Proteomics: Principles and Techniques

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Lecture No. # 38
Nanotechniques in Proteomics

Welcome to proteomics course. In today's lecture, we will talk about Nanotechniques in proteomics. In the last few lectures we talked about different type of proteomic technologies. We started with conventional gel based proteomic techniques. We moved on to mass spectrometry different type of quantitative proteomics by using mass spectrometry. We then discussed about microarrays different type of microarray platforms including conventional protein microarrays and cell free expression based protein microarrays. Then we started discussing about different type of label free techniques. In the last few lectures we focused more on new and different type of label free methods, such as surface plasmon resonance, surface plasmon resonance imaging, ellipsometry, interferometer and different type of platforms. In the same theme and same continuation today we will talk about different type of Nanotechniques. How they can be use for various type of proteomic applications? We will discuss more on their principle some of the advantages and disadvantages. Which each of these methods offer and very briefly we will touch upon. How these nanotechniques are applied for proteomics based applications?

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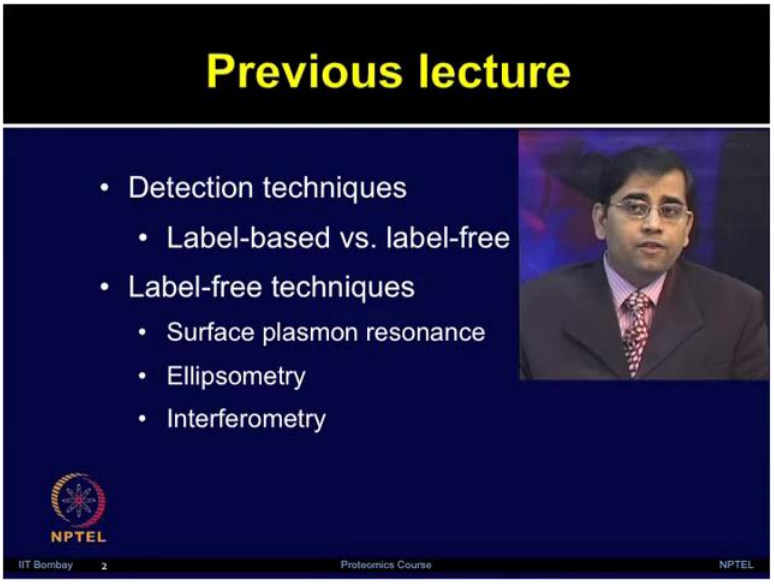

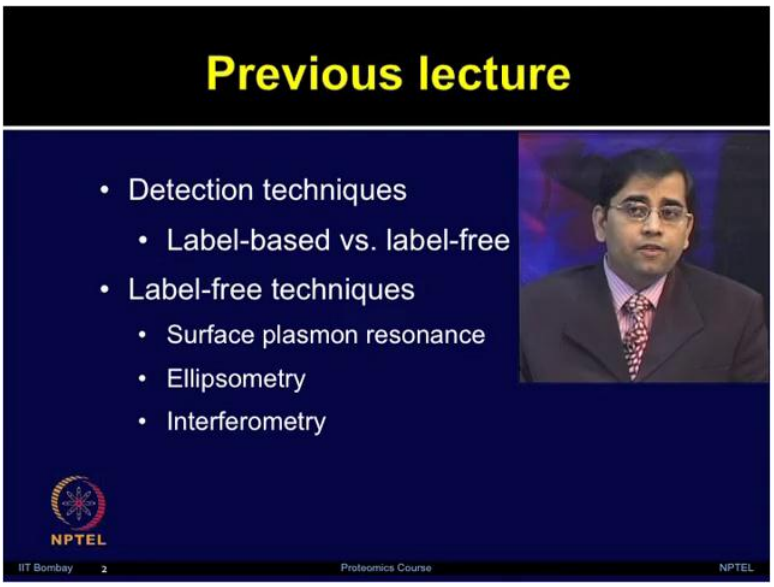

So, in the previous lecture just to refresh you we discussed a comparison of Label based and Label free techniques. We talked about advantages and disadvantages of each of these type of Detection techniques. We then focused more on specific label free techniques, such as Surface plasmon resonance, Ellipsometry based label free techniques as well as Interferometry based label free techniques. Now, today we will talk about some of the nanotechniques which are applied for proteomic applications these nanotechniques offers several advantages over the conventional proteomic techniques such as miniaturization of assays, real time multiplexing capability, low sample and reagents consumptions very high sensitivity and quicker assaying time.

There are several nanotechniques such as carbon nanotubes and nanowires, quantum dots, gold nano particles, silicon nanowire field effect transistors, which are now increasingly being used for various proteomic applications. These applications include biomarker discovery immunoassays label free detection as well as different type of bio molecular interaction studies including protein-protein interactions. The successful integration of nanotechnologies with proteomics has now introduced a new field in this clinical research area known as nano proteomics. This is one of the very rapidly emerging areas for the biomedical research which may have ultimately tremendous therapeutic potential.

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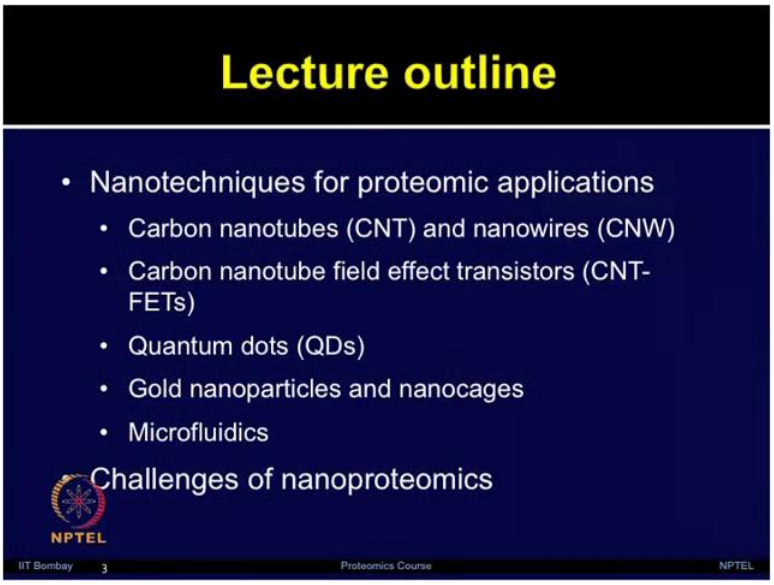

So, in today's lecture, we will talk about different nanotechniques which are applied for proteomics applications. We will talk about Carbon nanotubes CNT's and nanowires CNW Carbon nanotube field effect transistors CNT, FED s, Quantum dots also known as QD s, Gold nanoparticles and nanocages and microfluidics. Then there are many new emerging nanotechniques which are also being used for proteomics very briefly we will touch those techniques as well. Then further we will discuss about challenges of this new field nano proteomics. How even the integration of these two nanotechniques for proteomics has a still various challenges and how one can overcome those challenges.

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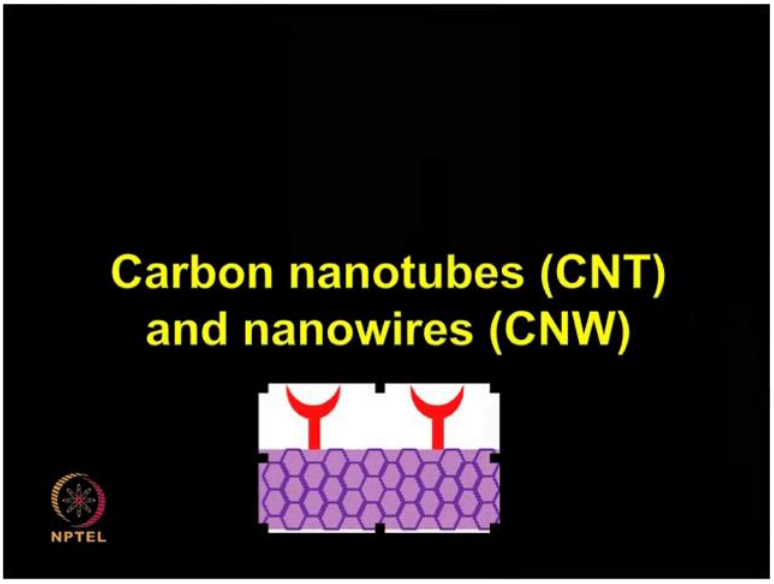

So, let us fist talk about Carbon nanotubes and nano wires. There are various novel inorganic nano materials which have been explored in biological research with an intention of developing new types of analytical tools. Due to the rapid advances in synthesis and surface chemistry optimization process there are various classes of nano structures, including nanowires, nanotubes and nano crystals which have been used for the clinical proteomics research CNT's or CNW's carbon nanotubes or nano wires they detect changes in the electrical conductance after the target binding and they show sensitivity in the nano molar tube pico molar range.

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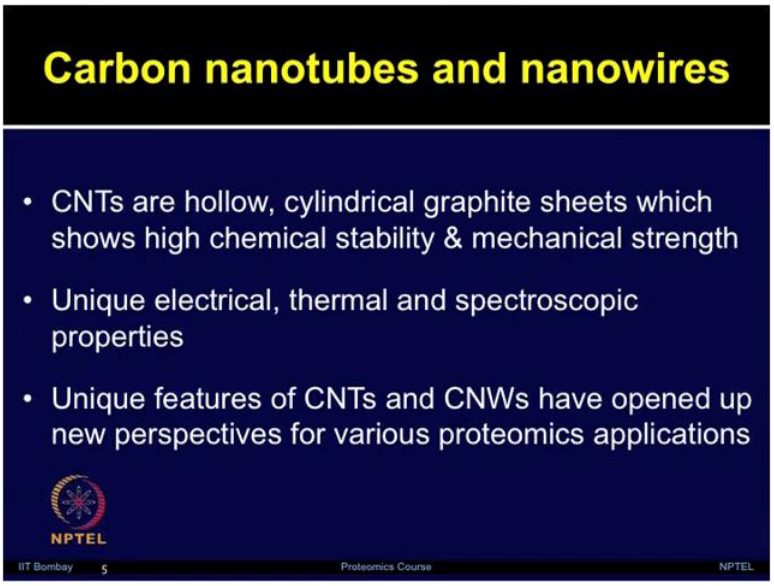

So, what are these CNT's these are hollow cylindrical graphite sheets, which shows very high chemical stability and mechanical strength these CNT's and nanowires they offer very unique properties electrical properties, thermal as well as spectroscopic these various unique features of carbon nanotubes and nanowires have opened up various new applications in the field of proteomics.

