Instability & Pattering of Thin Polymer Films

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Lecture No. # 21

Soft Lithography- IV

Welcome back, we will continue our discussion on soft lithography, we already have discussed about some of the techniques which include capillary forces lithography, micro molding in capillary, solvent assisted micro molding, and some such methods. The common thing about all the methods we have discus so far had been the fact that all this method successfully generating topographically patterned surface. Now, right at the beginning of this course we have defined are discuss what is the different between a topographically pattern surface, and a chemically pattern surface.

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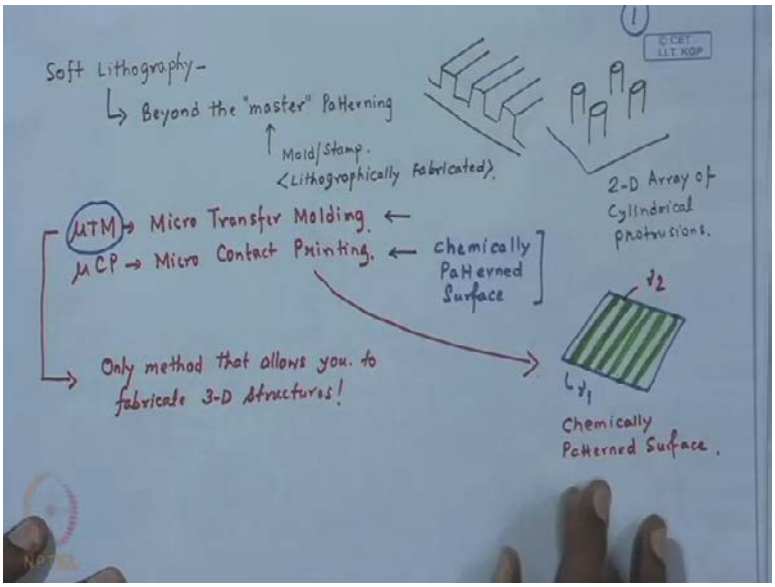

So, topographically pattern essentially, there is a physical contour along the surface on the surface its lets it can be something like this, this like a getting at the simplest form or more complex patterns. Now, the knowledge we have occurred. So far we understand that it is possible by almost all the methods, we have talk the soft lithography do for techniques as well as methods like to generate a perfective negative replica of a stamp

pattern. So, if we want to make complex pattern, let us say array of scrap pillars or secular pillar are something like this. Eventually, all you need to have, so may be this can be 2 d array of cylindrical protrusions.

So, what is necessary is that you have the approached of the desire stamp, which of course contains the negative replica of the final patterns you want to generate; however, we have also talked about the fact that soft lithography two some extent is limited by the availability of the procreates type of stamp, which in most cases as to be made by some other lithography technique which can be photo lithography are any one of the direct right methods.

So, these are some of the limitation of soft lithography and in the previews class, we also discussed there. So, called concept which is now becoming very popular, the concept of beyond the master patterning master eventually, here means the mold of the stamp available to you, which is lithographically fabricated and the ideas are very simple. So, let us say you have one stamp with simple grating what you try to generate structure which are no long the limited to a perfect negative replica, you can generate more complex patterns you can play around with the dimension, juncture line, width height what about. So, what it makes is that this really makes soft lithography a method which can be implemented are executed by non expects. Non expected hear I mean you people you do not have significant lithography it facility, because at (( )) if you look majority of the soft lithography methods are very simple to execute, but what happens is still are stock up, it sudden requirement hardware requirements like the stamp what about.

So, that those are some of the thinks we discussed, today we are going to talked quickly about two three more methods for generating topographic pattern all of which essentially make a perfect negative replica of a stamp, but there is to execute, but sudden cases they work with some specialize classes polymers are required, sub specialized type of stamps. And then we move on to two interesting aspects, one of them is we talk about micro transfer molding.

We have already talked about this method briefly in one of our previews classes and eventually we talked about micro contact printing though methods of sort of sound quiet similar there is some somewhat significant differences in in the final products what they finally, make and both are unique as compare to other methods, because of the farther

micro contact printing is probably the main stage of making a chemically pattern surface, majority of structures of which methods which make chemical patterns essentially, if you member we have talked about what chemical pattern is. So, you do not have a topographic future, but let us say we have a surface and you have different wettability reigns are reasons on the surface.

So, let us say these green pitchers corresponds to zones, which have surface energy let us say gamma one as compare to a background surface energy gamma two of the surface. So, this is a chemically patterned surface and the only method by which we can make such a surface is micro contact printing. Micro transfer molding is also wither unique in the sins the this is the only method that allows you to fabricate 3 d structures will this is interesting, because of the fact that soft lithography are any other lithography technique we have talked about there all essentially surface pattern in techniques and therefore, there output are the patterns we generate two large extant limited to the two dimensional world but. It was also realize that it would be really good, if some of these method can be extended for fabricating 3 d structure and that essentially what it some limitation of course, micro transfer molding as sort of allows as to fabricate.

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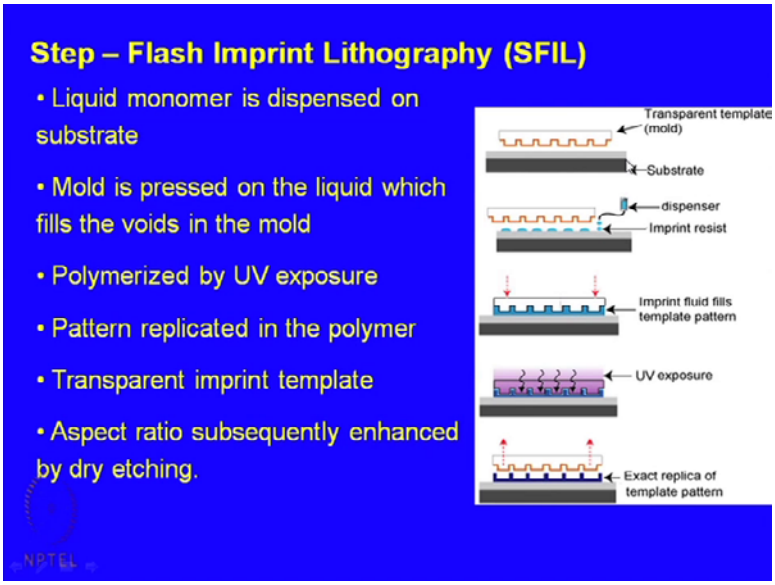

So, these are some of the methods we will be talking today. So, the first method we talk is essentially this goes by the name step and plash imprint lithography or SFIL.

