooth way for, a smooth surface as I am showing you tube it to you. Right? Now, now Prime the single side polished wafer is comparatively cheaper, than the double side polish ever, this is single side polish ever, if I have double side polish wafer then it is comparatively costlier single side is cheaper double side is costlier, tweezer you can hold the wafer in a fashion I am showing it to you right over here, right. And this is how the wafer is holder, Right? It depends on how you want to place it. Okay? So, you're going to place it in the, in the little graphic section mask aligner. Right? Then you have to adjust your primary flight with respect to secondary flat and so on. Now, again you see that if you see the colour, the colour is not really great, this is like a little bit brownish colour, not exactly grey and the reason is because there is a thin layer of silicon dioxide, on the silicon wafer thin layer of silicon dioxide, on this silicon wafer. Okay? So, what I have shown you, I have shown you the silicon wafer and you can see that with respect to primary flat, in a secondary flat is at 180 degree we can easily identify it is n it is a 1, 0, 0, wafer. Right? I'm holding another wafer, again 1, 0, 0, you see the

secondary flat here with respect to primary flat is at 180 degree, single side polished refer, single side polished refer. Right? Okay? Good.
So, there are several steps that one has to follow to fabricate a MOSFET. Right? And that comes under the lithography and micro fabrication nanofabrication, this is another wafer, the second if right is respect is that one will be 180 degree with respect to primary flat, you can see there are some patterns on this, on the oxidized silicon wafer. Right? Now, these patterns are for some sensors, but irrespective of that I was just telling you that this is how you can fabricate MOSFETs as well Right? The, the process remains same, the equipment would change, the mask would change, the recipe would change. Right? But you have to still go for a Fab Lab; you're to still fabricate a device. Okay? Having said that, I'll just put the reference back right, once you are done with the wafer, you don't have to, use it you have to throw your blouse right into a garbage bin alright, you don't have to reuse the glove that is a wrong way of working in a laboratory, please once you, once you use the glove discard the glove hmm, So, just to ever contamination just to avoid contamination. Okay? Now, if you further see the slide, what you see is? a types of wafer we have seen now ,this is a video okay?

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This is a video, let me play it and this video will show it to you what exactly cleanroom and classes are now ,the advantage of understanding this video is, that we need to understand, what exactly the cleanroom classes are there? And what exactly room is Okay?

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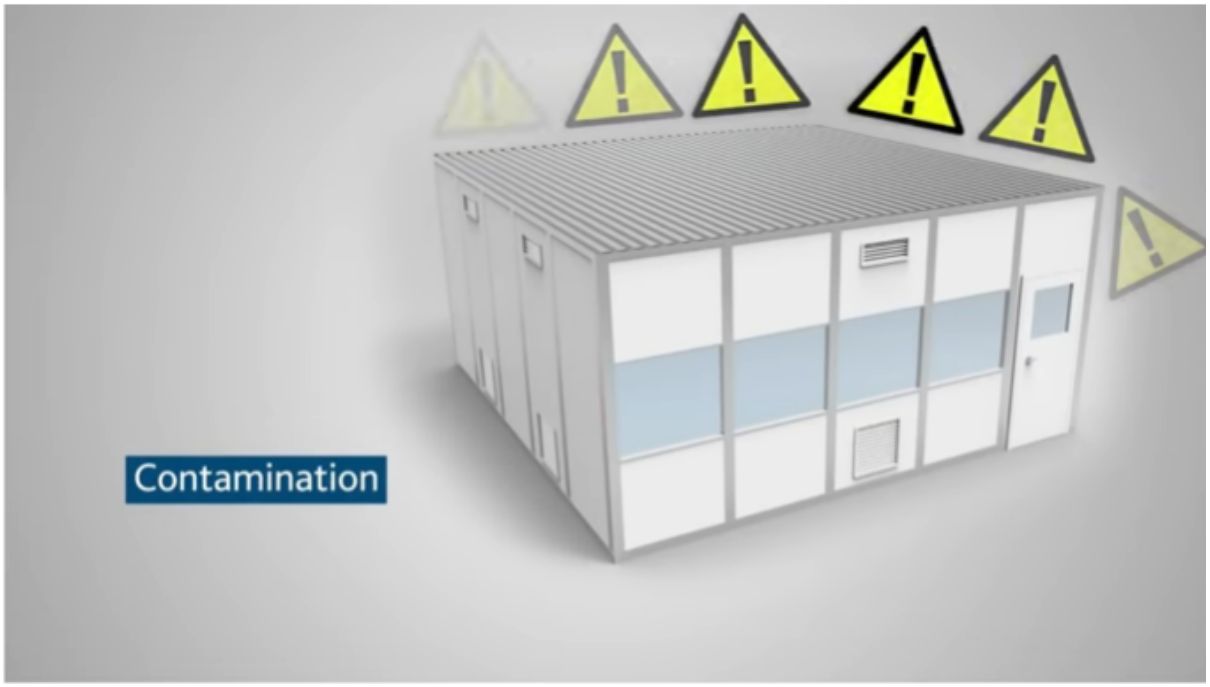

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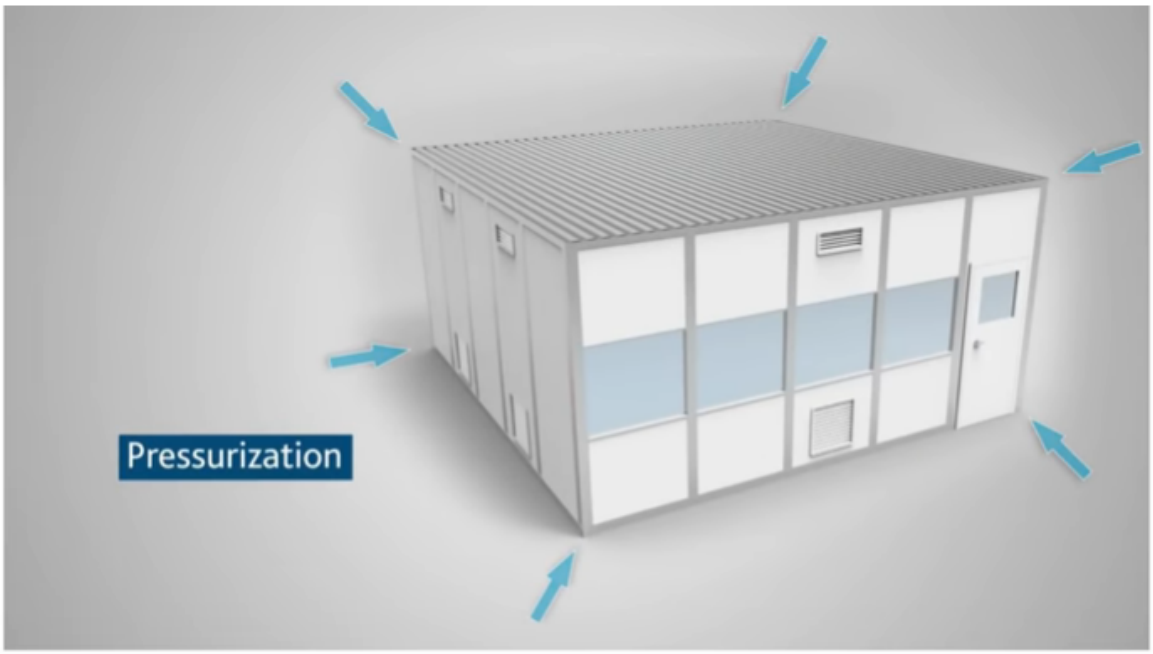