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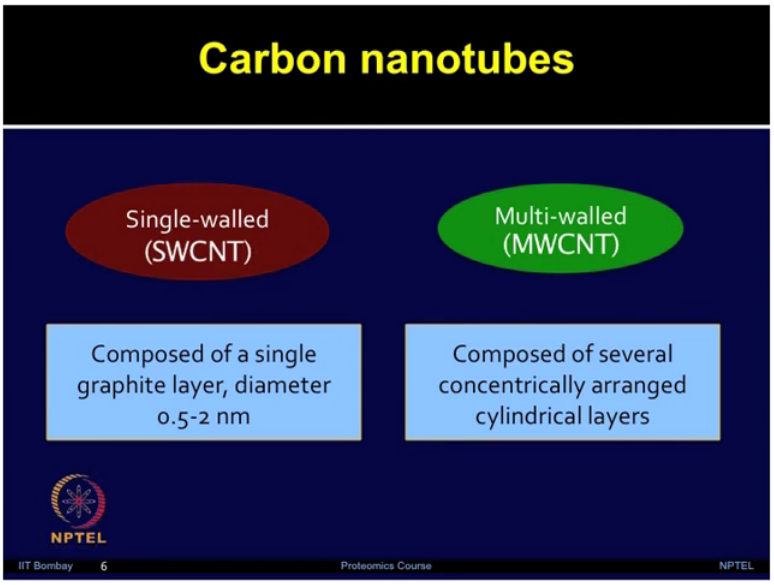

These carbon nanotubes there are two different types single walled or SWNT single walled nanotubes or multi walled MW nanotubes. The single walled nanotubes they are composed of single graphite layer with the diameter in the range of 0.5 to 2 nanometers where as the multi walled nanotubes. They are composed of several concentrically arranged cylindrical layers there are various properties for each of this group, but we will more focus on how these nanotubes are applied for proteomic applications.

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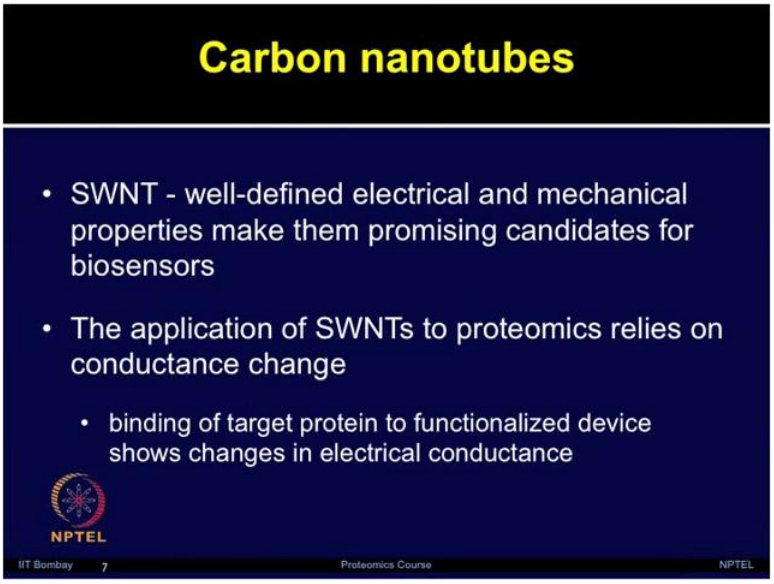

These single walled nanotubes these are well defined electrical and mechanical properties which make them very promising for biosensor candidate. The application of single walled nanotubes to proteomics is based on measurement of change in the conductance. When it target protein is functionalized on single walled nanotube device after that, when a binding partner a protein binds then electrical conductance changes.

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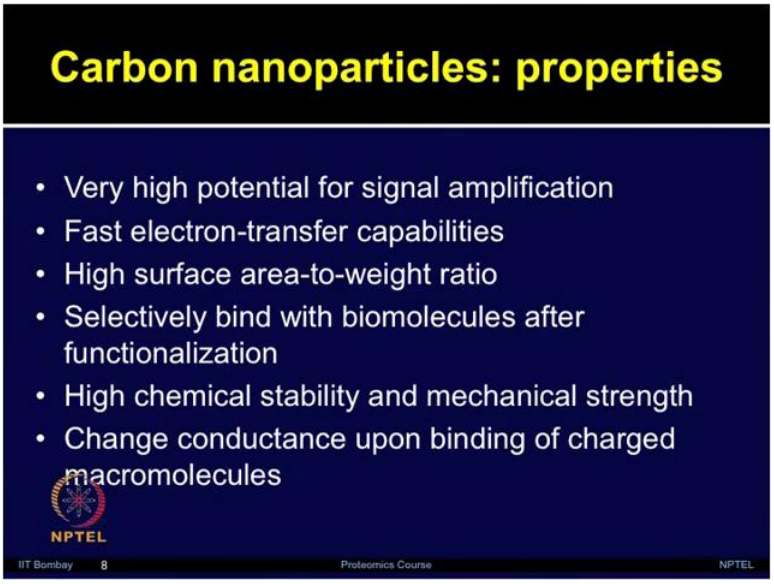

And that is measured for the monitoring the change in the binding. These carbon nanoparticles they have various properties. This is the broad field, these are generic

properties for various nanoparticles. They have very high potential for signal amplification. They have fast electron transfer capability they exhibit very high surface area to weight ratio. They can selectively bind the biomolecules after fuctionalization and this selective binding with very high sensitivity is the key advantage of using these nanotechniques. They exhibit high chemical stability and mechanical strength as we discussed earlier and in the changes in the conductance upon binding of the charge macromolecules are monitored for these binding reactions.

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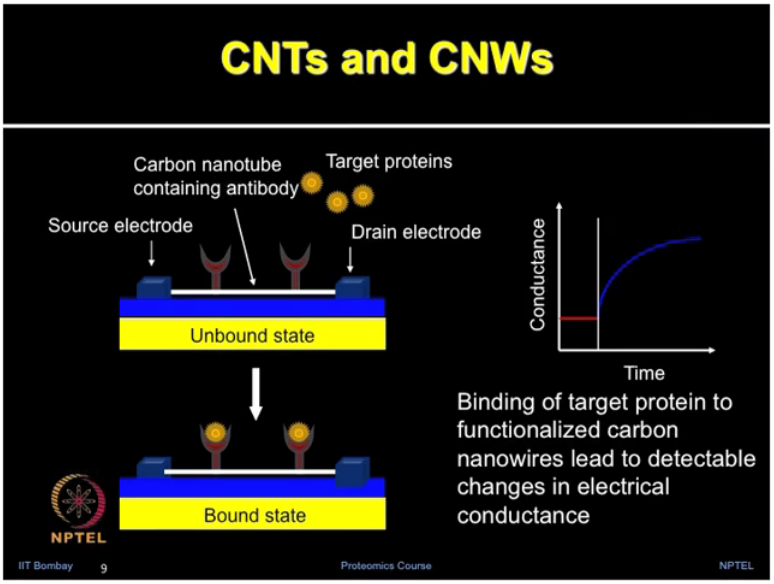

Now, in this slide, I am showing you the image for the carbon nanotubes which has a functionalized antibody the top one is showing the unbound state where you have source electrode drain electrode and then there are some target proteins after binding which is shown in the bottom panel, there is a change in the conductance which is shown in the right panel the binding of this target protein to the functionalized carbon nanowires lead to the detectible change in electrical conductance. This is very high sensitive and this change in conductance is measured for measuring different type of proteins as well as some small particles including viruses there are various applications have shown the potential of this technology.

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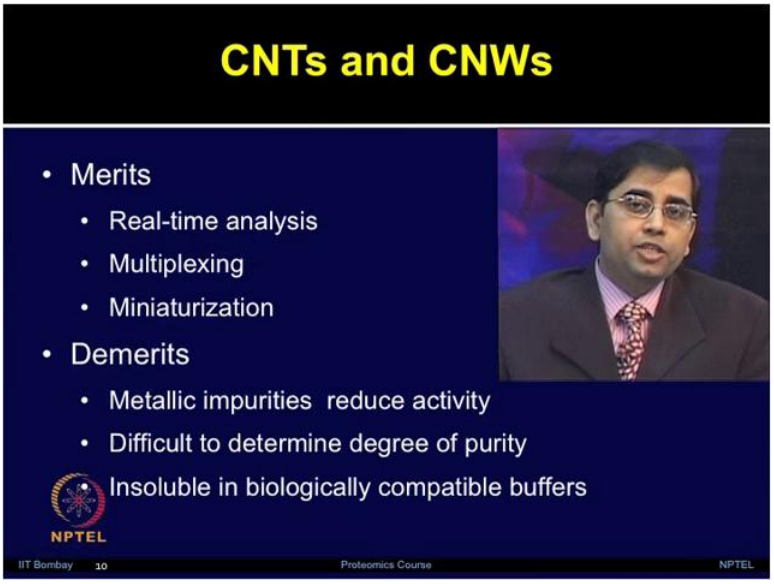

Now, let us discuss what are the merits and demerits of using carbon nanotubes and carbon nanowires. They allow real time analysis similar to what we talked about some of the previous label free techniques, including SPR, where we have opportunity to monitor the reaction in the real time, which is not case with the label based detection techniques. Which are mostly the end point assays? Now here we can monitor the how reactions are changing and one can actually change the experimental condition in the real time to modify the binding. This also provides the multiplexing capability and gives the miniaturization.

There are various demerits as well, a metallic impurities they can reduce the activities of these assays it is not very easy to determine how pure these preparations are. So, degree of purity is one of the major limitation here, but one of the other major limitation is their insolubility in biologically compatible buffers. They are not always compatible in the various biological buffers to demonstrate the principle of using carbon nanotubes and nanowires.

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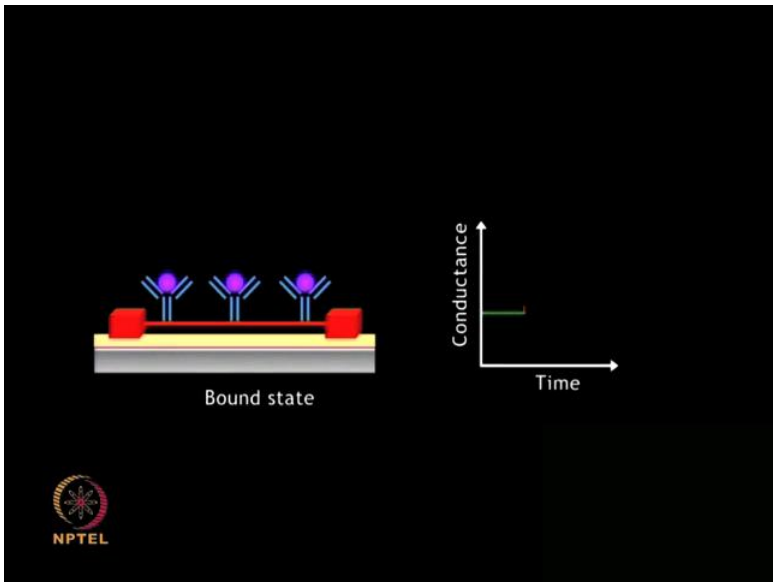

Now, let us look at this animation, carbon nanotubes. The carbon nanotubes are hollow cylindrical graphite sheets that exhibit very high levels of chemical and mechanical stability as you have seen here, there is a drain electrode source electrode and on top of the carbon nanotube the antibodies are functionalized. So, these nanotubes can be suitably functionalized with the antibodies or other agents like aptamers the antibody coated nanotubes show no variation in conductance, when they are in the unbound state. Binding of target protein to the antibody is detected by a change in conductance of the carbon nanotube with time. As you can see in the right panel, the time axis on the x axis and conductance is spotted on the y axis, which is showing a chain in the conductance due to the binding state of these target proteins. These nanotube devices have been extremely useful for real time label free detection of low abundance protein and analyses and it can achieve sensitivity in the nanomolar tube picomolar range.