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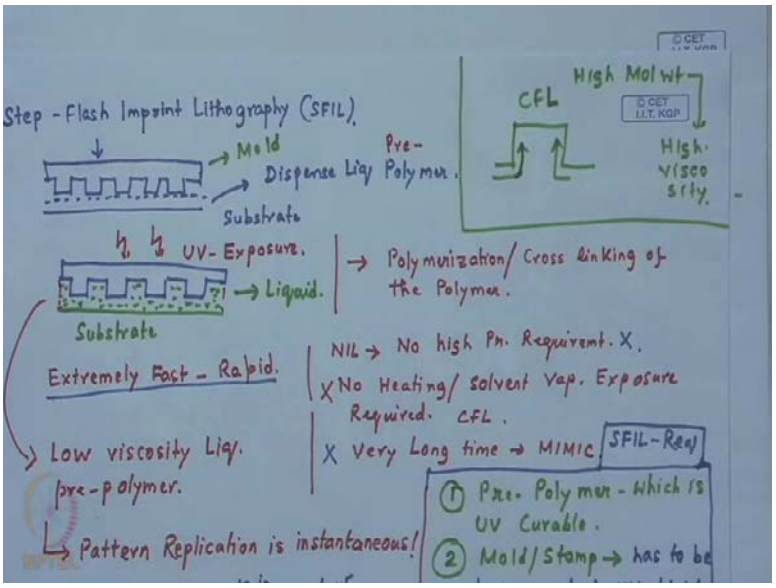

It is something very similar to it is a combination of imprinting and molding I would say so on. What is done is that you take a subscribe you dispense a liquid polymer. So, this is a liquid stage. So, viscosity very low and then you begin a stamp are a molt and simple place it over it are apply a low presser. So, what happens is you archive mold filling wither easily. So, this other archive and this is please remember, this is in a liquid from. So, only problem is that you have to somehow some it is otherwise it is of no use, because what is going to happened, the moment you are going to withdraw the mold its go to plat and out.

So, one is this consecration what is done in this method is that we do and u v exposure and this u v exposure needs to end, polymerization of cross linking of I would add the word pre polymer hear of the polymer. So, this is a very simple method very fast also that is another disadvantage of SFIL, that its extremely fast put it rapid or unlike NIL or unlike NIL no high pressure requirement is there, no pre processing in the form of no heating solvent vapor exposure required like capillary forces lithography I do not require that, we do not required high pressure, they we do not required very long time, like mimic. The biggest advantage is that you take a pre polymer which is at a freely flowing liquid condition.

So, it is a low viscosity liquid pre polymer and therefore once you bring in the mold and top of a it may be just play photo liquid little amount of extramural pressure may be do

not put in any pressure, what happens is the pattern replication is instantaneous areas. It is the biggest advantage that pattern the limitation there are couple of material limitation that comes in with SFIL which as makes the method a little bit of specialize. There are actually if you have follow the flow sheet carefully you immediately realize that there are two specific material requirement and one additional hardware requirement. In comparison to something like capillary force lithography which is even more simple which is not confine are which not restricted wither requirement of these additional things.

So, what are those requirements if you just k to think over a minute. The first requirement is that we need a pre polymer, which is UV curable. So, any liquid pre polymer won't work, because the way the method that has been designed it essential that your pre polymer is UV curable, the second requirement is the mold of the stamp this as to be transparent to UV light. So, if you just take a stamp let us say which is effect to UV then what is happen are u v exposure want reach the film an want reach the pattern liquid pre polymer film. So, it won not harden it won not cross link and therefore, the method will work you will get in see to pattern by placing the stamp, but we will fail to convert them in to into permanent structure.

So, this is the second requirement, the third requirement is off course you need to have a UV exposure system. So, these are the additional requirement of SFIL for perfect implementation are proper implementation of SFIL. However, still this method as quiet if you advantages. So, if you have this facilities and if you have the digger type of polymer, it is the easiest thing, it is the extremely fast and rapid and sins the mold filling is in liquid state and is with a low viscosity polymer, low viscosity pre polymer I would repeat. So, pattern replication is excellent it is excellent actually, because one is understand that if you compare this with capillary force lithography you add actually archiving the pattern replication with a polymer.

So, we have capillary liege. So, I just revered back to CFl for a minute you have the deigned capillary riles that the capillary rise is of a material which is in a liquid form, but it is a polymer. So, it has long change molecules the molecular weight is high and high molecular weight would in variable need to higher viscosity. So, the dynamic will be in ardently slow, in come fast hear in SFIL we are working with a pre polymer. So, the material as not a polymerize the change have not cross linking they have they are sort of

pre flow in liquid like and in many cases the polymers you work with for SFIL their more in a straight like simple water. So, always do is the moment you place the stamp on top of this pre polymer layer, you immediately have a sort of a pattern replication taking place and you get. So, very fast replication as well as the think important think is the fidelity of the structure is very good.

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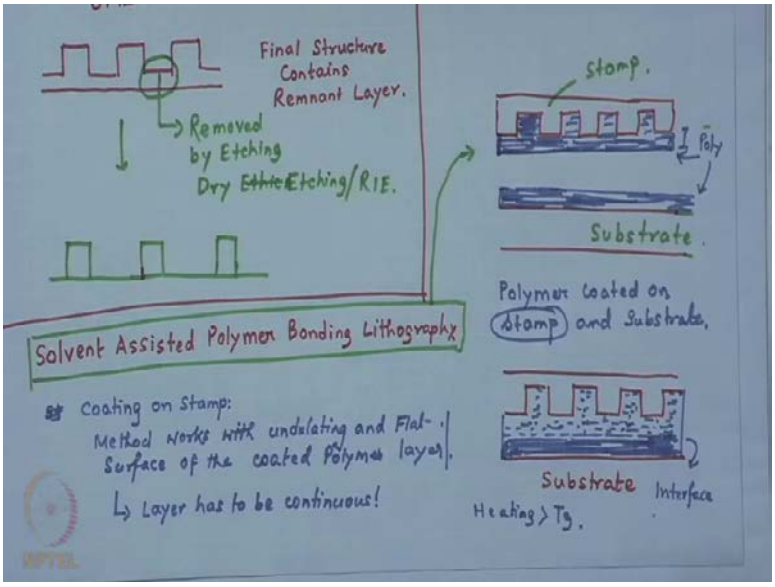

So, this is in an action your SFIL of course, you must understand that SFIL could be leaving behind structures with a remnant layer, because you have dispensed a liquid like this. So, you have a polymer both over the values and the patricians of the pattern layer. So, the final structure contains remnant layer, and therefore these as to be removed by some etching technique, dry etching or reactive etching. So, eventually that way with combination of etching you can get pre standing polymer structure and also compare to this pattern aspect ratio of the structures we will also go.

