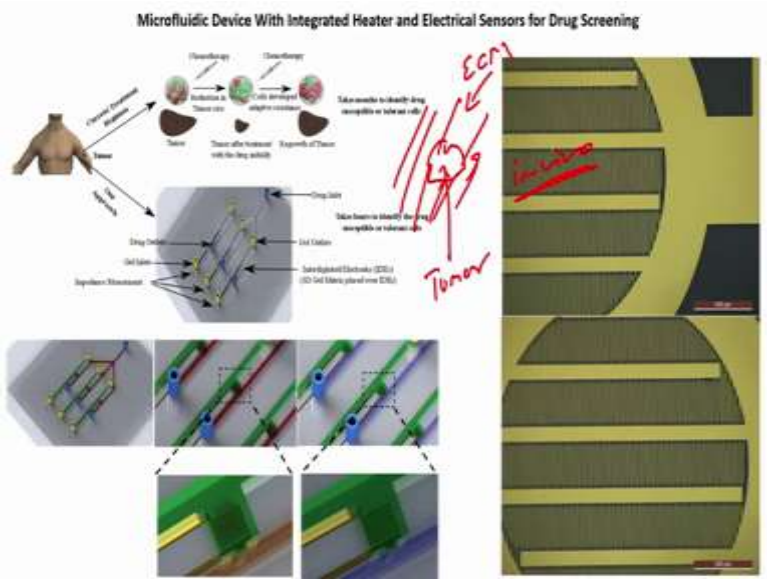
Sensors and Actuators
Dr. Hardik J. Pandya
Department of Electronic Systems Engineering
Indian Institute of Science, Bengaluru

Lecture – 61
Microfluidics based Drug-Screening

Previously we have seen that what is the problem right now in screening a particular drug, for the given 3 drugs which drug to give to a patient so that the patient can recover faster. All 3 assuming that they are of the same cost all are FDA approved and all are meant to kill that particular disease, right. How the clinician will come up with an idea or with the intervention that which one he or she has to prescribe to for a particular patient?

Now, can we design a chip that can screen this drug for a given patient? What do I mean? Suppose you take an example of for disease where you can take the cells of the patient. And if you see the screen and I will tell you more about that.

(Refer Slide Time: 01:34)

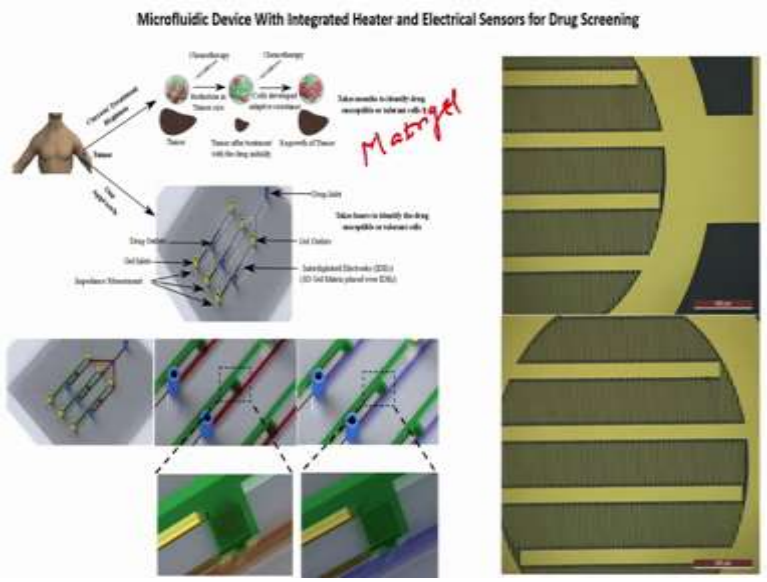


So, right now what happens is that the cells are taken, right and then they are grown to form a tumor and then there is chemotherapy and at the chemotherapy is effective, then initially the cells which are dying tumor will reduce, but after some time this tumor will regrowth, alright. So, it is very important to identify which drugs are susceptible all tolerant, for that particular tumor. Now, what we want to work on is if I, so if you see a

tumor, right, the tumor is always surrounded by something called extracellular matrix, ok. It is called ECM extracellular matrix this is your tumor, alright.