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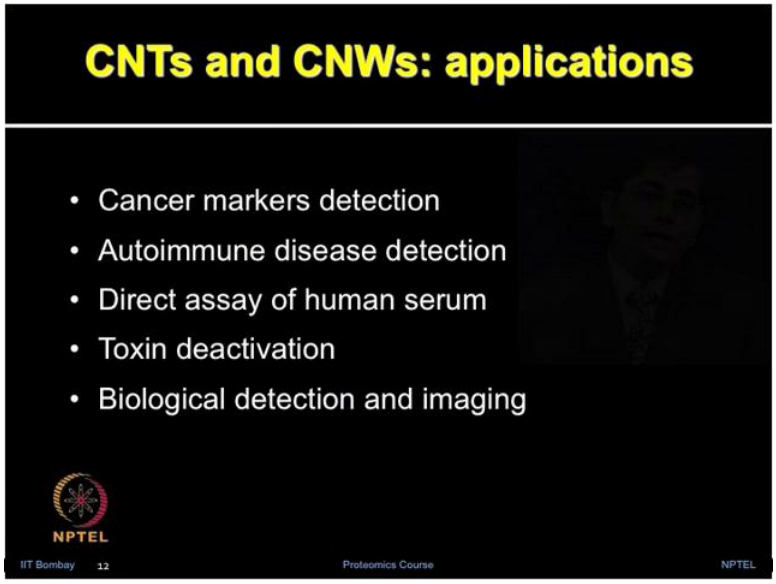

So, now after looking at the animation, you are clear with the principle of using these nanotubes. Now let us discuss briefly about various applications. So, carbon nanotubes and nanowires have shown unlimited potential for various applications in different field. Here, we are just talking about in the context of proteomics. So, for the proteomic applications, various type of clinical studies people have performed and used nanotubes and nanowires to test the potential of these nanotechniques for Cancer biomarker detection. It has also been used for Autoimmune disease detection, Direct assaying of human serum deactivation of toxins, Biological detection and imaging these are just a very small list of unlimited applications, which have emerged out of these potential techniques.

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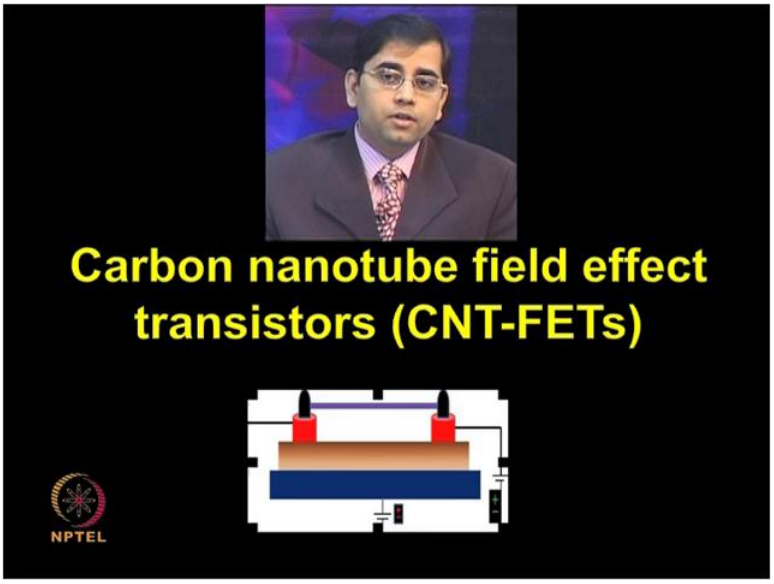

Let us now move on to another platform which is Carbon nanotube field effect transistors CNT FET s

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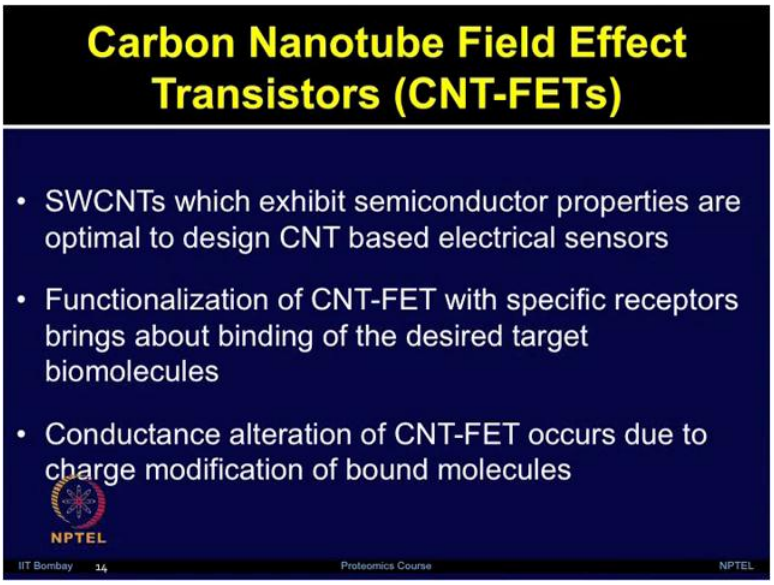

The successful combination of carbon nanotubes with filed effect transistors has led to the development of this novel sensing device known as Carbon nanotube field effect transistor. As we have discussed the different type of carbon nanotubes, single walled SWCNT's and multiple walled MWCNT's the SWCNT's or single walled carbon nanotubes, which exhibit semiconductor properties are optimal to design the carbon

nanotube based electrical sensors the functionalization of carbon nanotube field effect transistors with specific receptors brings about binding of the desired target biomolecules for example, we can immobilize a surface with specific receptor antibodies and then target proteins can be used to detect the binding if those are specific interaction. If the biomolecules are showing binding then the, that binding can be monitored by looking at the change in the conductance. So, the conductance alteration of carbon nanotube field effect transistors occur due to the charge modification of bound molecules.

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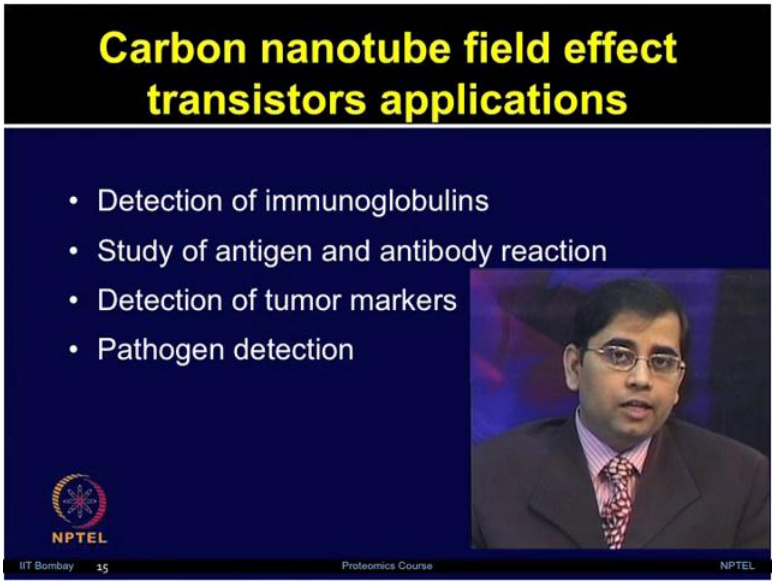

Again, there are many applications of Carbon nanotube field effect transistors. Here, we are listing few based on proteomics application. This platform has been applied for Detection of immunoglobulin's studying the interactions of antigens and antibody Detection of various cancer marker and Pathogen detection. So, one of the other interesting topic is bio difference and how one can a detect various type of pathogens which have potential for biohazards. So, different type of bioterrorism attacks usually have taken attention especially on the anthrax and different type of salts based biological agents. So, these nano techniques have shown some various specific detection of various pathogens and now those have also been applied for very potential applications for bio difference field.

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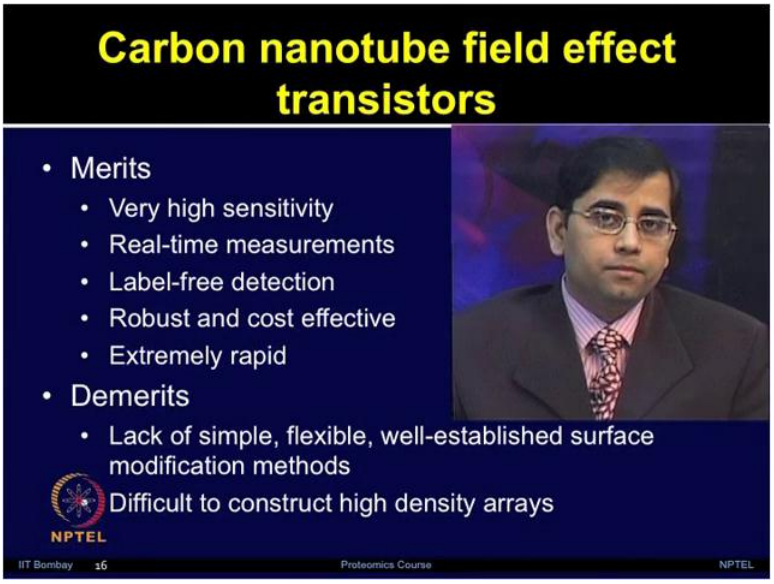

Let us now discuss about Merits and Demerits of using carbon nanotube field effect transistors this technology offers very high sensitivity it provides Real time measurement capability one can monitor the reaction in the Label free environment where there is no need for adding a label this is very Robust platform also cost effective and provides very high speeds Extremely rapid. There are various demerits of carbon nanotube field effect transistors which include the lack of simple flexible and well established surface modification protocols. When we talk about application of these nanotechniques with microarray platform then this particular platform is difficult to construct for the high density arrays. Again in the proteomics field, there is a increasing trend increasing interest to apply various type of label free techniques as well as nanotechniques and coupled them with the high density high throughput array platforms.

So, that one can not only monitor the reactions in the very very low volume in the real time in the label free environment, but also identify or study thousands of bimolecular at a same time on the same chip platform therefore, there is an increasing trend of applying various type of nanotechniques also with the array based techniques.