The second method that like to talk about is what is known as, the solvent assisted polymer bonding lithography this is simple method all we do is that we take a stamp and we coated with a layer of polymer. So, this is your stamp are the mold and this is let us say your substrate. So, these we are discussing hear. So, this is your substrate which can be any standard substrate like silicon wafer or glass or whatever this is your stamp and you can work with PDF stamp hear again and like in SFIL, where in you required a specialized UV transparent stamp.

So, so while we do here is we cote the substrate as well as the stamp with the layer of polymer and in the previews class. We have talk that where you try to cote a pattern substrate are topographically pattern substrate with a with a liquid by spin coating, what happens you my get this continuous structure may get continuous structure with undulating top surface or you can get a continuous structure with flat surface. The key that if you structure if this height of liquid layer significant larger than the future height then it becomes flat.

So, what you have you start off with a layer of polymer and which is coated both on the stamp and substrate, important thing to remember that coated on coating on stamp this will work with both undulating and flat surface of the coated polymer layer. We are talking about little just remain, we are talking about this layer please refer to previews this class lecture 20 on soft lithography of soft lithography lecture 5, when we talked what can be the lightly consequence morphology. If you coated directly coated a polymer layer on a topographically structure surface and let me remain the this method works for ether this layer to be perfectly flat or even.

If it is undulating key requirement is that the layer has to be continuous with a with the first situation want we talked to the concentration is too low and we have isolate structure then it of course, does into what and once we have these layer coated all we do is we bring the two in contact. So, this is your stamp now, this your substrate and you simple bring then in contacts. So, this is where the inter face lies. So, this part of the polymer was coated on the substrate, this part was coated on the film and once you bring then you contact you can do several thing in you can press them hot, we can heat them hot if it is a liner change polymer what we will happen that by heating no on T g it will be liquid light form.

So, eventually we what will happen this interface, we will disappears interface between the two polymer layer one coated on the substrate on one coated on the stamp.

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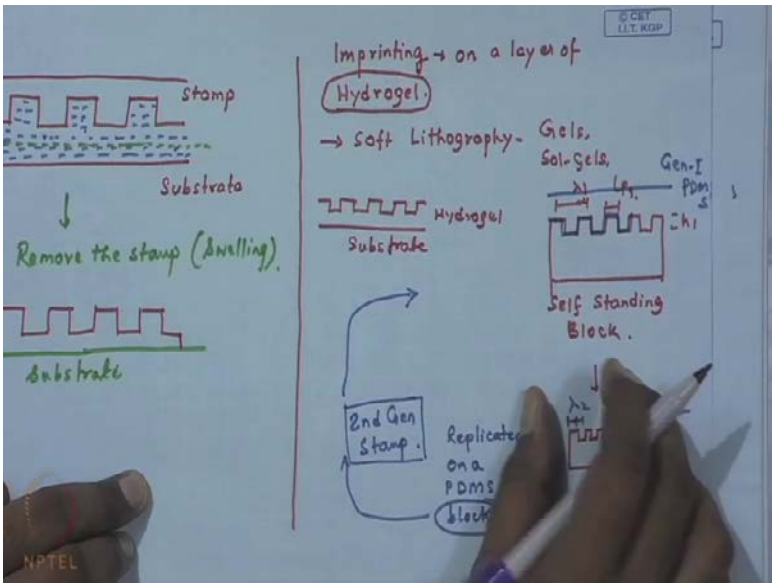

So, interface disappears and what you will be left with is a single layer of polymer. On a single layer of polymer, which is now this simple cohesive bonding cohesive attachment. So, this where let us say we have the interface and let us say we have heated it up they on the gas transition temperature and. So, it is all liquid its single moment single block of the polymer. So, is it into do be to cool it down again room temperature. So, that the whole mask now solid if and then just remove the stamp, which can be archive by let us say something like swelling or something like that and then if you remove the stamp, we have the substrate and we are left with the polymer layer.

So, this is what solvent assistant polymer bonding lithography, it is one of the simplest methods very easy to execute not material specific at all and you virtually required know hardware other then the stamp there is another. So, some extension of these methods can be a nice work I just thought that I will. So, it is imprinting are replicating it is very close to all the concept of SFIL or simple imprinting also, imprinting on a hydro gel and we talked in the previews class we give some examples of pattern behind the master. So, this is another example of that now, while introducing to you soft lithography we did talk that soft lithography works very well for different types of material like, not only polymer, but gels in organic sol gels etcetera.

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So, we can just check out this hydro gel this is a soft solvent polymer network, which contented lot of water. So, if you remove the water in a control fashion, we absorb a significant amount of shrinkage of this hydro gel layer. So, in this particular method what was done is that. So, soft lithography as been pretty rout in the use for pattern in hydro gels not a great deal, but typically people as use soft lithography to pattern a thin layer of hydro gel.

So, this is let us say, the substrate and this is the hydro gel layer can by any of the soft lithography techniques. We can very easily get and a get replica of the stamp in this particular method, what was done that instated of a thin layer a block of hydro gel was pattern, the self standing block. It is simple replica molding; we can say hydro gel is liquid like at room temperature you sort of place the stamp get in a get in a replica and then you so, what about done. So, after this layer was pattern it was now, allow to shrink with give operation of water. Now, the moment water starts striking there significant volume reduction which can be the order of the 16, 17 are even 90 percent depending on the initial water contain.

Now, the idea was as this block of hydro gel shrank the surface futures present on the surface of the gel block of also shrank. So, we stated off with something like this, we do a controlled give operation and you get a block size like this. So, what is the advantage we have stated of? Let us say with a future damnation of let us say lambda 1 height of 8, 1 are line width of l p 1 let us say and, because of the shrinkage, you have now reduced to of lambda 2 l p, 2 and h 2, each one of them is smaller than the damnation and the original master.

Now, this is what was subsequently done was this pattern and the hydro gel surface was reproduced all this was now replicated on PDMS block. So, we know have a negative replica this structure on a PDMS block which now becomes the second generation stamp. So, you have a PDMS block which contain the negative replica this structure which was the. So, this is the PDMS stamp generation one stamp, you imprint with that a block of hydro gel we shrinkage it, this shrank hydro gel layer now the structure on top of that is replicated, an another PDMS block. So, that becomes a second generation stamp and you just continue the same process. So, now, you use this second generation

stamp to pattern another block of hydro gel again archive controlled shrinkage of give operation and then you can get even smaller future size.