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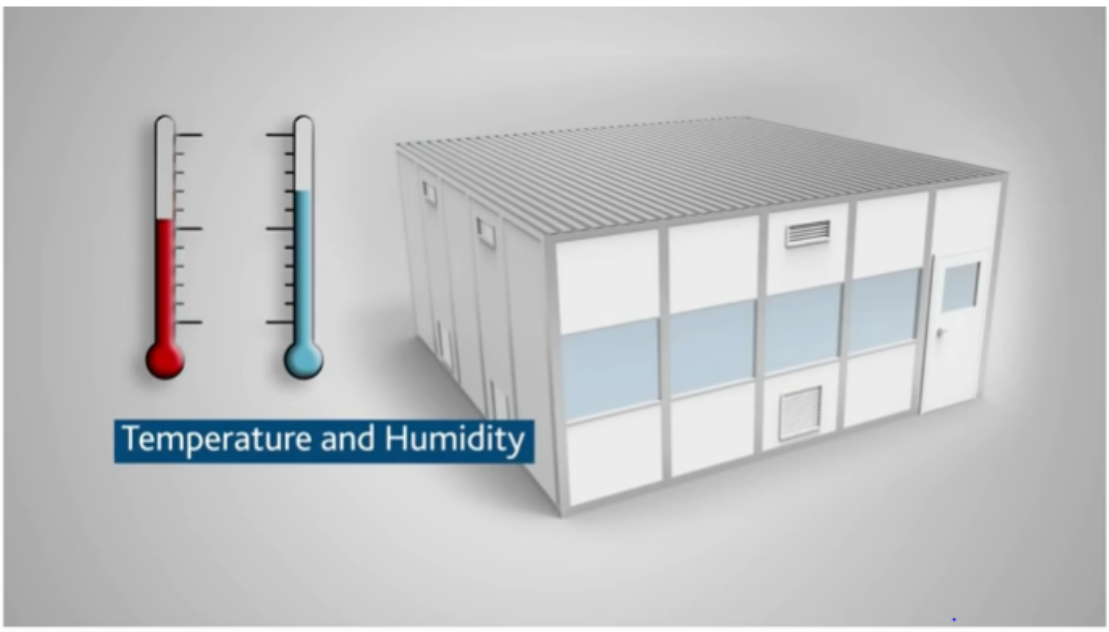

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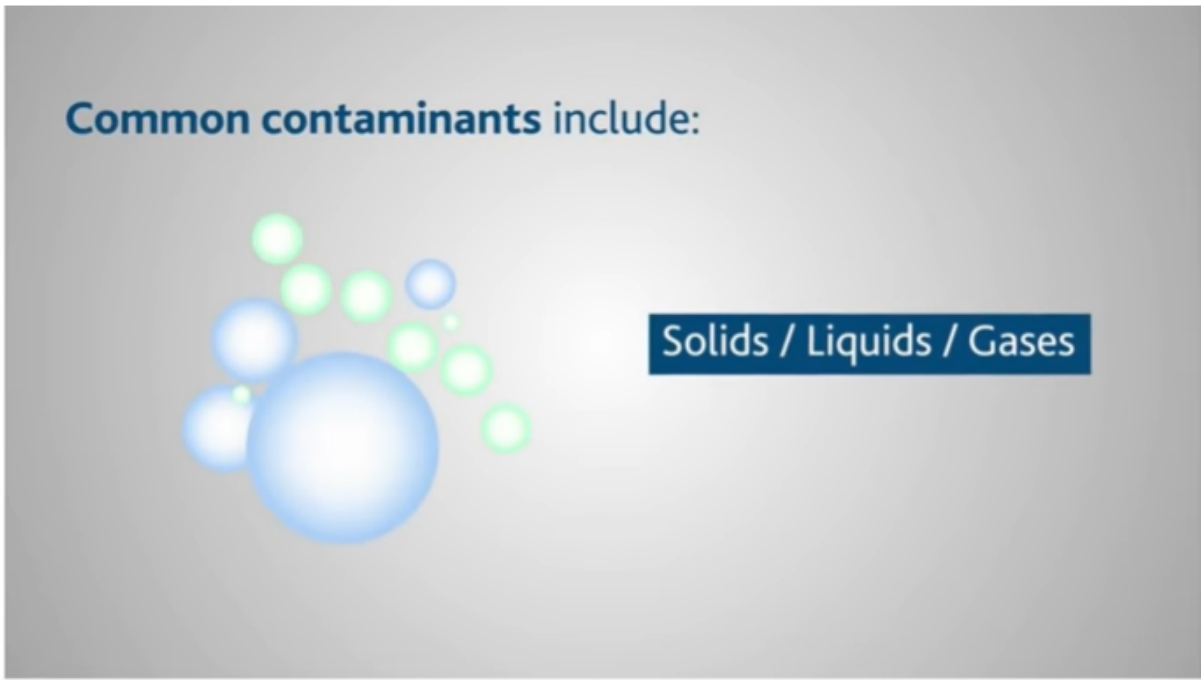