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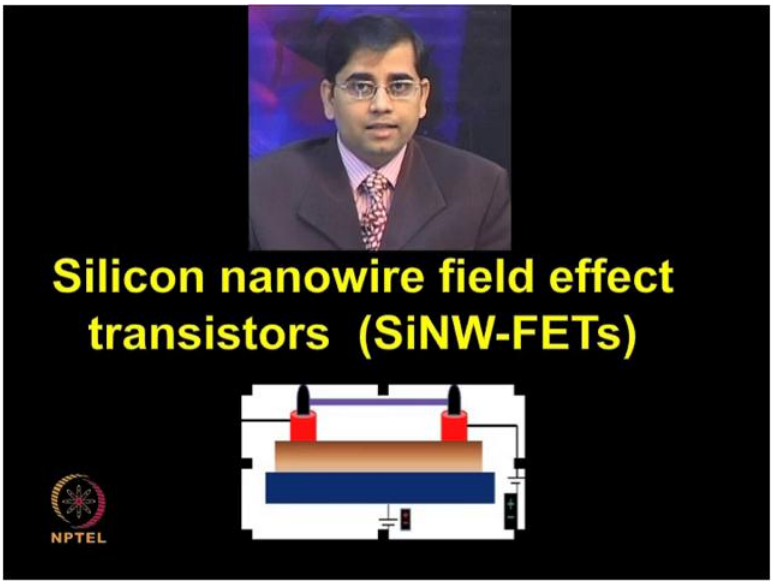

Let us now talk about Silicon nanowire field effect transistors or SiNW FETs. The planer field effect transistors modified with molecular receptors for the analyze of interest can monitor the binding of charge specious through the accumulation of carriers on the surface of transistor. Although this transistor directly into measurable changes in conductance or related electrical properties their physical parameters post constrains for sensor fabrication none the less the nano scale FETs have overcome those limitations to large extent, but they have their own drawbacks.

For example, the presence of metallic nanotubes and lack of well established surface modification techniques. The silicon nanowires which are always semiconducting are potential building blots to fabricate the functional nano senses that overcome some of these limitations, which we just discussed in addition they allow sensitivity to be fine tuned as per their requirement by controlling the type and amount of dopant in the semiconductors.

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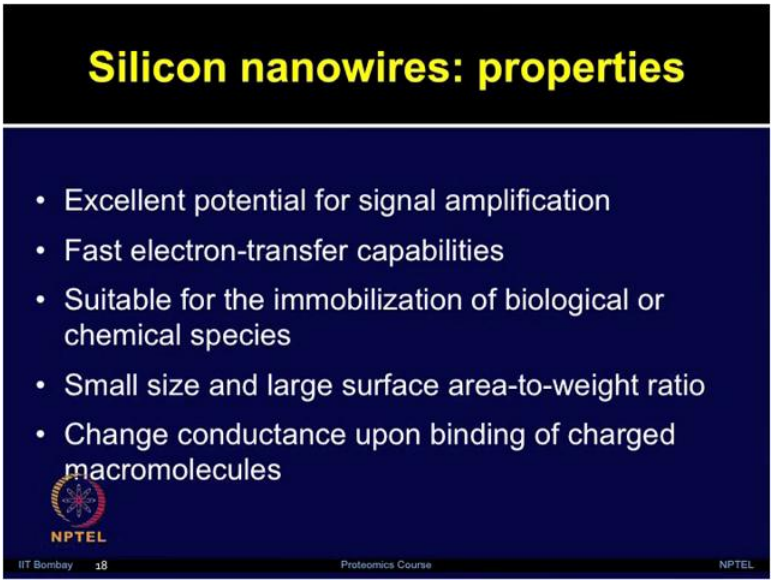

Let us discuss some of the properties of Silicon nanowires they have very high potential for signal amplification they have Fast electron transfer capability silicon nanowires are Suitable for the immobilization of various biological and chemical species. They are Small size and have large surface area to weight ratio. Again the Change in the conductance is measured here upon binding of charged macromolecules.

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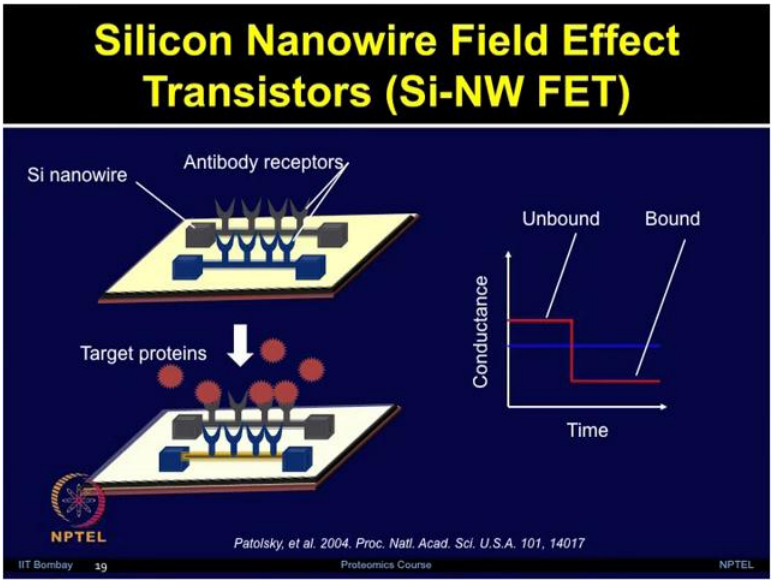

Now, let us discuss how this Silicon Nanowire Field Effect Transistors are applied for some of the proteomics base applications. As you can see in this slide, the top panel is

showing the silicon nanowires which are coated with the antibody receptors. Now when you want to study some target proteins and if there is any interaction with the target proteins with the anti bodies.

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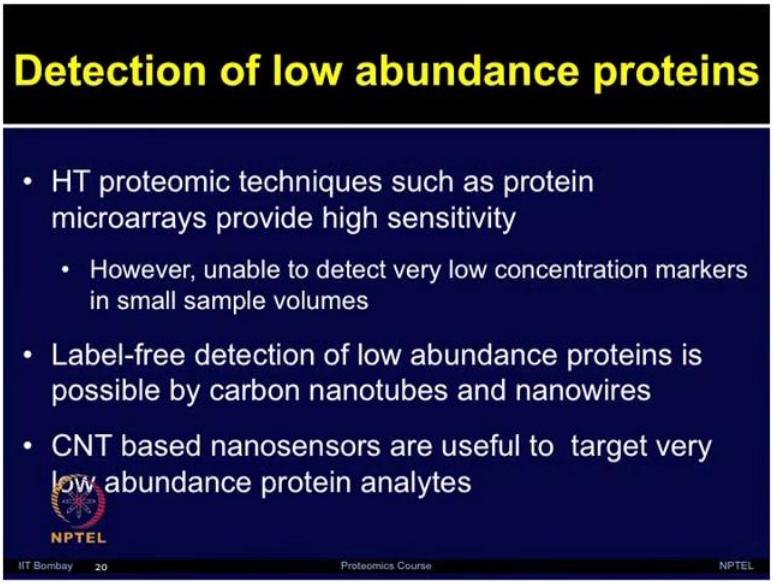

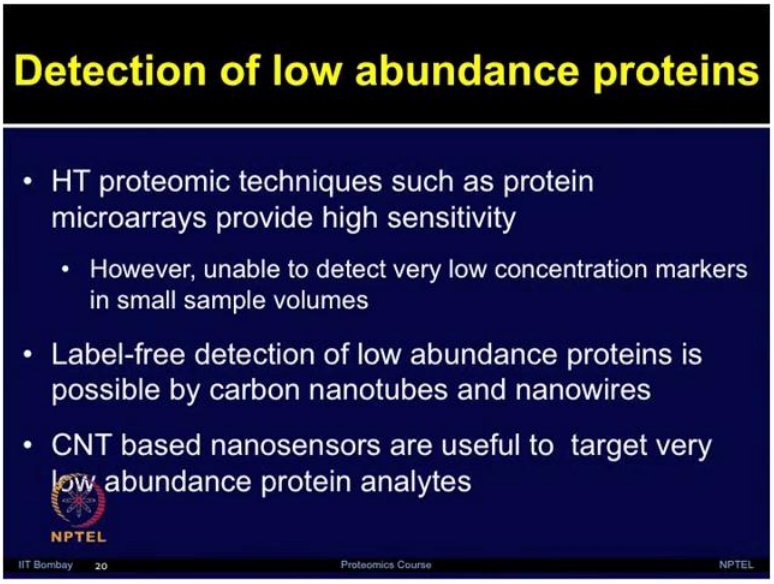

So, as shown in the bottom panel, these target proteins will bind to the antibody receptors and now these silicon nanowires will show the change in the conductance, as you can see in the right panel, where conductance spotted on the y axis and time scale on the x axis. So, for the unbound state to the bound state there is change in the conductance and that is measured to detect the interaction of antigens and antibodies. In proteomics detection of low abundance proteins remains one of the major challenge.

So, many high throughput proteomic technologies including protein microarrays, they provide very high sensitivity, but one we are screening with the biological samples biological fluids detection of very low concentration biomarkers in a very small sample volume remains very challenging remains a previous lecture. If you remember the previous discussion we have talked about how from the serum the various type of high abundant proteins which are present one need to remove those proteins deplete those serum to actually look for the low abundant proteins, but there are many high abundant proteins which are present there, which mask the overall low abundance proteins.

Similarly, these are present in. So, low amount the technique has to be very sensitive. Therefore, various label free detection techniques are aiming towards detection of low abundance proteins and by using carbon nanotubes and nanowires various studies have shown the potential of using these nanotechniques for such applications, where low abundance proteins can be detected with high sensitivity. So, carbon nanotube based nanosensors have shown their use an applications to target very low abundant protein analytes and this is one of the major advantage of using these platforms.

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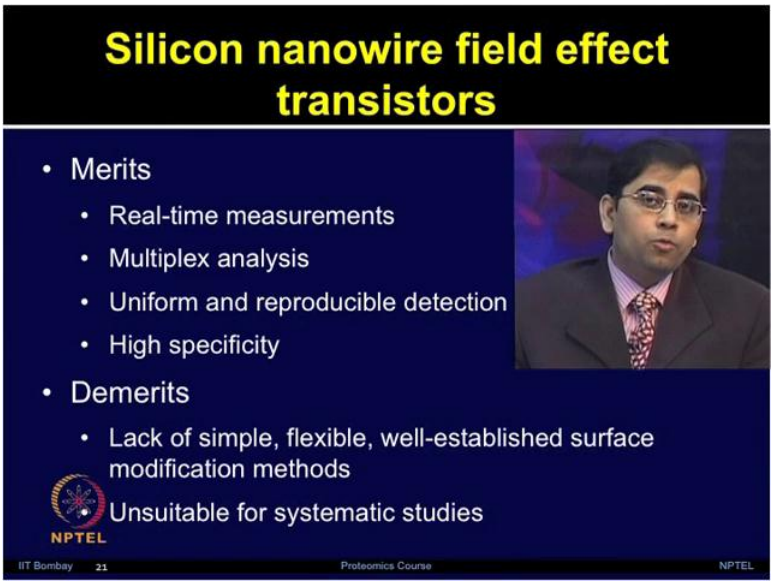

So, continuing on to the Silicon nanowire field effect transistors their different Merits and Demerits. So, this platform provides us the real time measurement capability also it offers multiplexing analysis, that is uniform and provides reproducible results for various biomolecular detection and it shows very high specificity. Now discussing about

Demerits of this platform the lack of simple flexible and well established surface modification protocols is one of the limitation and is also not very suitable for systematic studies.