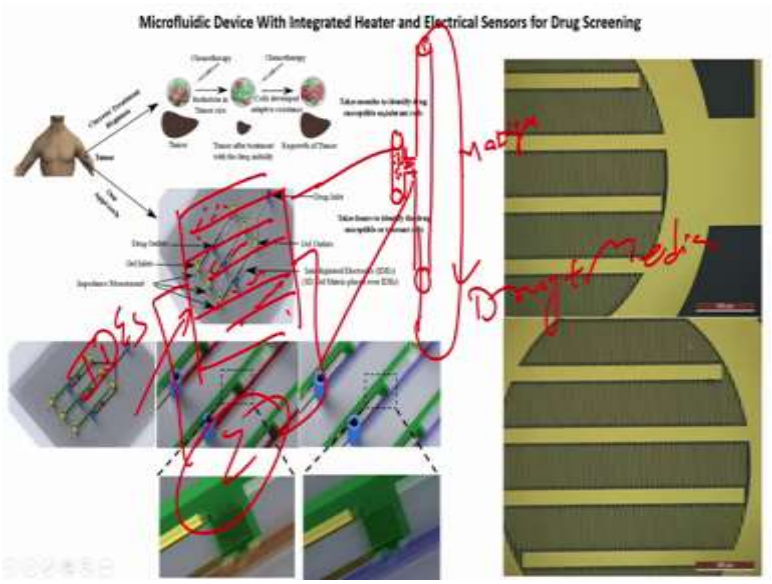
Now, how to replicate this tumor an extracellular matrix? This is an in vivo within the body. How to replicate this condition on to the microfluidic chip such that we can use the platform for drug screening? So, for that what we do is, this ECM that I was talking about, right. ECM can be replaced by matrigel, right. ECM can be replaced by matrigel, one thing.

(Refer Slide Time: 02:44)



Second thing, if I have a microfluidic chip like this and below it, if I magnified this particular section then this is like interdigitated electrodes are there below the chip like this, this particular section, ok. So, now, we have interdigitated electrodes. I will load the cells; I load the cells on to this particular platform with matrigel. So, cells with matrigel, alright. So, cells would be here with matrigel where from where you get the cells? Cells from the patient, right.

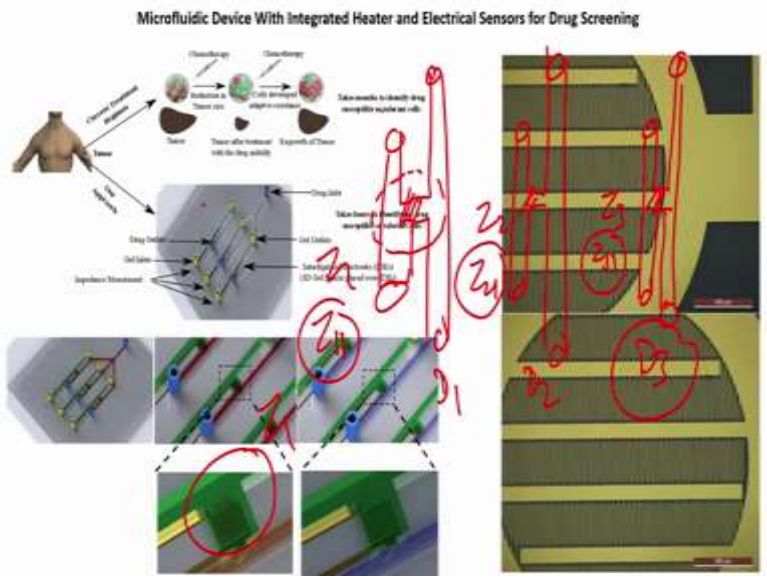
(Refer Slide Time: 02:56)



If I have cells with the matrigel on this particular interdigitated electrodes I can measure impedance called Z, alright. And in this channel, we can flow continuously drug with media, right. Drug with media is like as if you are giving a drug to the blood and blood flows to the channel, alright.