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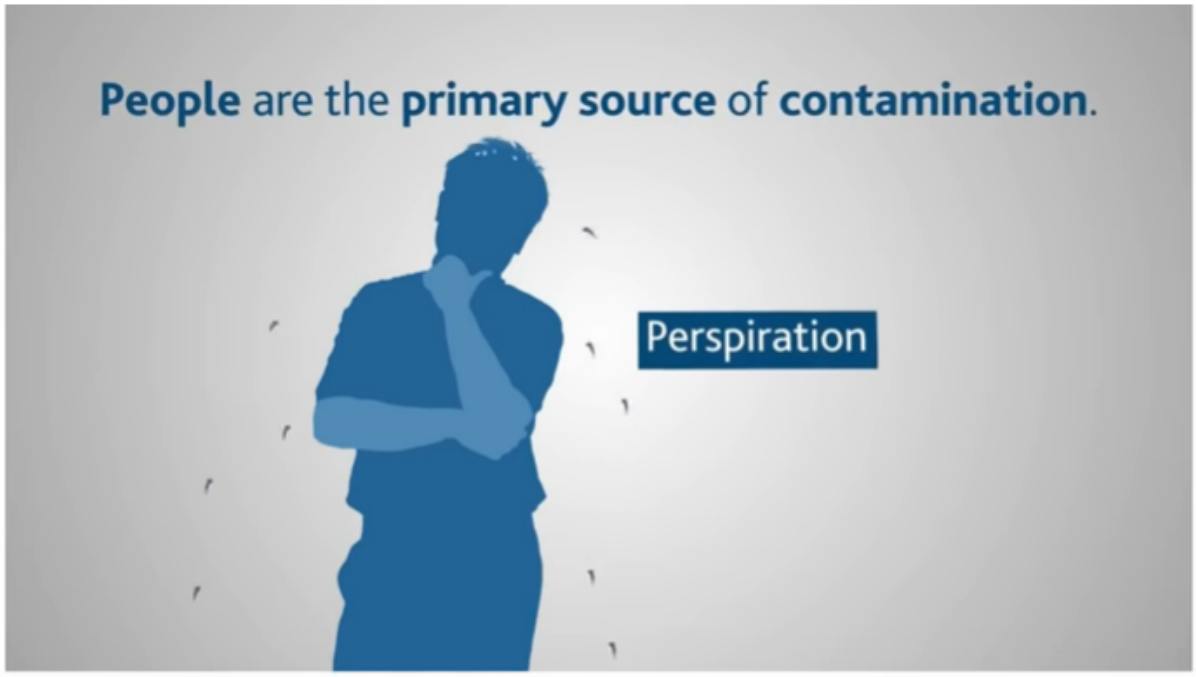

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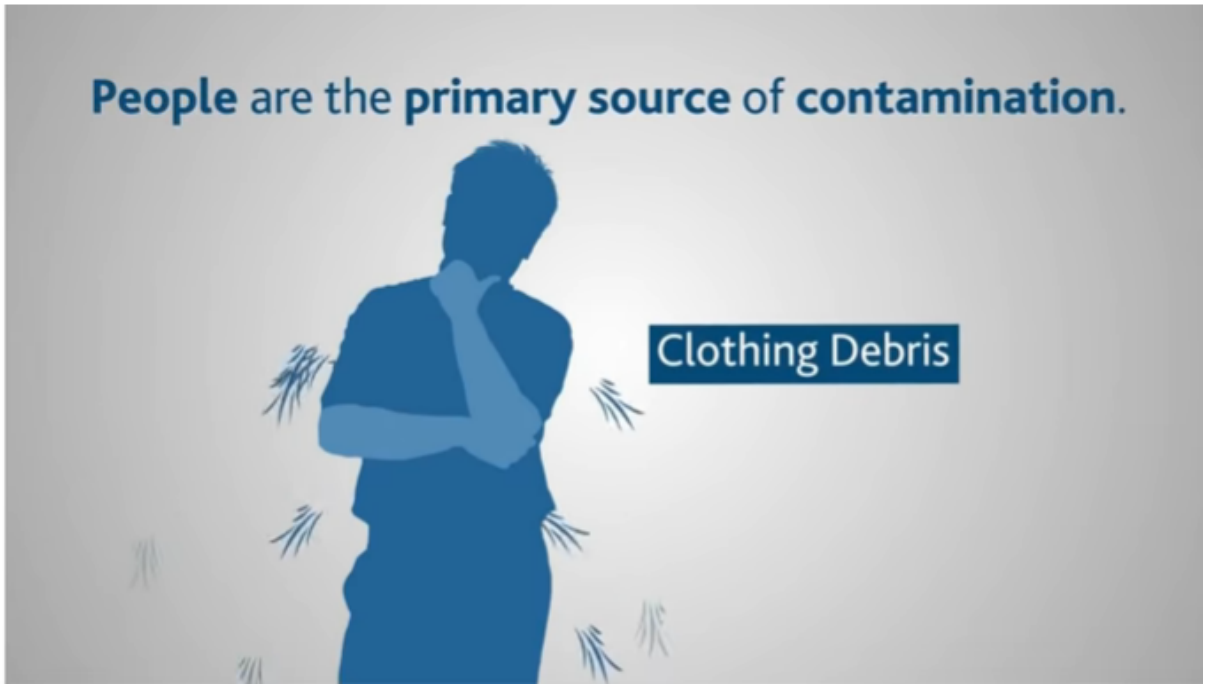