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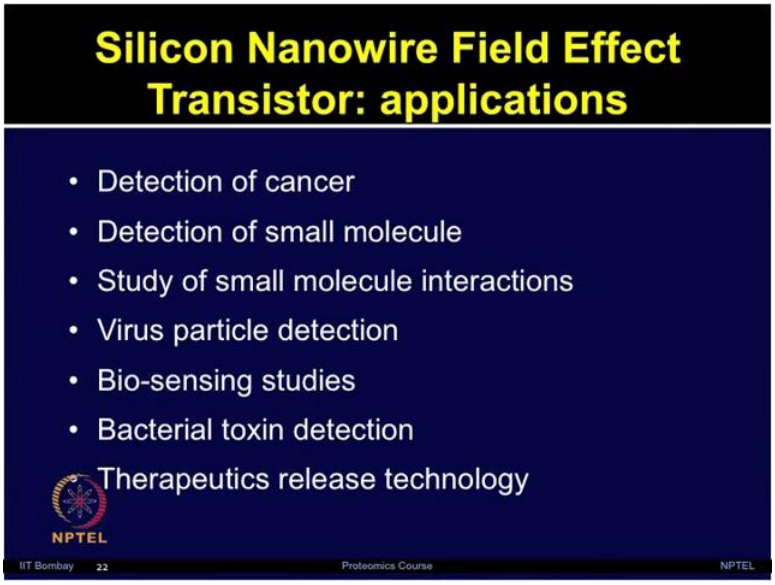

Despite some of the challenges some of the demerits of Silicon Nanowire Field Effect Transistors, they have been applied for various type of studies in proteomics area including Detection of cancer, Detection of small molecule, Studying small molecular interactions, detection of Virus particles, different type of Bio-sensing studies have also been performed and again similar to virus particle detection different type of Bacterial toxin detection have also been tested by using this technique.

So, overall many Therapeutics based studies have shown the potential of silicon nanowire field effect transistors which can be applied well for cancer biomarkers as well as other diseases. So, let us now look at this animation for silicon nanowire field effect transistors.

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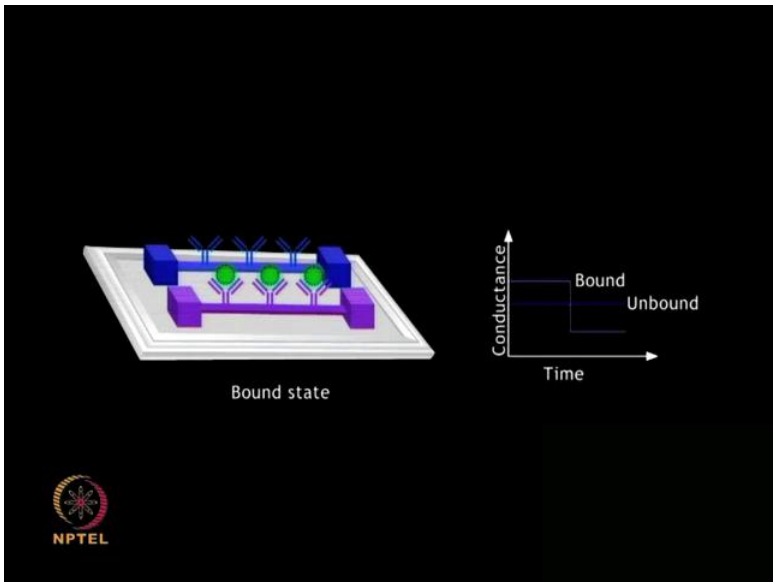

So, that we can understand the principles more clearly. Silicon nanowire field effect transistors silicon nanowires can be functionalized with several chemical and biological species and used as sensitive detection devices antibodies are commonly immobilized on silicon nanowires for detection of protein antigens.

No change in the conductance of the nanowire is observed in the unbound state, as you can see on the right hand panel in the graph which is plotted within the time and conductance. Binding of target protein to the antibody is detected by change in the conductance of silicon nanowire overtime. While the conductance of the unbound antibody functionalized nanowire remains unaltered. These devices offer excellent sensitivity in the picomolar to femtomolar range that and are capable of detecting molecules even at single particle level.

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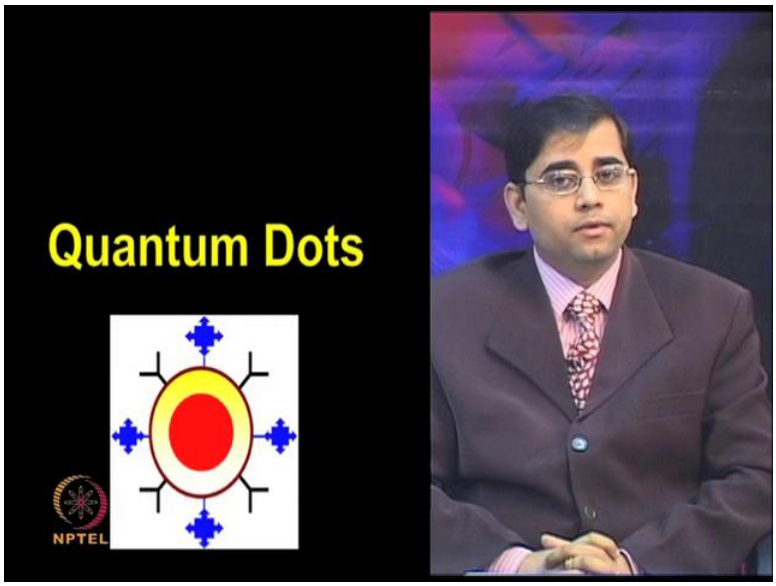

After discussing the principle of silicon nanowire field effect transistors. Let us now move on to Quantum dots or QDs the QDs have shown wide variety of promising applications in different areas of biological sciences such as immunoassays, nucleic acid detection, analysis of genetic polymorphism, diagnostic imaging, single molecule detection, cellular localization studies drug delivery as well as discovery and proteomic and genomic studies.

So, you can realize it offers very wide range of applications in different field of biological sciences the superior optical properties and ability to conjugate with several biomolecules like peptides, nucleic acids, antibodies, half establish QDs as sensitive detection tool in clinical proteomics research.

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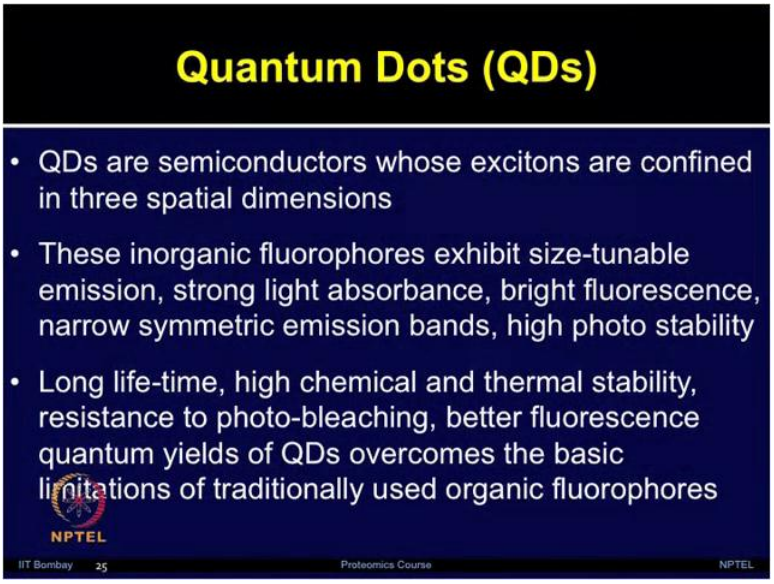

So, what are these QDs these are semiconductors whose excitons are confined in 3 special dimensions. These are inorganic fluorophores that exhibit size tunable emission, strong light absorbance, bright fluorescence, narrow symmetric emission bands as well as high photo stability.

The long life high chemical and thermal stability resistance for photo bleaching ability to provide better fluorescence quantum yields of quantum dots, have overcome several basic limitations of traditionally used organic fluorophores and that is why they have become a fluorophore of choice and applied for unlimited applications in different biological fields.

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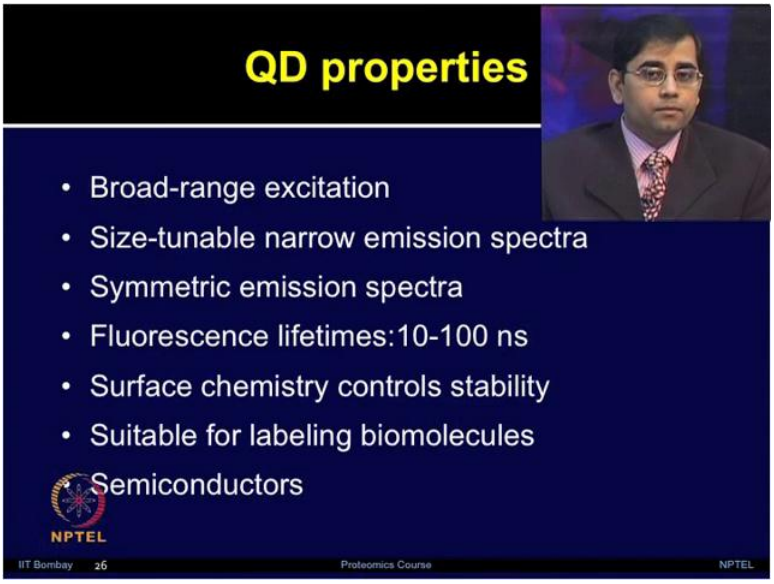

What are different properties of Quantum dots they are Broad range excitation, Size tunable narrow emission spectra they have Symmetric emission spectra the Fluorescence life time ranges between 10 to 100 nanoseconds the Surface chemistry controls their stability.

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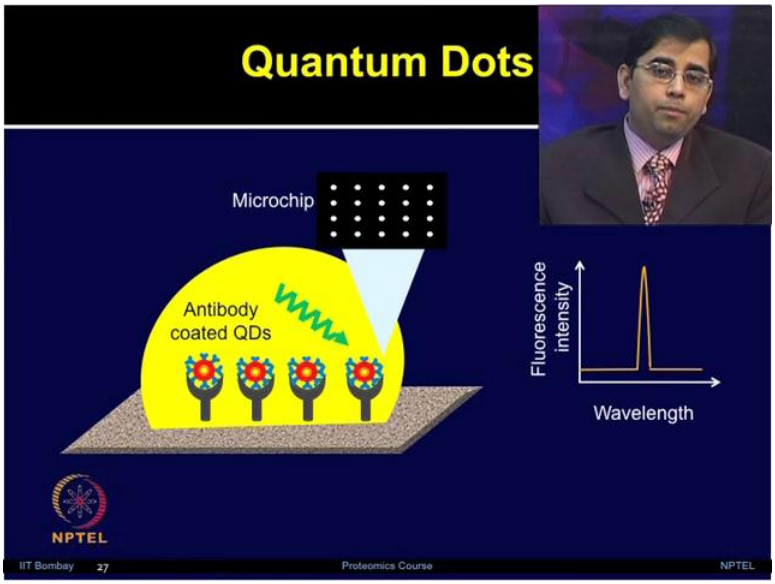

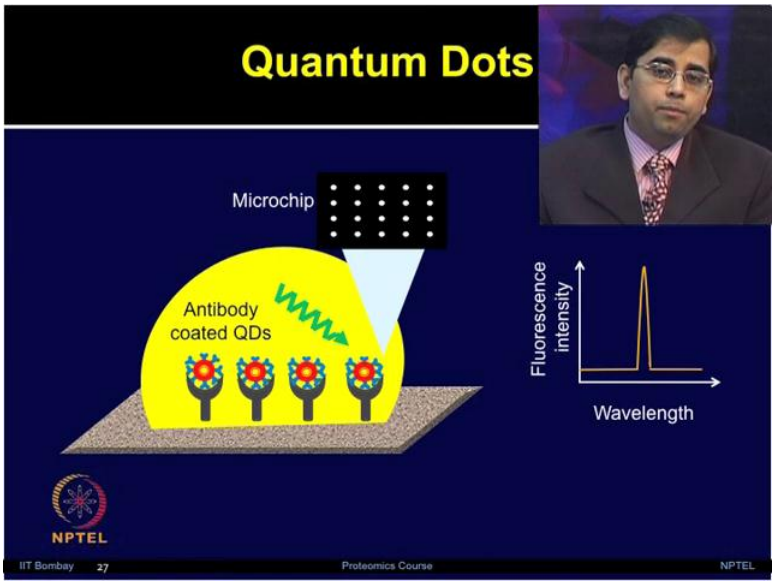

It is suitable for labeling variety of biomolecules. It has applied as semiconductors. In this slide one of the application of quantum dots is shown the application of semiconductor quantum dots as labeling agent for sensitive detection of target proteins in an array format is shown here. The protein analyses are detected by monitoring the emission spectra of bound quantum dots. The excitation of quantum dots with incident light leads to formation of excitons due to the absorbance of a photon with higher energy than that of a band gap of composing semiconductor and this fluorescence intensity is measured as shown on the right hand slide graph.