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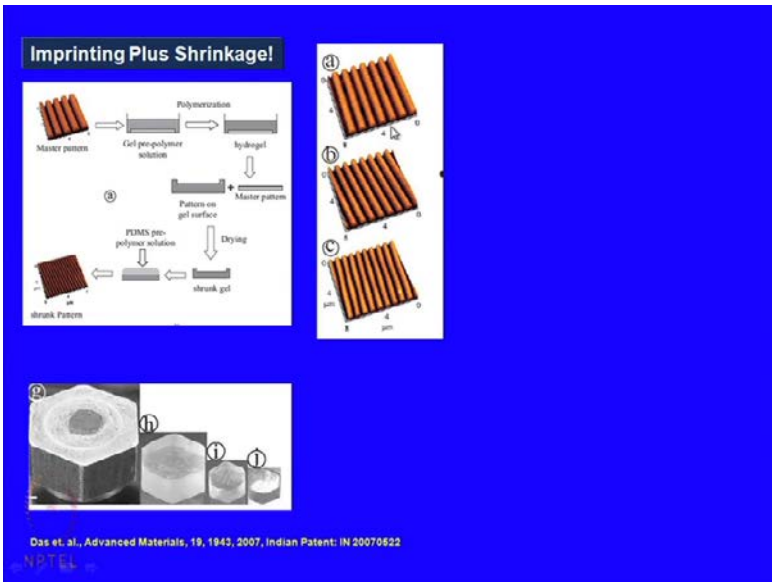

So, you see here that starting off with a layer a, b which is let us say periodicity city one and of micron. In the second generation you archive now, raffle 40 percent shrinkage periodicity as now, drop to about micron you can measure that here you have it micron and you all most have it strips here you raffle six and this now. So, this is now second generation stamp, you re imprint another block of hydro gel with this one to get a third generation stamp, which as even small a future height these very unique concept, where a combination of imprinting plus shrinkage has been sort of used to archive pattern switch as smaller, in future the mention as compare to the original stamp size.

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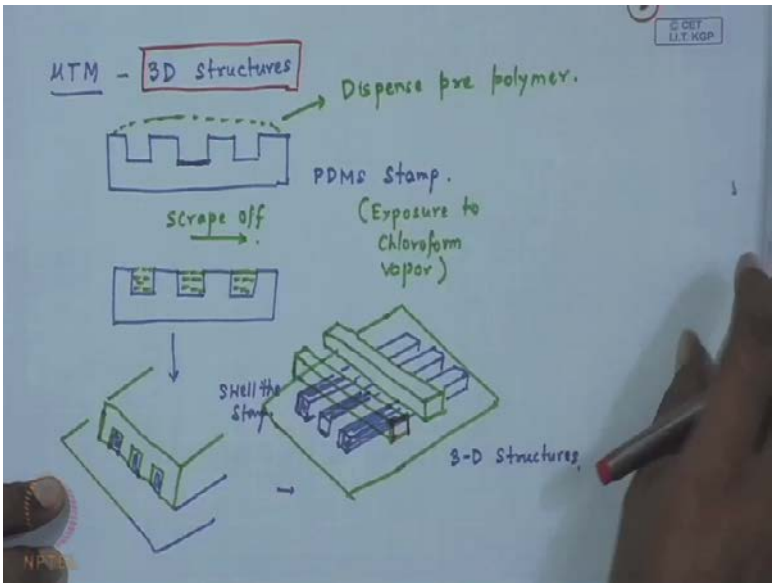

Now, this brings now to micro transfer molding, which is as I have already point out slightly unique in the fact, that this is a method by which we can make three dimensional structures. So, let us again very simply to execute all we do he is you initially PDMS stamp and cote it dispense a liquid pre polymer. We have already talked about pre polymer in case surface SFIL which not polymerized, we dispense a pre polymer and then what you do you sort of strips it off from the top. So, you are left with a structure like this. So, you moles are field up with you pre polymer and then do in situ polymerization.

So, scrap off do a in situ polymerization and then what you do, you just turn it somehow swell this stamp this PDMS stamp we can be easily swell by a exposure to chloroform vapor its swells. So, this way if you turn it down. So, what happens is if this is let us say, getting structure. So, these are individual sort of strips of this polymer. So, he turn it down keep it in a substrate. So, here is a substrate here you bring in the, this is now contains the polymerized strips this is now, turn hear.

So, now you what you do is you swell the stamp, so that it detaches and withdraw the stamp, you if behind isolated strip was the material on the substrate.

So, this is fine you have some nice strips like this, but what is the advantage? Advantage is you can repeat this processes again, you can take another stamp scraper filled up with dispense polymer script of do the polymerization there and now suppose bring in that

stamp and place it over here swell it. So, in the places now you can place this you steps of strips like this. So, you have let us say these steps over here and. So, this way you can go on building in away layer by layer and go on adding the different layer. So, again third layer can coming like this.

So, this sort of gives the ability to create two 3 d structure, the examples I it up is up understanding is of course limited to the fact that you have taken a grating stamp, that you can start off with more complex stamp and can have heretical future other type of future by micro transfer molding, but this is please remember this is probably the only soft lithography method that allows you fabricate structures which are with full are two 3 d capable.

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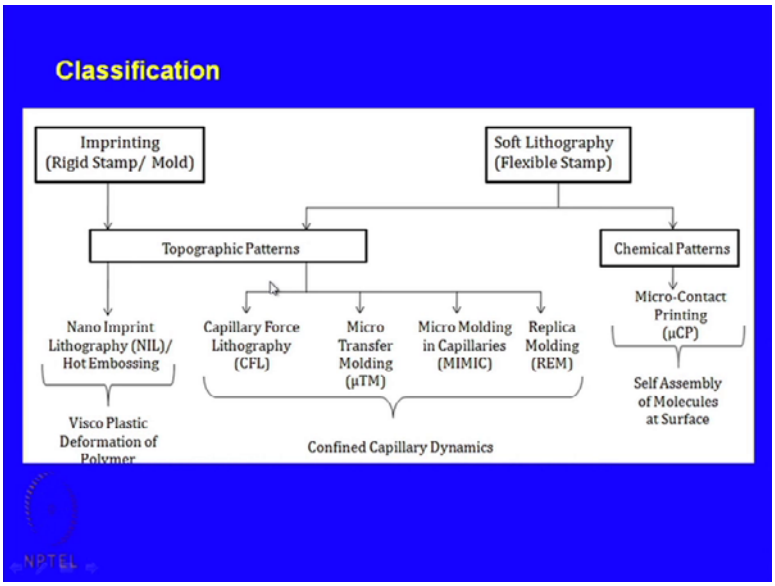

That brings to micro contact printing thing eventually, let us have a quick look at the classification again what are the things we have discussed. So, we have already discussed the NIL group of method. So, imprinting group of techniques with in stamp are mold then you have significant discuss the soft lithography group of methods which use flexible stamp. So, have we do wither conform the part of the table to discussing about topographic patterns and now, you see most of the names of that which is here we will make sensitive you.