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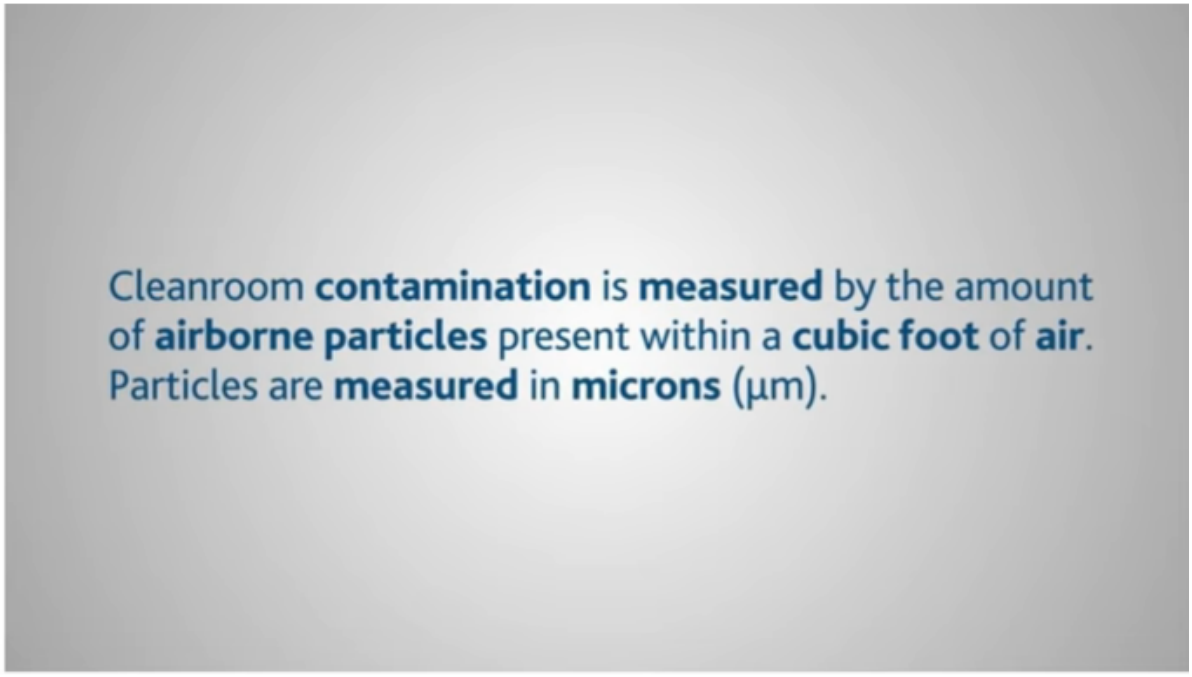

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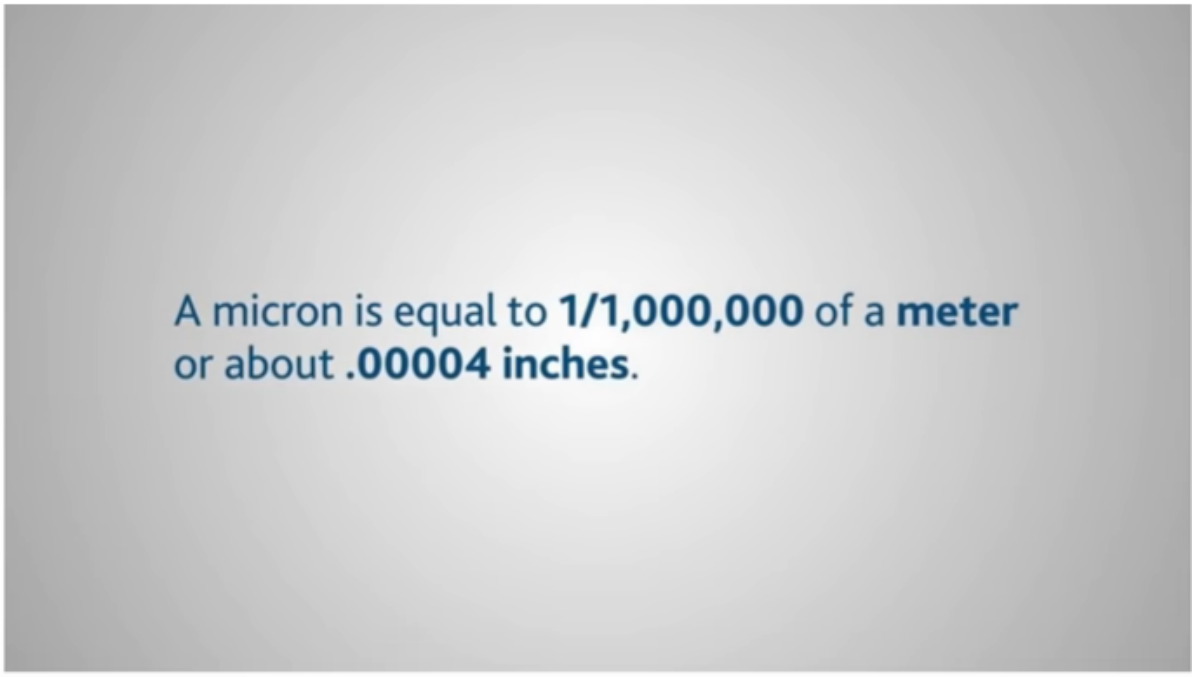

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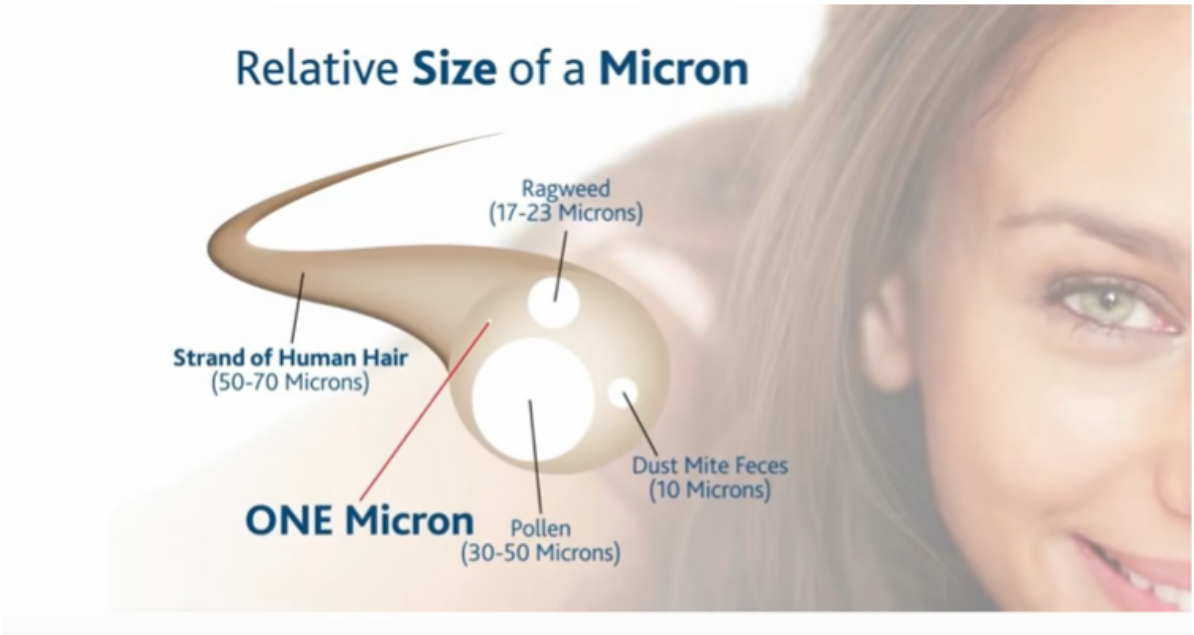