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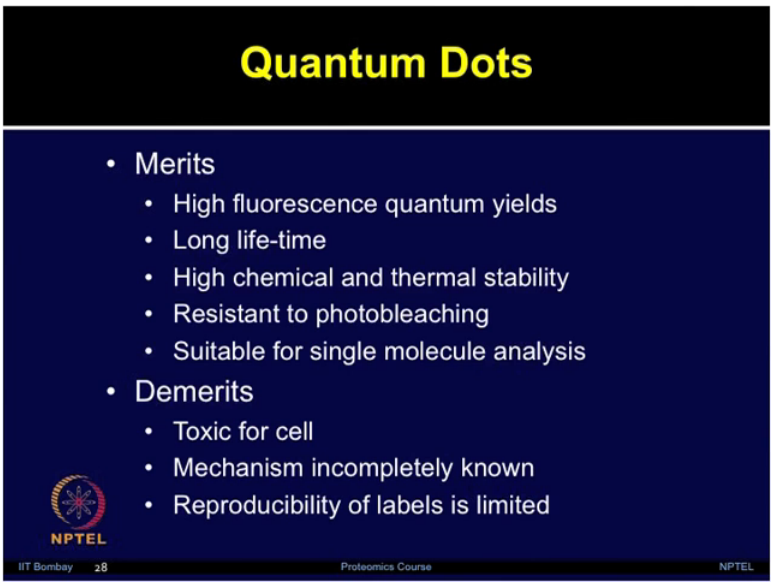

There are various Merits and Demerits of using quantum dots merits include High florescence quantum yields, Long life time, High chemical and thermal stability, Resistance to the photo bleaching and its Suitability for single molecular analysis its Demerits include Toxicity for cells, Mechanism is not completely understood and Reproducibility of labels are also limited the cellular toxicity and biocompatibility these are the major limitations of using QDs as there is a limited knowledge on their (( )) in the living system.

However, there are ongoing research to make these QDs more biocompatible by surface modifications including hydrophobicity or encapsulating them within the phospholipid missiles. So, more advance research will definitely make them more widely applicable for different applications.

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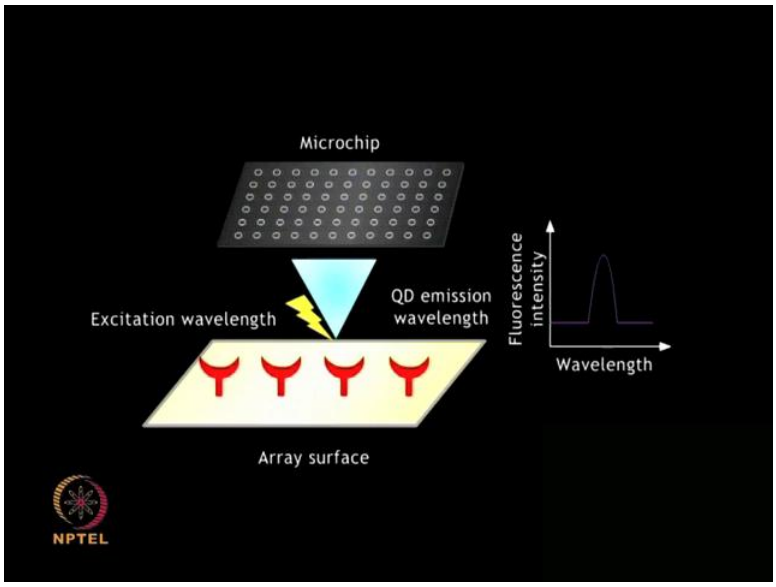

Let us now look at these animations of Quantum Dots the changes in the emission wavelength upon binding to the antibody conjugated quantum dots are recorded by the microchip and used for detection of various bimolecules. Quantum dots are capable of detecting molecules down to femtomolar levels and provide significant advantages over conventionally used organic fluorophores. As you can see on the right hand side the wavelength versus fluorescence intensity is plotted and change in the fluorescence intensity is observed when the molecule is binding on the antibody surface which is labeled with the quantum dots.

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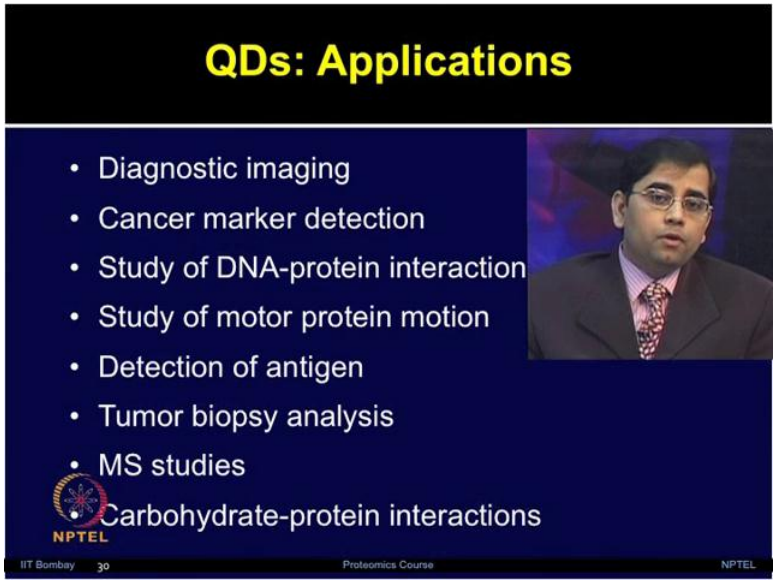

So, as you have seen its principles are very easy for the quantum dots and the same basic principle are applied for variety of applications such as Diagnostic imaging biomarker detection in cancer, Studying d n a and protein interactions, various Studies to monitor the protein motion, Detection of antigens different type of Tumor biopsy analysis have also been performed.

Now, mass spectrometry based studies have also started exploring quantum dots. As well as it has been used for Carbohydrate and protein interaction studies these are some of the published studies, but there are many studies which have shown the potential of using quantum dots for various proteomic applications.

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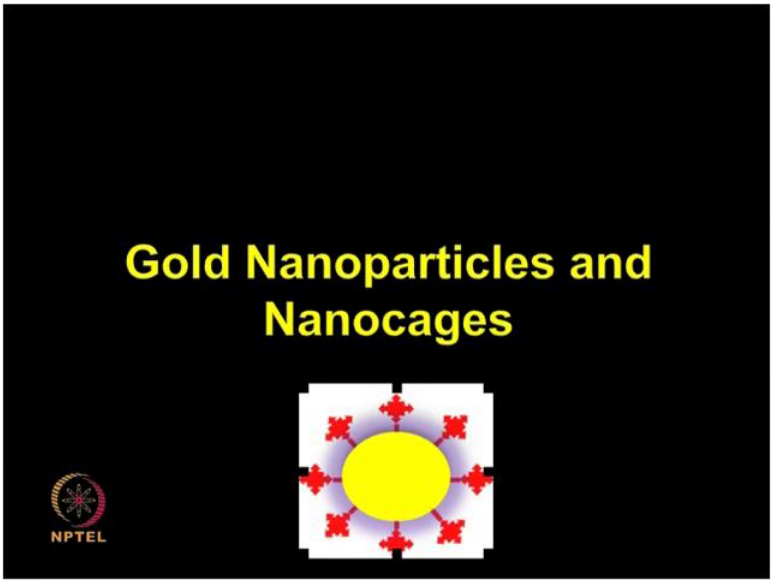

Let us now move on to another platform Gold Nanoparticles and Nanocages the gold nanomaterials have shown versatile biomedical applications due to their attractive structural and physicochemical properties. The size of gold nanoparticles determines the proportion of absorption to scattering with the biological imaging requiring a very high scattering cross section, which is achieved by increasing the size of the nanoparticles.

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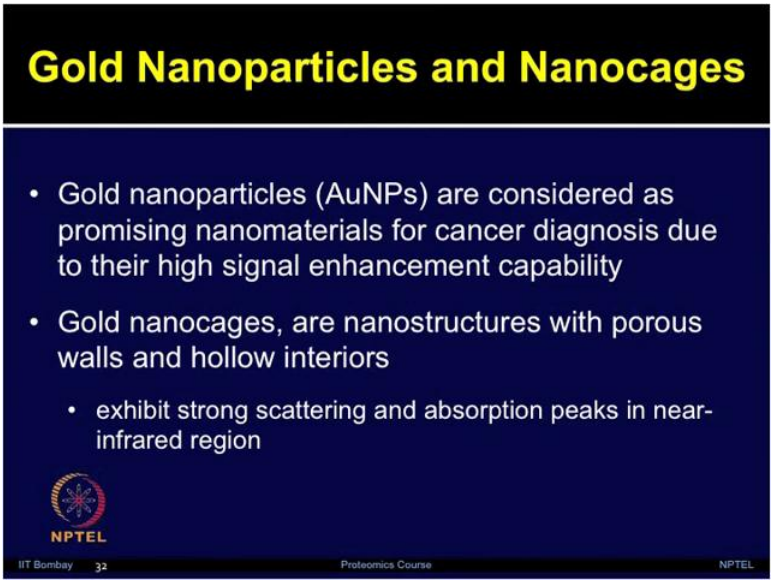

So, these Gold Nanoparticles and Nanocages they are considered as promising nanomaterials for cancer diagnosis, because of their high signal enhancement capability.

Gold nanocages which have been developed more recently are nanostructures with porous walls and hollow interiors they exhibit strong scattering and absorption peaks in the near infrared region.