So, CFL you understand, micro molding in capitalizing you understand, replica molding you understand, you have also talked about methods likes some in. So, we have talked

about like polymer bonding lithography and you just talked about micro transfer molding and the last part offered discussion and soft lithography we will now focus on how to make chemical patterns, we already understand what we mean by a chemically pattern substrate.

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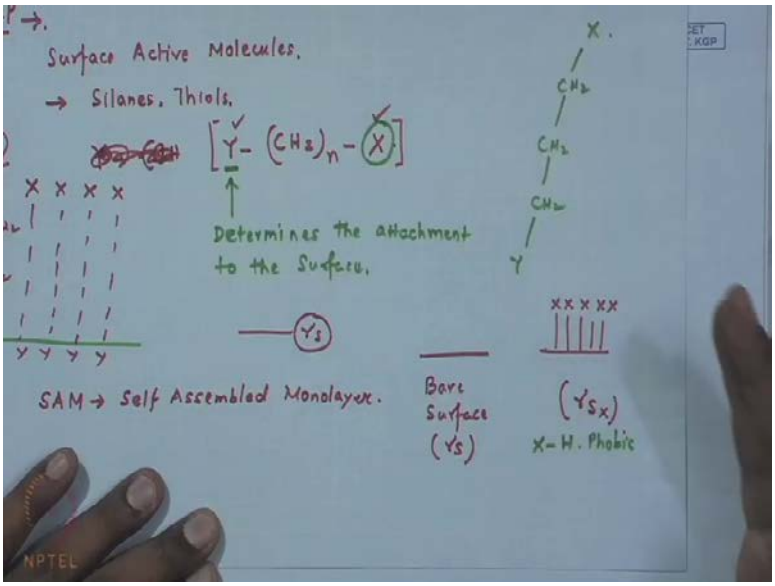

So, essentially we have you have a surface like this where you have different wettability resumes and this is archive by the method of micro contact printing interesting, this is the first soft lithography method that was develop way back in early 90s and this realize and what is known as self assembly of molecules at surface. So, we will discuss that.

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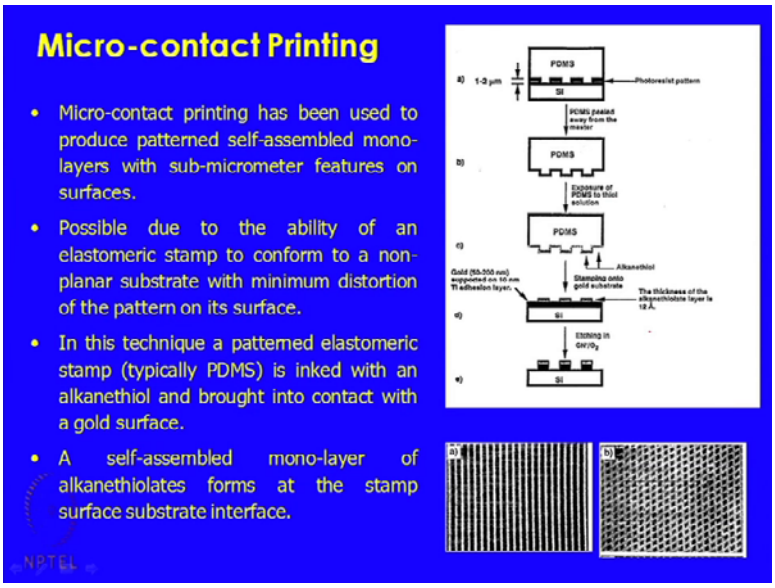

So, it is everyday simple method essentially, you use some special type of molecules surface active molecules.

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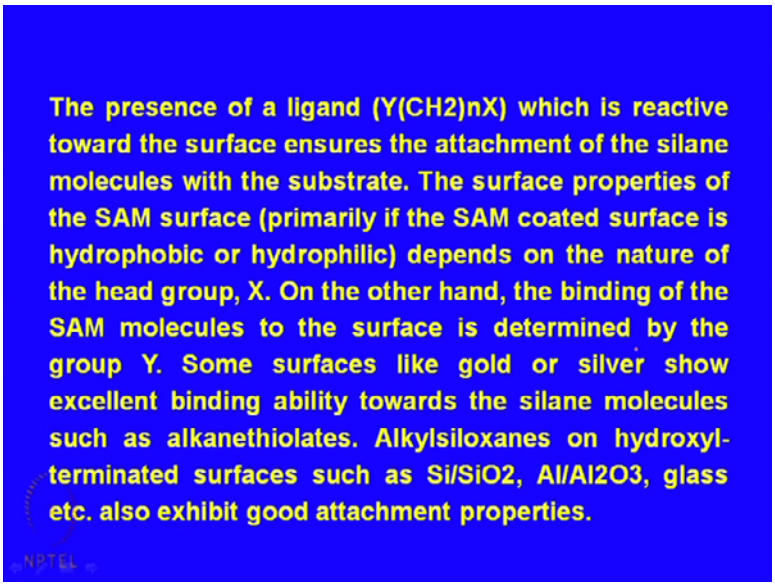

Now, these molecules are primarily of Alknethiolates, some example we one going to the chemistry. So, these are like silane of thiols, this class of molecules and they have a generic structure.

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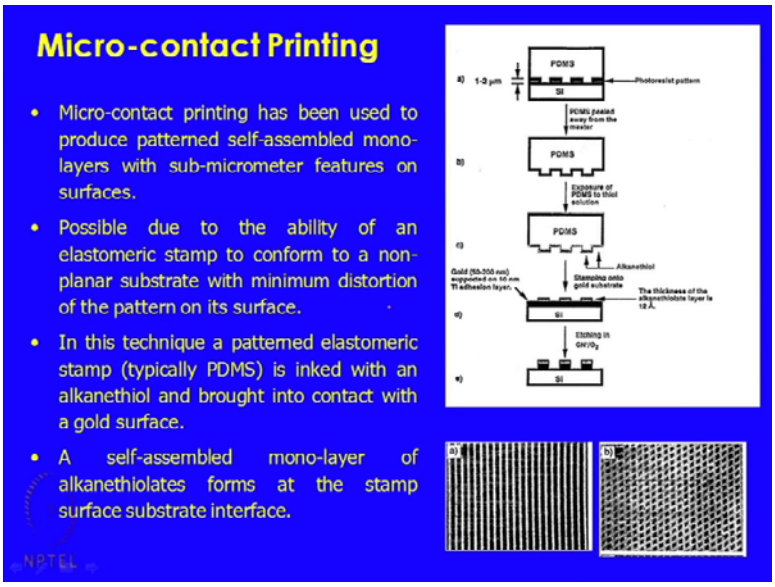
So, these are again launch in hydro carbon, but they have the two legends y and x at the two ends this out of this to lagans y is the one the detriments. So, essentially what you have is a launch and molecule like this and this y end of the molecules determines the attachment to the surface. We have long time back in the initially few lectures talked about surf act in the molecules about surfactants.