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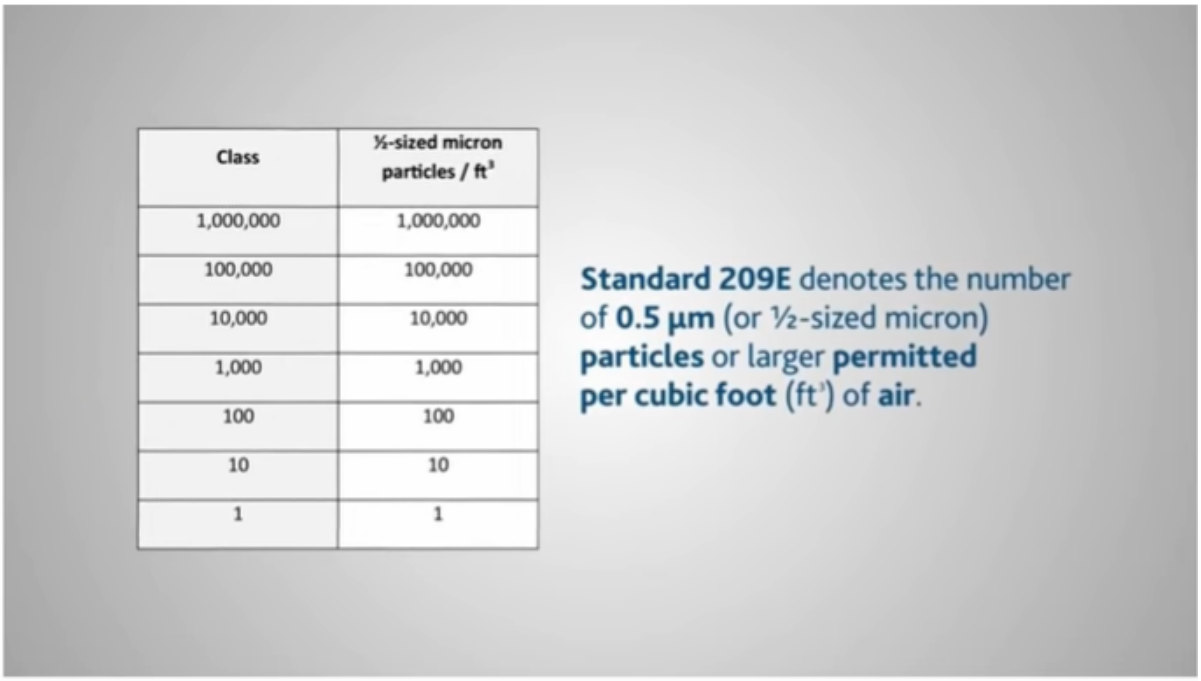

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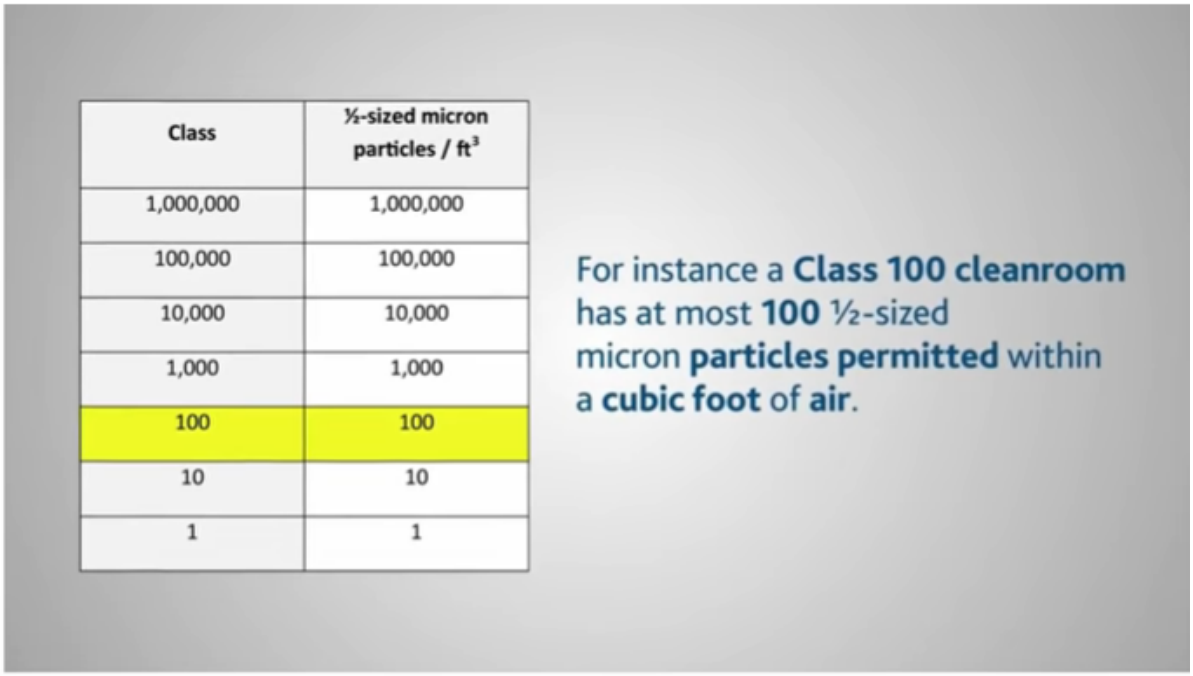