Now, let us understand how this works. So, if you have the chip and you have 3 of this then you can test 3 different drugs for the given patient, is not it. So, you see this particular schematic, the green one is where you load these cells with matrigel the red one is a drug that can flow. Now, for the given patient you can test 3 different patients for this particular chip, right because you have cells for patient 1, cells for patient 2, cells for patient 3 and you have a single drug that you are flowing, but like I was drawing earlier you can test different drugs for the same patient.

(Refer Slide Time: 05:01)



That means that if I have this one which is my first microfluidic chip, right, like this, and then another microfluidic chip like this, and then the third one like am showing you the figure, right. And if I load cells here, here, and here, then I apply I flow drug 1 here, drug 2 here and drug 3 here. What will happen is, so if I zoom this particular part it will look like this, ok. It will look like this. That means, the matrigel is sitting on matrigel with cells are sitting on the interdigitated electrodes when that happens there is impedance Z 1, in this case, it will Z_1, in this case, it will be Z_2, in this case, it will be Z_3

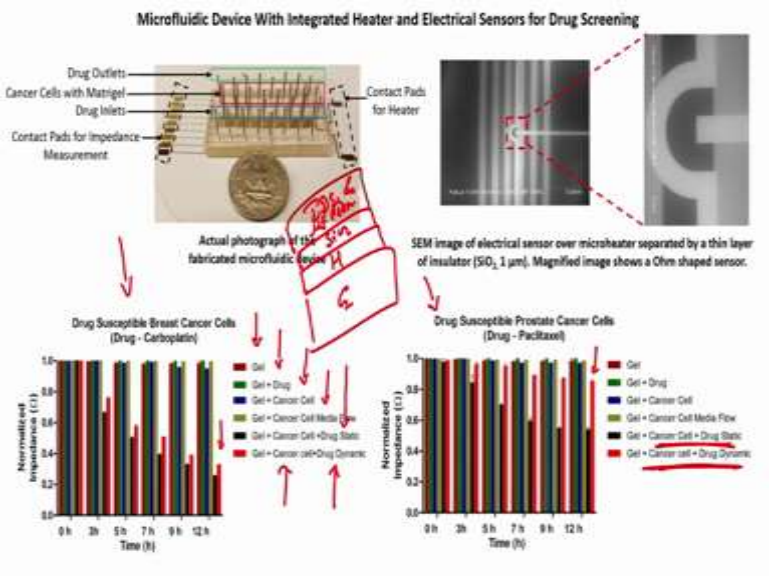
Now, when I flow drug, the drug will diffuse into this particular matrigel as we start killing the cells based on the efficacy of the drug. How much drug is efficient? The drug is efficient then the cells would start dying when cells are dying I will have Z_{11}, Z_{21}, Z_{31}.

Now, the impedance would change based on the conductivity of the media, right, the conductivity of the medium would change if the cells die more. The cells dying is called lysing and, the cell lies in the connectivity would increase and impedance would decrease; that means, if I flow drug on this particular three channels, right drug 1, drug 2, drug 3 for 24 hours and if I see a larger change in impedance values then for the one which is showing the more conductivity I can use that as a drug for a given patient rather than drug 1 or drug 2. For example, if the drug 3 shows higher conductivity or higher change in impedance values compared to drug 2 and drug 1, then the 3 would be more

effective for the given patient. For a second patient, it may not be true, again you have to do the same experiments and you may find that instead of drug 3, drug 2 may be useful.