So, in away if you have a surface and you simple inverse it forget about micro contact printing are anything inverse it. In a solution of this surface active molecules are silane what is going to happen is, that this y is going to tag itself to the surface and then the molecule we will take a shape like this. So, if the surface is now fully covered you this type of molecules like this. What will happen suppose, if gamma s was the original surface tension of the surface energy of the substrate, some layer are coated a silane layer coated surface. We will exited a completely different surface energy and the surface energy and that we will be the surface energy corresponding to the legend x.

So, what is Sam? Sam this refer to layer of self assemble mono layer. So, this molecules for all particular purpose behave some sort of a surfactant the moment you moment you defect surface which of course as the ability to bind to y the y and of the molecules we will come and by into the surface and the whole surface we will get covered we this molecules. So, eventually the future height of course it looks very long these are one molecules the damnation. So, which is sub Nano meter may be couple of hang strums. So, virtually there will be no change in the future height are whatever, but effectively. So, you have these bare surface and now with coated with this layer of Sam, let us say bare surface and let us say a surface energy gamma s this win for all practical proposes have surface energy of gamma s x.

Now, please do not confused that if you cote a surface with Sam layer its go in to be hydrophilic or hydro phobic it is not like that wither the surface energy increases are not what will be. The generic nature of the Sam coated surface depends on the nature of the x. So, if the legend x is hydrophobic then what is going to happen this the whole coated surface will beaver as a low energy hydrophobic surface and other hand, if x is hydrophilic then after coating you can sort of get a more wet table type of surface.

So, here is the formal statement the present of a ligand which is reactive to the surface ensures the attachment of the silane molecules with the substrate. The surface properties of the Sam surface, if the Sam layer coated surface is or hydrophilic hydrophobic depends on the nature of the head group x. On the other hand the binding of the Sam molecules to the surface is determined by the group y. Some surfaces like gold or silver show excellent binding ability. So, this is important much time you have to coated surface with gold or silver, because the show excellent binding ability towards the silane molecules which are alknethiolates. Alkylsiloxanes on hydroxyl terminated surfaces etcetera glass also can be used.



Now, the idea is that is show after we understand this concept of self assemble mono layer.

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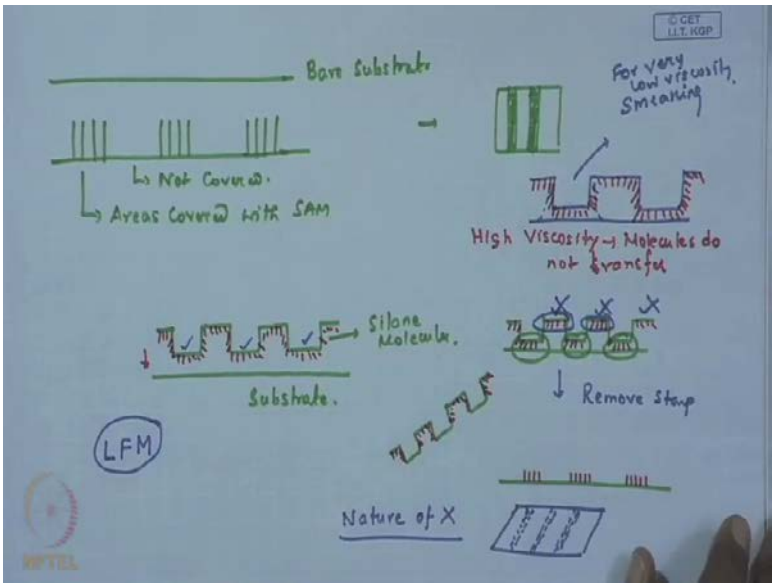

The idea of generating a chemically pattern surface essentially, is to control spatially the attachment of this molecules. So, suppose you have a bare surface and instated of a covering it fully with this Sam layer coated molecules, if you can somehow do something. So, that only parts of the surface get covered with these molecules, then affectively what we will see different chemical pitchers correspondence to this. So, these are areas covered with Sam not covered, if you deputy substrate into a Sam into a solution off course this is not archive, because everything we get covered with the Sam.

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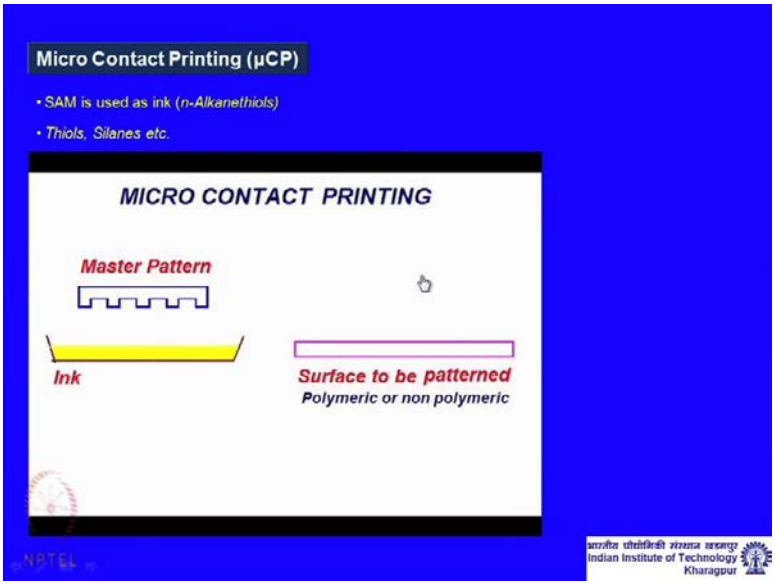

So, this is archived by very simple method and we can sort of look at this movie. So, what we have is a master pattern are a stamp which can be PDMF stamp which is the PDMF stamp and link is nothing, but a silane solution, the solution of the surface active molecule and this is the surface to be patterned. So, that the substrate what we do you take this stamp you deputy. In the solution its non as the inking process of course it not possible to inking like this typically one deposit in the solution and then this stamp is carried back and he simple placed and the pattern surface on the surface to be patterned.