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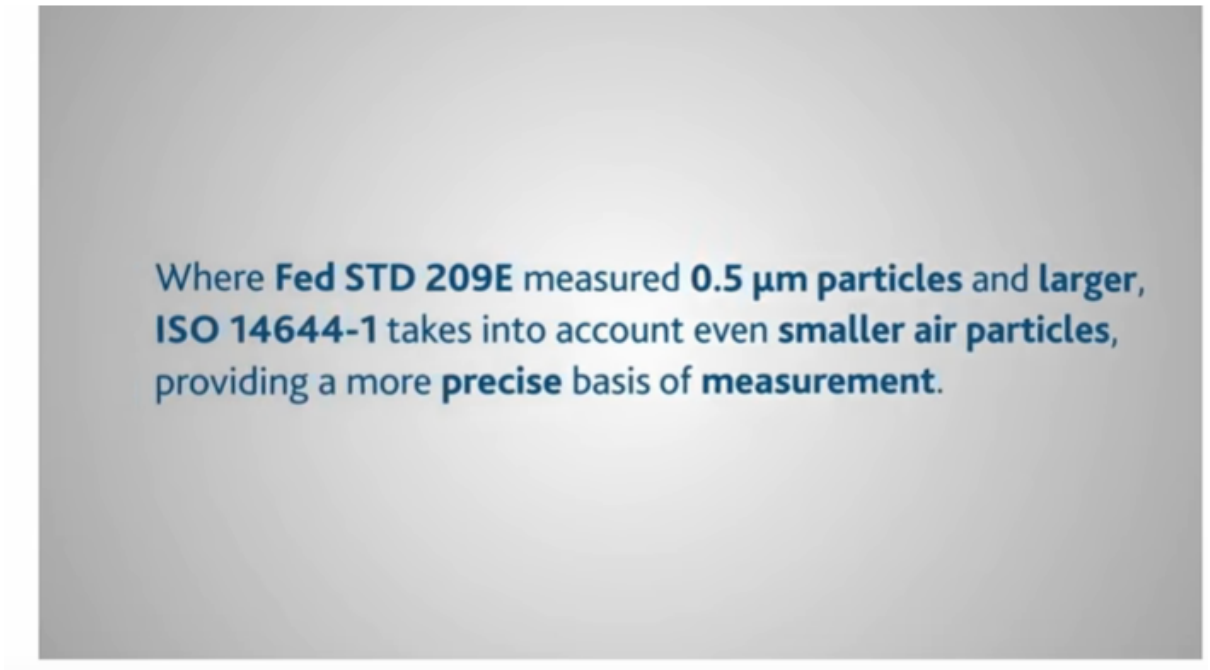

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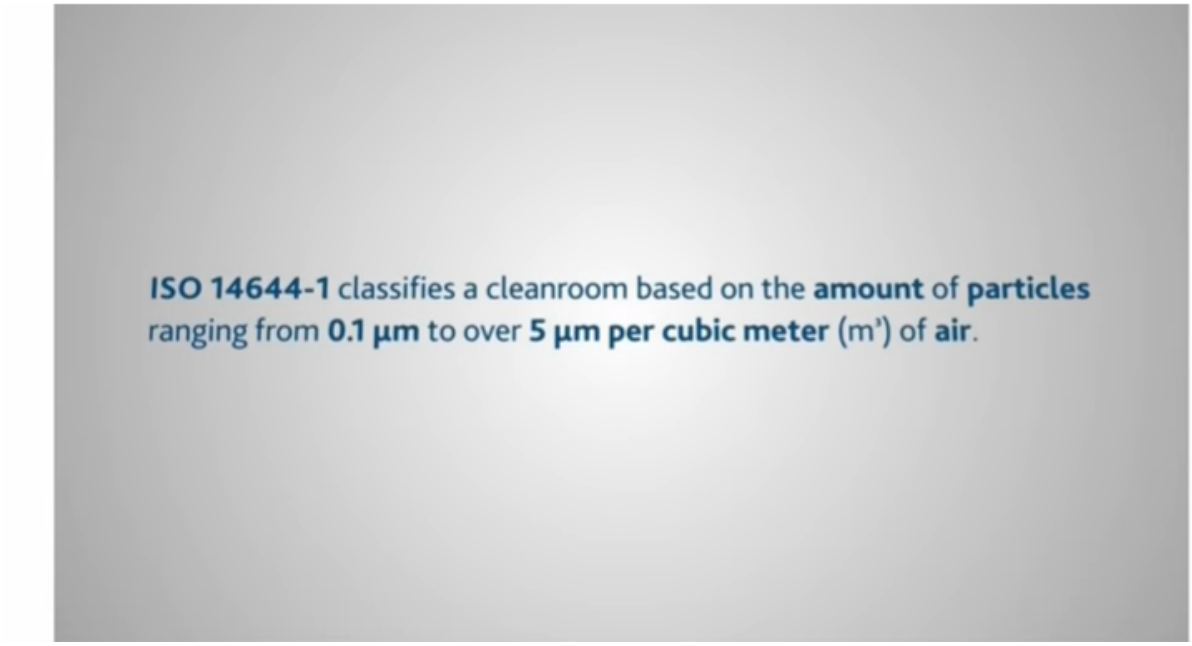

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ISO 14644-1 Cleanroom Standards

CLASS	Maximum Particles/m³					
	≥0.1 µm	≥0.2 µm	≥0.3 µm	≥0.5 µm	≥1 µm	≥5 µm
ISO 1	10	2.37	1.02	0.35	0.083	0.0029
ISO 2	100	23.7	10.2	3.5	0.83	0.029
ISO 3	1,000	237	102	35	8.3	0.29
ISO 4	10,000	2,370	1,020	352	83	2.9
ISO 5	100,000	23,700	10,200	3,520	832	29
ISO 6	1.0×10^{6}	237,000	102,000	35,200	8,320	293
ISO 7	1.0×10^{7}	2.37×10^{6}	1,020,000	352,000	83,200	2,930
ISO 8	1.0×10^{8}	2.37×10^{7}	1.02×10^{7}	3,520,000	832,000	29,300
ISO 9	1.0×10^{9}	2.37×10^{8}	1.02×10^{8}	35,200,000	8,320,000	293,000