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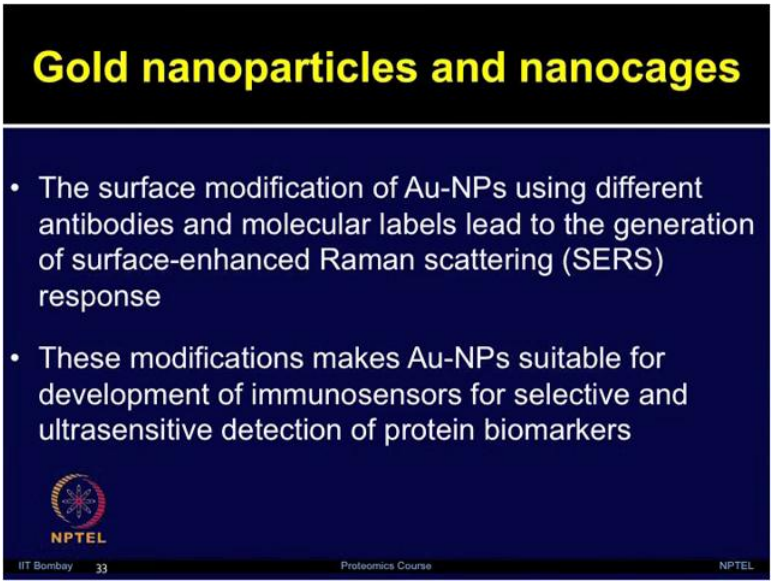

Various type of surface modifications have been tried for gold nanoparticles by using different type of antibodies as well as molecular labels which can lead to the generation of cells response or surface enhanced Raman scattering response. These modifications have made Au NPs or gold nanoparticles suitable for developing immunosensors for selective as well as ultra sensitive detection of protein biomarkers.

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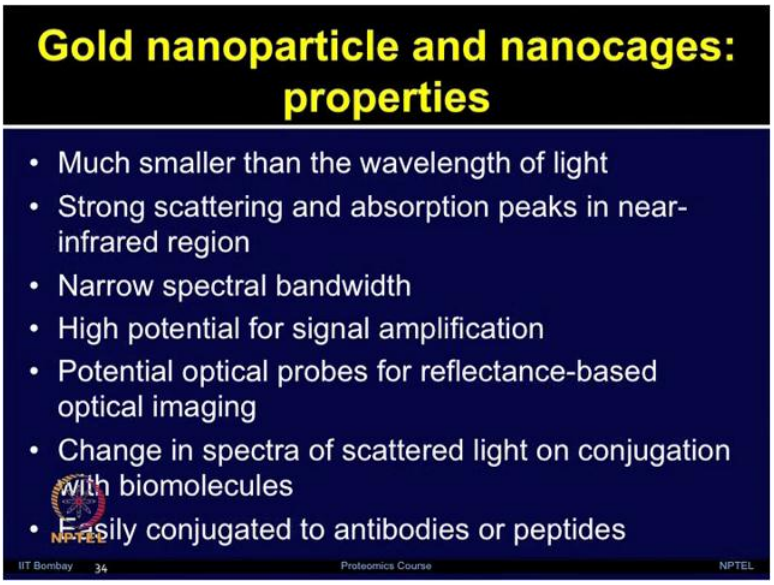

Let us look at different properties of Gold Nanoparticles and nanocages these are Much smaller than the wavelength of light. Therefore, Strong scattering and absorption peaks in near infrared region. They have very Narrow spectral bandwidth they have High potential for signal amplification. They have Potential for optical probes for reflectance based optical imaging. The Change in the spectra of scattered light on conjugation with biomolecules, occur while using these gold nanoparticles and nanocages they can be Easily conjugated to antibodies or peptides.

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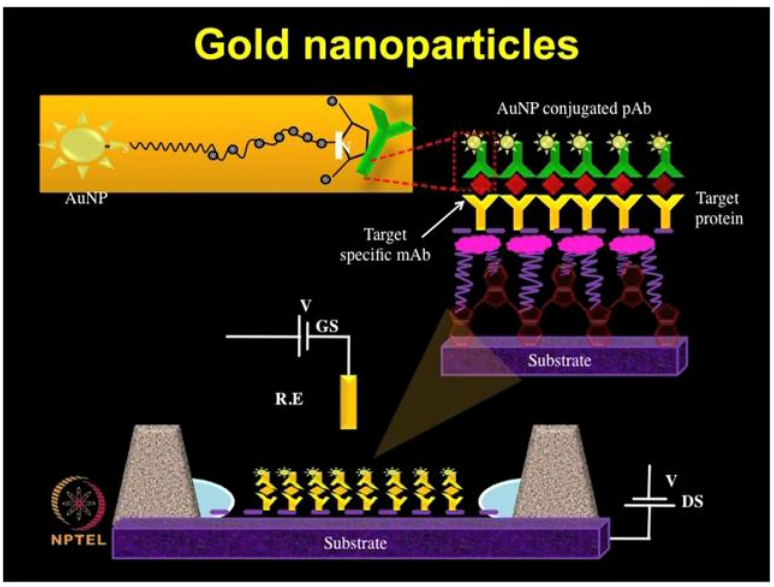

So, these gold nanoparticles exhibit unique optical electronic and catalytic properties and signal enhancement capabilities, which make them suitable for selective and ultra sensitive detection of various biomarkers. The implication of gold nanoparticles in electronic biosensing process leads to signal amplification as shown in this slide there are monoclonal antibodies which are immobilized on these gold nanoparticle surface which enables specific detection of target proteins.

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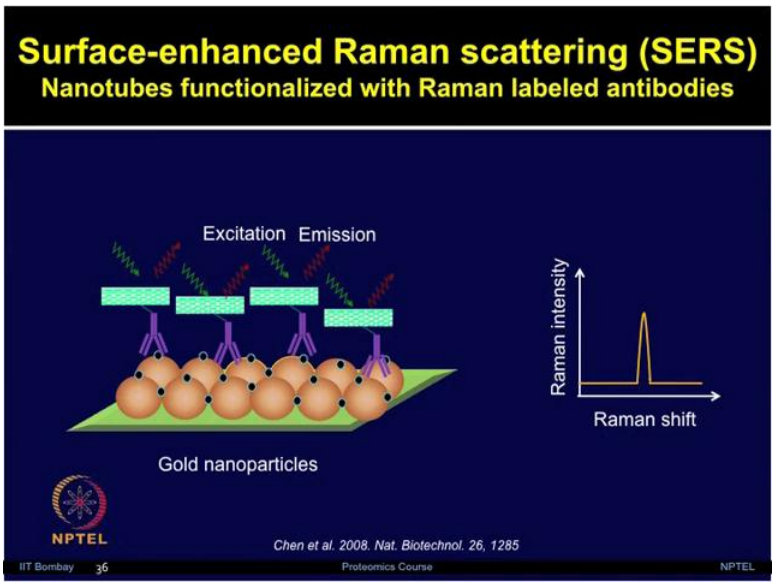

Now, let us discuss the surface enhanced Raman scattering the nanotubes functionalized with the Raman tube labeled antibodies. The surface enhanced Raman scattering or Raman spectroscopy, which lacks a sensitivity, but silver and gold nanoparticles can be used to enhance the substrates. The signal intensity of Raman active molecules is enhanced due to an increased local electric field at the nanoparticle surface and by electronic coupling between the absorbed molecules and the gold nanoparticle surface.

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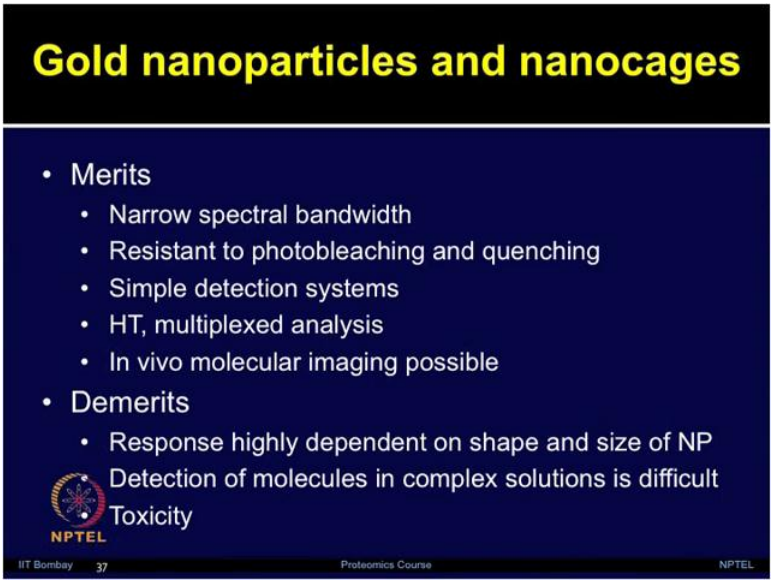

As shown here, in this slide these are Gold nanoparticles which are functionalized with the Raman labeled antibodies. Now on the right hand side, the graph shows the change in the Raman intensity due to the binding effect. There are various Merits and Demerits of using gold nanoparticles and nanocages. Various merits include its narrow spectral bandwidth resistant to photobleaching and quenching simple detection system high throughput and multiplexing capability in vivo molecular imaging is possible by using these nanomaterial.

Its demerits include response to highly dependent on shape and size of nanoparticles detection of molecules in the complex solutions is is still difficult. As well as toxicity associated with these nanoparticles the gold nanoparticles.

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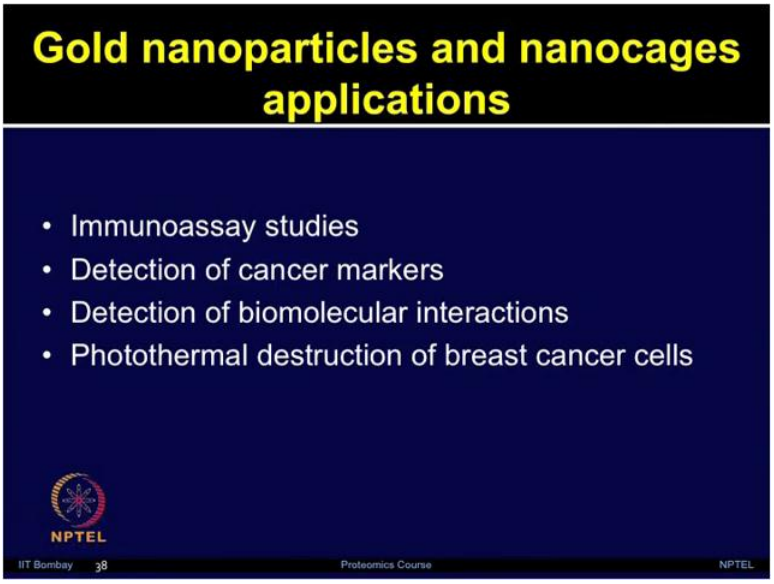

And nanocages have shown applications in variety of field specifically in proteomics they have been used for Immunoassay based studies, Detection of cancer biomarkers, Detection of various biomolecular interactions, Photothermal destruction of breast cancer cells. These are some of the published studies, which have shown the potential of using gold nanoparticle and nanocages which can be used for proteomics based studies.