So, what happens is the stamp which was (( )) silane solution now, contains silane molecules as the think waiting layer around it and when this stamp. So, these are the silane of the. When this stamp is got and placed on their substrate, which as desire level of the reactivity with the legend y and you simple place it. So, we bring it in and over the zones where the stamp and the surface on direct contact. The silent molecules get transfer and get attaché to the surface; however, over the other area sins there is no direct contact between these area.

So, there no direct contact between the stamp and the substrate. So, these molecules remain station on the stamp itself. So, and they cannot get transfer on to the surface. So, now, when you remove the stamp, its only over the areas which were in direct contact with the protchudate areas of the stamp the silent molecules get transfer on to the surface and the stamp now look something like this. So, the silane molecules which are over these areas remain attached to the stamp, but only the molecules over this zones, which came in direct contact during in the contact processes over hear as we can see get transfer to the surface. So, what happens, these now if you look at it 3 d view? So, suppose if you have a grating over this entire length of the straight we have self assemble mono layer on the surface, which now at as different wettability resumes depending on the nature of the aligned x.

So, this is one of the simplest methods very easy to execute of course, there are critically issues critically issues in valve lets me get quick detail. So, the viscosity of the silane, the solution is extremely important, because though it is the preferential attachment, that eventually guides the self assemble of this molecules on to the surface. One as to understand that if this waiting layer is two dry of the viscosity is too high then what it will happen even during contact this molecule my fail to transfer from the stamp to the surface. On the other hand if it is too weight, if it is very daily then not only other these

areas the molecules we get transfer, but it might actually farm a meniscus and you might are a wider zone over which the molecules may transfer, which can need to the effect of what is known as smearing for very low viscosity.

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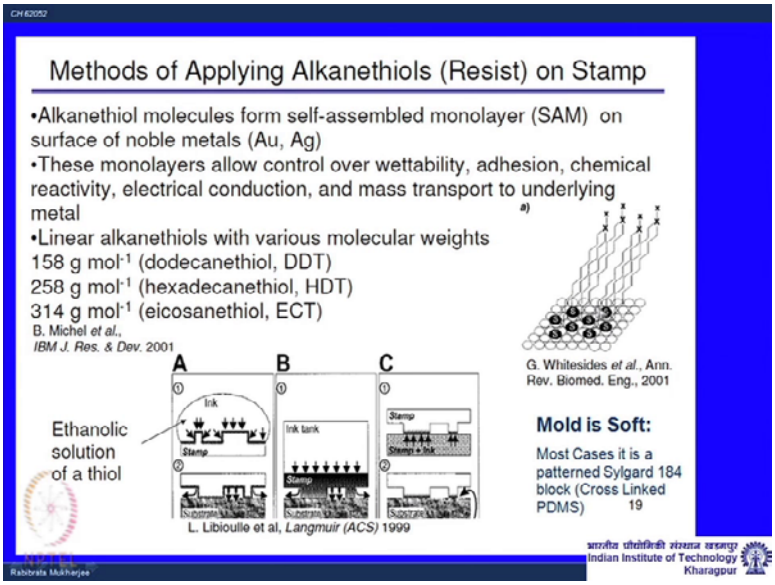

So, this incentive viscosity is something as that controlled in experiment and in many cases, it is sort of archive by drying the stamp after it has been withdrawn from the linking process are from the Sam solution. So, these are some critical experiment, we show this is what it is. So, this how looks like it is attach to the surface and to these finally, the effective wettability of surface of Sam layer coated, I think layer is determine by the interdiction are for the nature of the ligand x.

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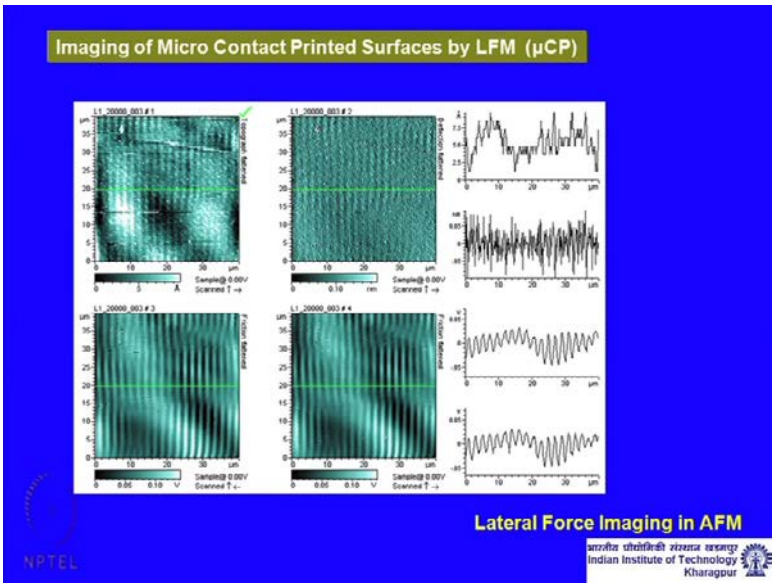

So, other important aspect you is, we will take it off in the subsequent lectures of we will talk about it is there, what is known as the lateral force microscopy which is important to image micro contact printing surfaces. So, this is just sort of a quick trial I would like to give you hear by talking about atomic force microscopy which is next topic we are going to take up, we will talk about a lesson and we will revise this particular image there and how it is important in one see in specifically, imagine micro contact printed are chemically pattern surfaces.

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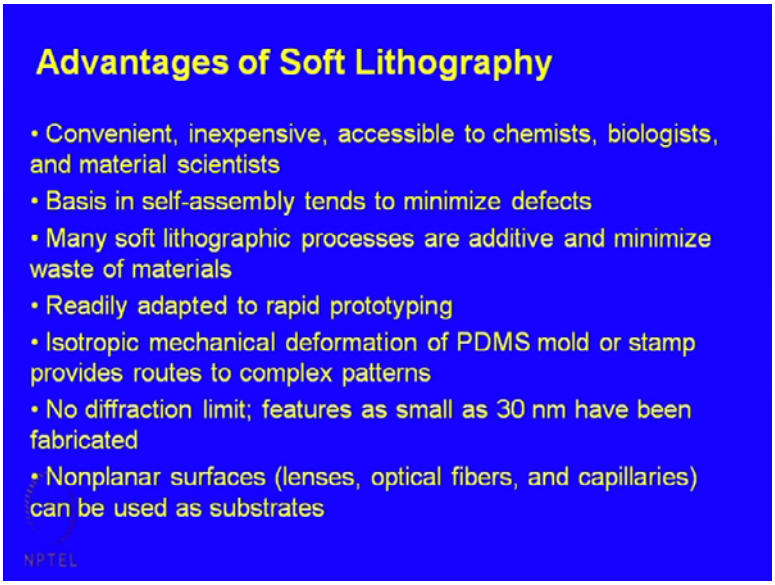

So, that sorts bigness to the end of our discussion on soft lithography soft lithography techniques. So, I will quickly revise it this classification like again and you. Now, see that we understand based on the classic lectures, we have then the different aspects of the different types of soft lithography methods. We now understand about this imprinting as well as the soft lithography group of techniques and we also understand then the different methods available for topographic patterning as well as for generating chemical patterns of course, this method is likely unique in since, that he one able to cannot this one micro transfer molding. We are able to generate 3 d structure is micro contact printing allows due to make chemically pattern structure and other once most of the other once make gives you the flexibility to make topographic futures.