Now, how these interdigitated electrodes can be fabricated is very simple I have taught you earlier, and this the right side is a schematic of one such interdigitated electrodes, right with 5-micron spacing. These lines that you see here 5-micron spacing and 5 microns width, alright and these are finger electrodes or interdigitated electrodes that we have fabricated, very clearly defined interdigitated or finger lines are there.

(Refer Slide Time: 08:01)



And this chip can be used for screening of drugs you can see here that if I take an example of breast cancer cells versus the prostate cancer cells, then only gel there is no chain, gel plus when you have gel plus drug on the channel there is no change. Gel plus cancer cell no change. Gel plus cancer plus media flowed no change, but only when there is a gel plus cancer cell on the static platform and when you flow on the dynamic platform then you have changed.

What we static platforms? You take a chip, you load the matrigel everywhere and you load cells like this, you load a lot of cells like this, and then you load this thing with some kind of drug. Now, this drug is in continuous contact with the cells. When the drug is continuous contact with the cells the cells would die, but this is a static platform form. Our body is not static, our body is dynamic, and that is why we had to rely on a dynamic platform instead of a static platform and that is why we had to go for a microfluidic

platform. So, we can see that when you flow the drug that drug plus cancer cell in a dynamic mode is showing a different value for also prostate cancer, it shows a different value compared to the static platform and that is why we had to rely on a dynamic platform.

Also, this is very good because we can get something around fourteen hours we get all the understanding of the efficacy of the drugs. So, it is worth trying this platform as a patient-centric platform. For prostate cancer, we have used paclitaxel as one of the drugs and for breast cancer, we have used carboplatin as one of the drugs.

Now, you know that the cells need to be alive when you do not for the drug, right. So, for that, you had to have an incubation medium and for that, you can have a heater and then interdigitated electrodes. So, if I draw this block here then the middle block is glass, then there is a heater, then there is an insulator which is SiO_2 on which there is there are interdigitated electrodes and microfluidic platform, alright. So, this is how the microfluidic chip can be fabricated for drug screening. It is a, we can also name it as a patient-centric platform.

And this is the end of this particular module, right. So, what we have learned till now is how can you design a microfluidic platform with the help of electrical sensors for drug screening and we have just, I have just shown you the breast cancer cells, what is prostate cancer cells, but the people have used for a lot of other applications, all right. So, till then you take care. If you have any questions you let me know through the, to the medium, right. We have a beautiful forum through which we can ask a lot of questions. And again if you have a really important question, you can also shoot me an email, alright.

So, I hope that overall you like this sensor and actuators course and you are getting some new concepts into your understanding, right, where you can use it for several different applications starting from drug screening to gas sensors to (Refer Time: 11:24) sensors, atrial fibrillation, EMT sensors, which is electrical mechanical and thermal sensors, right. We have seen piezo resistors, we have seen interdigitated electrodes and we have seen a lot of lab components, alright.

So, you and there are a lot of assignments, I hope that you do not miss or any assignments. A very important part of the course is to go for the assignments and if you

have registered for the course and you have registered for the exam then you take this course. Believe me, the exams set, the questions that I have set are not that difficult, alright. It is all through the things that we teach here and some, of course, are about thinking, right.

If I give you an example that if I use a positive photoresist, negative photoresist and if I have a bright field mask, right what do you expect as the outcome. Then you can understand that positive photoresist when you whether the area which is not exposed will get stronger wherein negative photoresist, the area which is not exposed will get weaker, right. So, based on that how you can think. That is just I am giving an example, ok.

So, the point is once you understand the sensors and actuators part you can use it for several applications. I have taught about something on the medical side, but you can use it for space, you can use it for a lot of other applications including your mobile telecommunications, TV, right, displays that you use it in a daily routine, mobile phones and automobiles and a lot of other places, right.

So, this is my last class. If you have any questions again feel free to ask me through the NPTEL forum, right. I will see you on some other course till then you take care. Have a nice year, right wherever you are and be safe. Just go through each module, right and all the best for your exams. Bye.