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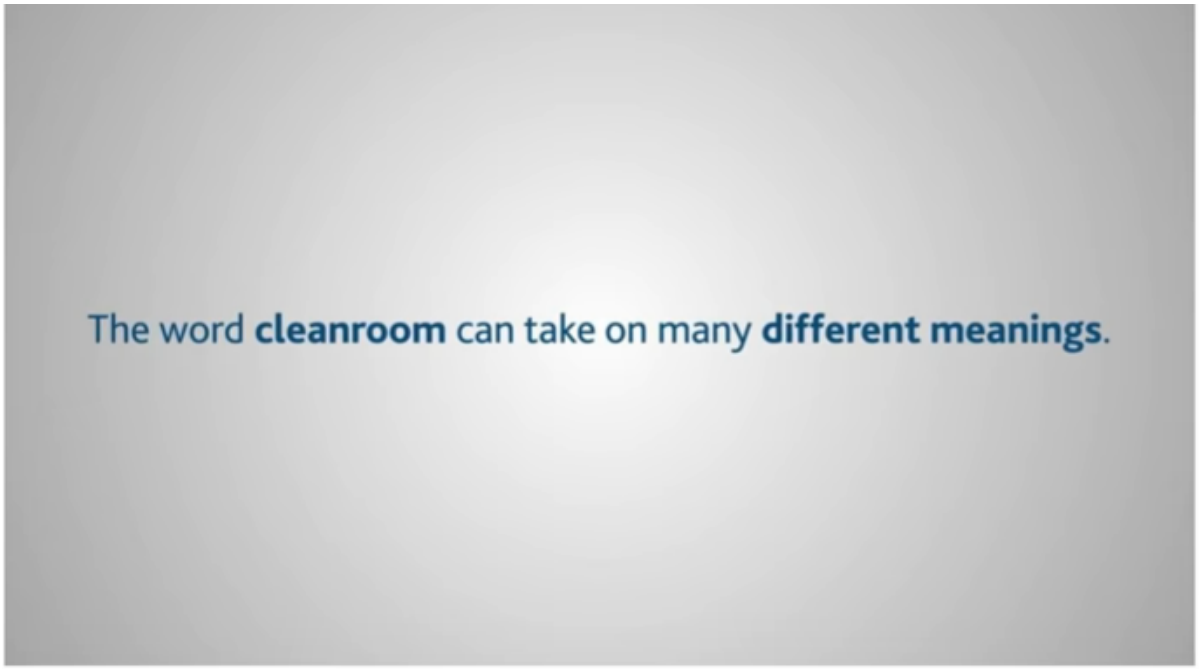

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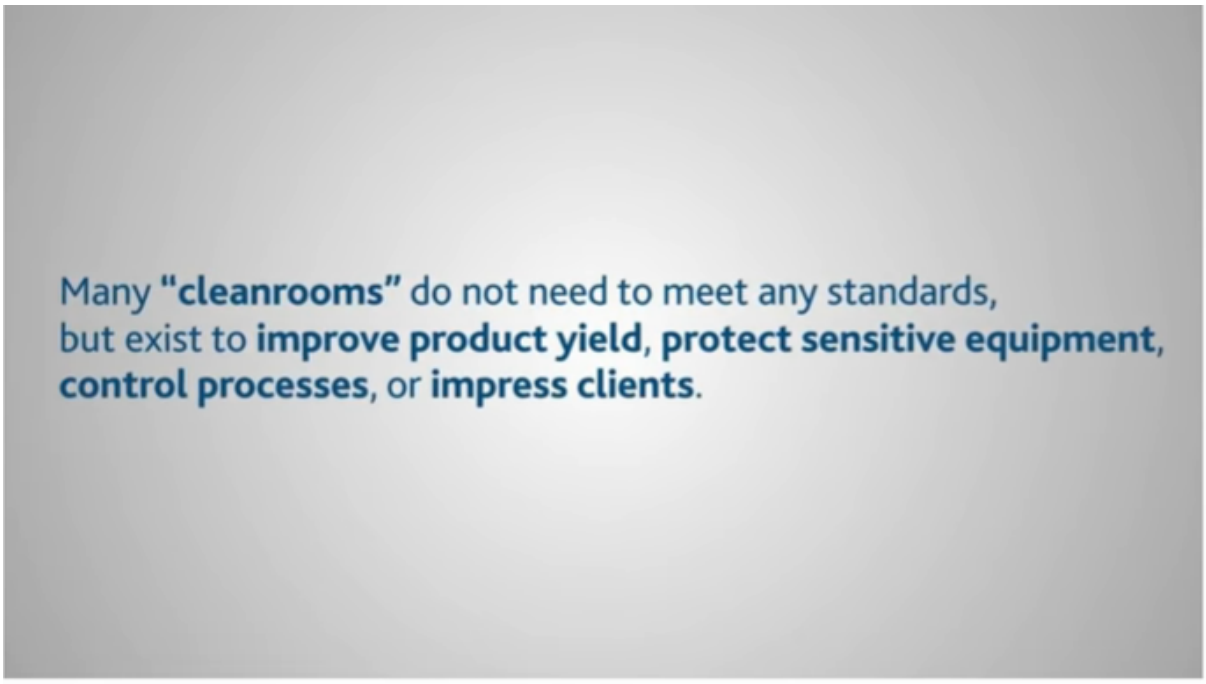

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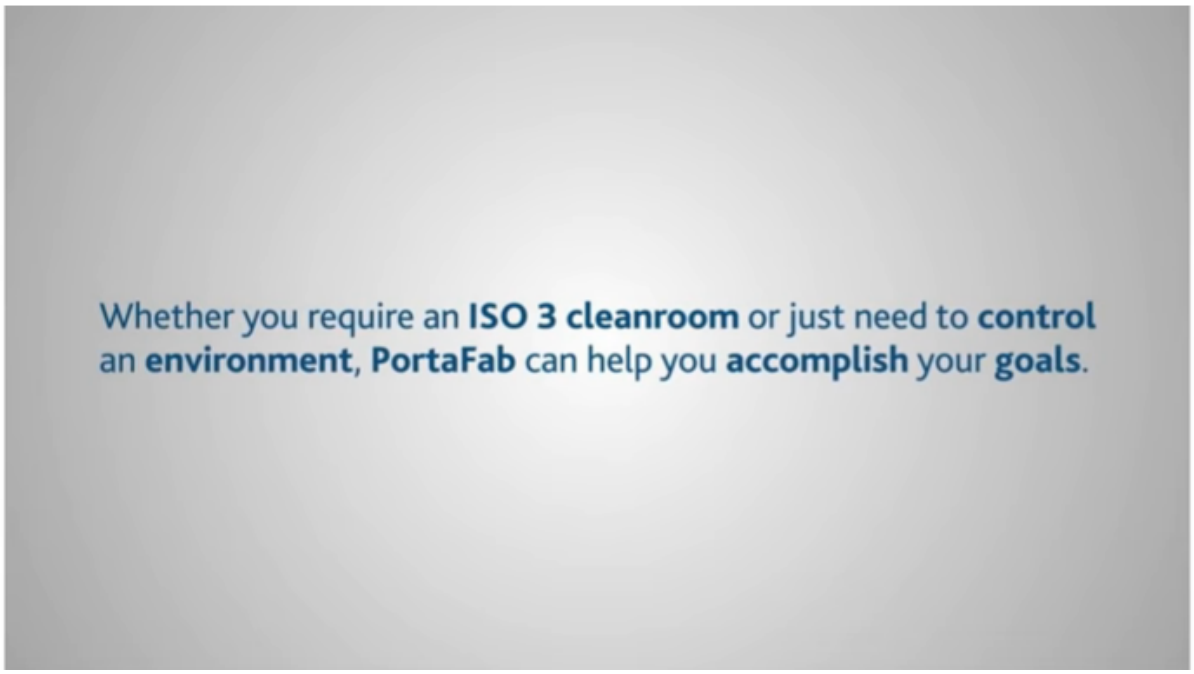