A quick look at some of the advantages of soft lithography, so it is convenient, inexpensive, accessible to all most everyone, people most importantly it was non expose to lithography. The basis of the most of the methods is self assembly of some sort of the other which tends to minimize defects. So, other than mechanical processes are motion like photo lithography for example, because here to be large it relive and pattern replication, on the forces like capillarity when also surface on the etcetera. Many of the soft lithographic processes are additive and therefore, the minimize wastage of material, we really do not going for processing like archive, we do not required that which essentially is nothing, but wastage of materials.

So, it can be the methods can readily adapted rapid prototyping. Isotropic mechanical deformation of PDMS mold provides routes to complex patterns. So, there is no diffraction. So, this is extremely important it. So, photo lithography is significant limited by the diffraction of the wave length of the light so, your using.

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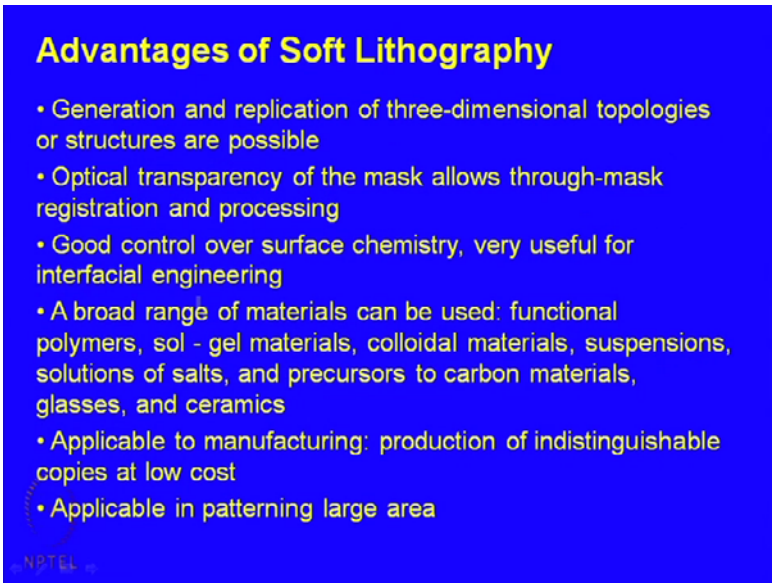

And 30 Nano meter, not even 30 Nano meter it futures as no assent Nano meter as be archive to a back in 2005 itself use of a flexible stamp allows you to pattern of film coated on non planer surfaces. So, lenses optical fiber capillaries etcetera, can be used as substrate generation and replication of three dimensional topographic or possible micro transfers molding. We have already talked, optical transparency is gives you to allows through mask registration and processing in some methods like we have talked about this SFIL. Good control over surface chemistry which is extremely useful for inter facial engineering. A broad range of material can be we pattern functional polymer solution, gel colloidal materials, suspensions, solution, because of the carbon material glass and ceramics etcetera, it is not limited to only one sort of material like photo resist, which is the case with photo lithography applicable to manufacturing.

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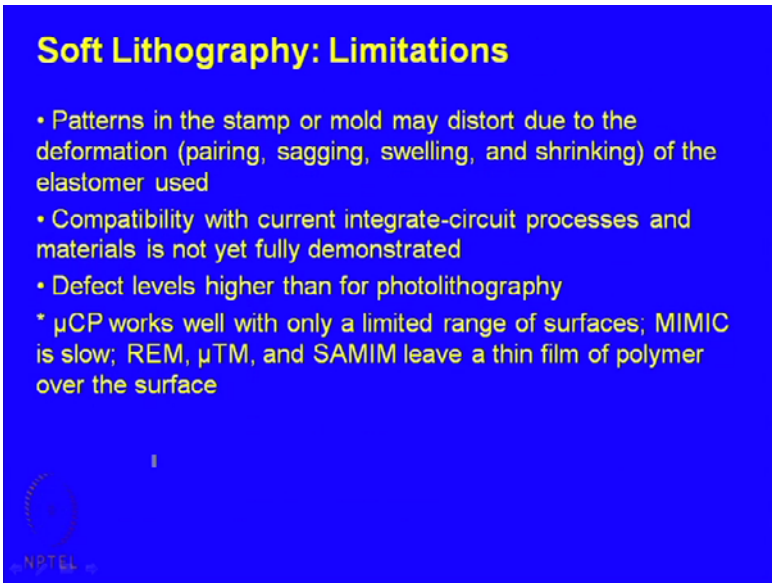

So, indistinguishable copies can made at low cost, patterning in the large area can be archive. Some practical limitations are patterns in the stamp or mold may distort due to the deformation we shows pairing, sagging, swelling and shrinking etcetera. You we have already talked about the fact that soft lithography to large limited by the availability of type of a stamp which is of course to limitation one of us to understand. It is effects are be made to make it compare with current I c processing technology.

So, this time extent that the soft lithography group of method its can be extended to the microelectronic paradil. Microelectronic industry defect levels off course higher then photo lithography and therefore, which makes it in does it indults for the microelectronic industry. Micro contact printing there are some material restriction for some of the method some example micro contact printing works well limited range of surface, it is like gold are silver coated surface, as we already talked because the surface as to offer god binding with the while legend. Mimic is slow, because it is capillary given processes dose two are for long lengths, replica molding, micro transfer molding and SAMIM in level thin of polymer or remnant layer we have already highlighted.

So, which as to be remove reactive archive are thinks like that, but still soft lithography is very exiting area very advancing area of such the lot of research still going on different aspects materials, they on the master pattern the and thinks like that and it is sort of a, it can be implemented without significant inform structure, which is absolutely magnitude,

in photo lithography soiled strongly encourage looking in to do soft lithography key word, and like is the soft lithography as the names of the technique. You have understudy and sort of argument whatever, you have learned to in this course on soft lithography thank you.