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So, I hope you have seen the video and you understood what is clean room? now if that you know what is clean room? you should also know what are the Gowning protocols? What is a clean roo Corning protocol? So, let us see this particular video from Tara Universal the earlier video was from global industrial, this is from Tara Universal, again this is a you tube link, you can again go back and see the you tube link, and you will see a video, where it where, where we can see how the gowning protocol we have to follow, all right and let me play it for you. Where does most clean room contaminants come from? usually, they come from the people who work there, that means that a well-designed gowning room and rigorously enforced gowning procedures are vital, to maintaining your required cleanliness classification, in this video, we'll review the procedures personnel should follow to get clean room ready, and some of the terror universal gowning equipment, that supports gowning protocol, the equipment and protocol depend on your required cleanliness classification, in ISO 807, clean rooms Frocks are often acceptable however, a clean room classified as ISO 6, ISo5 to clean room, generally require personal wear clean room overalls, made of Core-Tex, Tyvek or other nonwoven material along with hoods, gloves and booties, we'll be demonstrating gowning procedures for these applications. Before we get started, I need to mention two principles, that will prevent most contamination, that occurs during the gowning process, don't let clean surfaces contact dirty ones ,never touch a clean garment or a clean material, until you've washed hands thoroughly and Don clean gloves take care that garments don't touch a dirty floor or other surface, a contaminated surface spreads contamination and violates your cleanliness protocol. Second, when gowning start at the top and work your way down, once you've done clean gloves, you can put on your hair cover; hood, facemask, coveralls and finally booties now, let's back up and take that a step at a time. The first step literally and the gowning procedure is to clean street shoes before you enter the gowning room, Tara's automated shoe cleaner includes a HEPA filtered internal vacuum system, and multiple rotating brushes to remove particles from deep inside shoe seams, they normally install this outside the gowning room, adhesive man positioned at the entrance to the county, remove particles from the shoe bottom, dirty layers, after you've cleaned shoe tops and bottoms, put on shoe covers to minimize floor contamination, it's a good idea to do this right before you enter the gowning room, once I'm in the gowning room, the next step is to wash and dry hands thoroughly ,taras no touch hand glove washing and drying station ,which includes a sound damping for drivers purposes put on gloves liners. If they're required and then clean room gloves Tara makes wall mount and bench top glove dispensers

for both packaged and unpackaged gloves. Unwashed gloves may require another trip to the washing drying station.
Now, that my hands are clean, I'm ready to count up inside our demonstration gowning space again, starting at the top and working my way down, when designing your gowning area be sure to demarcate the clean floor from the dirty floor, in our set that side of the Gauteng bench is the clean area, only laundered booties are allowed in a designated clean area, which is frequently cleaned? with a fresh nonwoven mop, this side of the bench is the dirty area, where people can stand before they put on clean booties, another approach is to use Tara's clean room gowning platform, which clearly demarcates, the clean area in white from the dirty area in blue, I have all my reusable garments hanging inside Tara's garment and supplies cabinet the configuration you see here, includes one chamber with a hanging rod for frocks and coveralls and a second ,with shelves for hoods masks and other supplies ,models are available with a fan filtration system that uses a continuous stream of HEPA filtered air to wash particles off of stored garments. Tara offers coveralls in many materials disposable coveralls are generally either Tyvek polypropylene or other micro porous materials that meet most cleanliness requirements, when usable garments are made of Gore-Tex or a number of application-specific fabrics, including fedora maxima ESD for static sensitive environments, First comes a clean the font to contain hair, men with beards will need a beard cover next, I'll put on a reusable freshly laundered hood ,then I attach my face mask, use an easy clean gowning bench or lean rail, to help put on your coverall, Tara's cylinder two benches feature corner free construction with tube tops, to minimize particle accumulation and simplify cleaning. While you're dressing coveralls touch the floor only in the clean no-step area, hoods tucked inside the coverall, finally put on my clean room booties, both booties and gloves should overlap the coverall, then should be wiped down with a clean sterile wiper after every use, well as you can see I'm fully garbed and ready to enter the clean room, we'll almost ready, before I leave the Gauteng area I need to perform one more critical procedure a visual self-check to ensure I haven't missed anything terra offers several clean room mirrors to facilitate this process in both wall mount and freestanding designs the dual sided mirror, you see here, uses frameless construction and an electro polished stainless steel base for easy cleaning and easy positioning, where it best suits your room layout, the double plate glass viewing surfaces allow personnel on both sides to perform self-checks reducing congestion in your gowning room. Okay? So, that is the end of this particular module and I'm hope that you now at least know, how what is silicon wafer? Types of silicon wafer? P-type, n-type, one zero, zero one, one, one importance of primary flight, importance of secondary flight .Right? The grinding of silicon wafer, polishing of silicon wafer, single side polish, double side polished. Right? This is just understands, later on let's see, if I now there are several process you see if you talk about MOSFETs Right? What is there is a gate, as a source, there is a drain and below the gate there is a thin layer of our insulator Right? Silicon dioxide, let's say how can we go silicon dioxide? Right? Because, if I want to use operational amplifier then like I said, that we have to understand how the fabrication is done we just understand very basic of, how the silicon dioxide can be grown on a silicon wafer and then we will jump on to the op amp and its data, data sheet that's we will see the characteristics of an operation of different Right? Then you take care, I'll see you in the next module.