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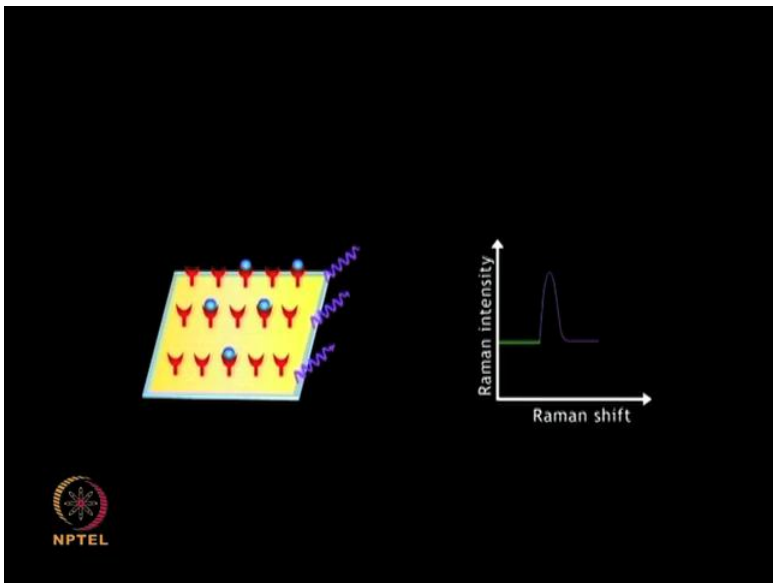

So, let us now look at the principle of using gold nanoparticles in this interactive animation. The gold nanoparticle surface is functionalized suitably by antibodies which

will bind to the analyte of interest. Any target binding is depicted by a change in the emission spectra. As you can see on the right hand side the Raman shift versus Raman intensity is plotted after these gold nanoparticles are binding with the antibodies, a change in the Raman intensity is observed as shown in the plot on the right hand side.

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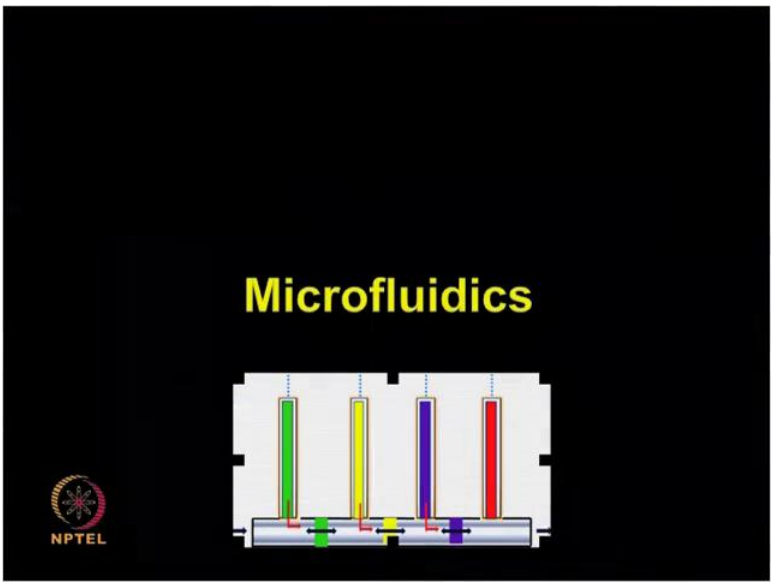

Now, let us move on to next technology Microfluidics. So, processing of ultra small fluid volumes with the help of channels of ten to hundreds of micrometers, which gives the sensitivity.

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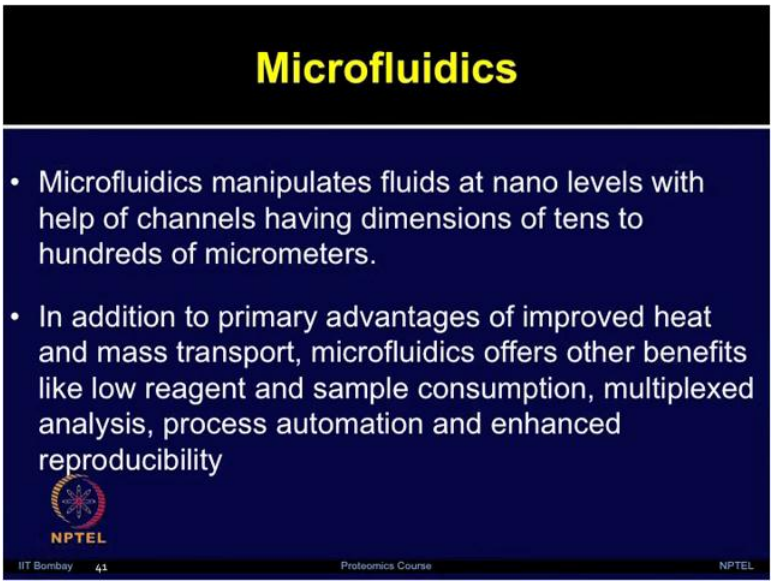

In the range of picomolar to femtomolar the Microfluidics they manipulate fluids at the nanoscale with the help of channels with dimensions of 10 to 100s of micrometers. So, in addition to the primary advantage of improving the heat and mass transport, the microfluidic system offers various other benefits such as, low reagent requirement, low sample consumption, multiplexing analysis, automation process as well as enhanced reproducibility of assays.

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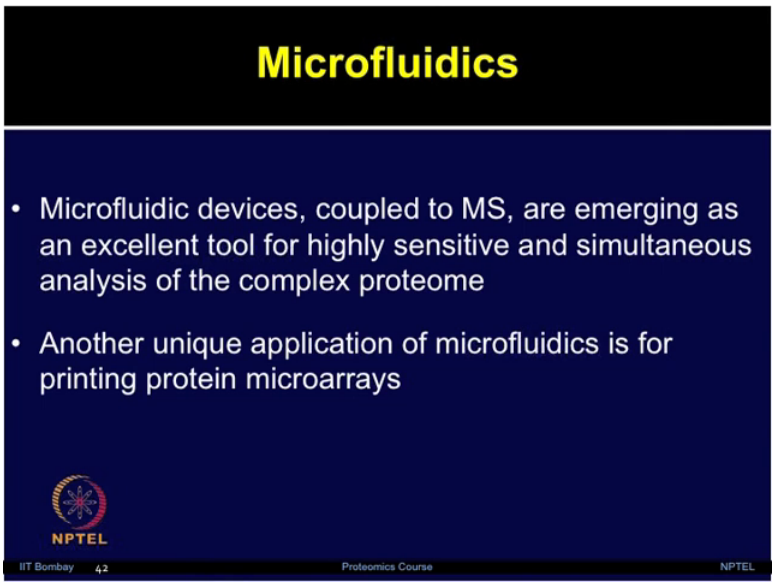

Micro fluidic devices are now increasingly applied in the proteomics field and they are coupled with different type of proteomic platforms such as, mass spectrometry as well as protein micro arrays there is lot of research going on in this field. Where there is an increasing interest of applying micro fluidic devices and coupling them with mass spectrometry. Which can provide as an excellent platform for highly sensitive and simultaneous analysis of complex proteome. Another unique application for the proteomics by applying micro fluidics is in the field of printing protein microarrays. Printing good protein or d n a or or any other molecules on the chip surface is always challenging and now different type of solutions are offered by using micro fluidic based systems to enhance the spot to spot reproducibility and lowered sampled consumptions for printing.

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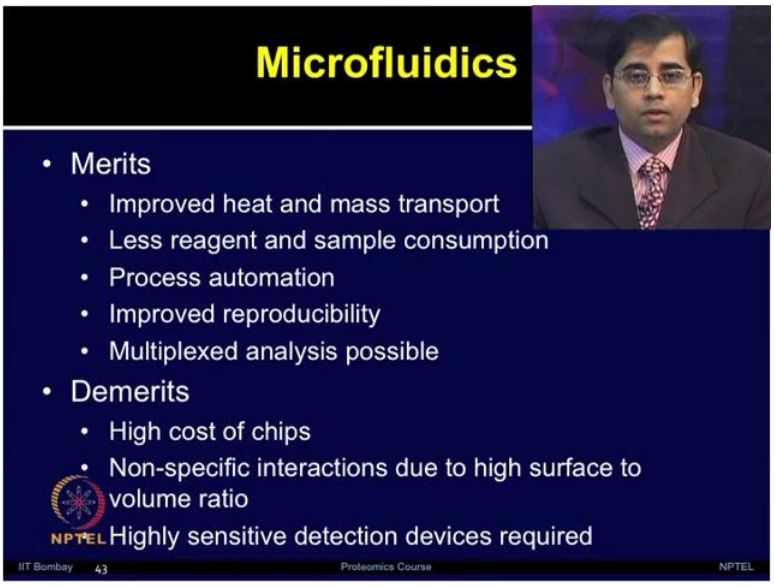

So, Microfluidic platform offers many Merits such as, Improved heat and mass transport, Less reagent and sample consumption, the Process is very automated, it also offers high reproducibility, as well as provides capability for Multiplexing analysis. The Demerits of micro fluidics includes the Higher cost of the chips, sometime Non-specific interactions occur due to the higher surfaced volume ratios and Highly sensitive detection therefore, it is still needed and more research is ongoing in this area by using micro fluidics.

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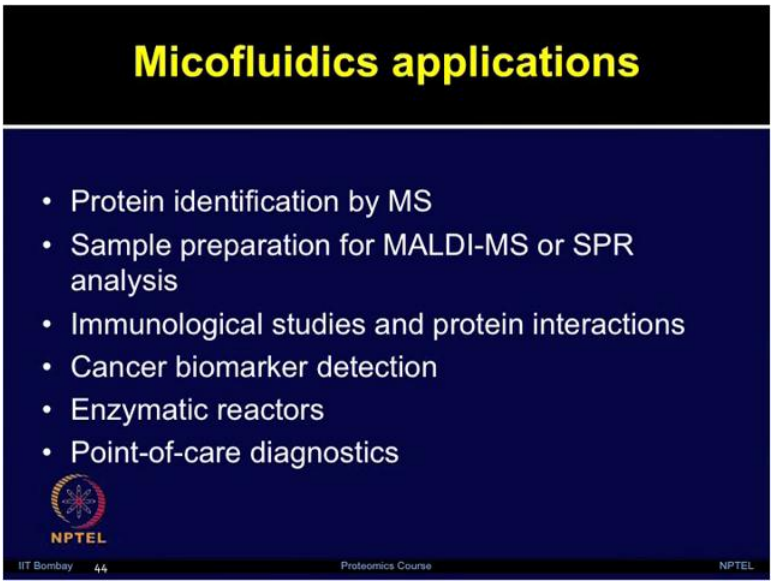

Now, let us briefly look at some of the major applications of using micro fluidics in proteomics field. The Protein identification is performed by mass spectrometry. Now there is increasing trend of applying micro fluidics based systems with mass spectrometry and micro fluidics is applied for sample preparation for maldi based mass spectrometry as well as it has been applied for other platforms such as surface plasmon resonance. Even in SPR analysis now micro fluidic based systems are increasingly used. It has been used for immunological studies, as well as a studying protein interactions, for different type of biomarker studies including cancer biomarker detection and enzymatic reactors. These are just few of the micro fluidic based applications other than some of these techniques which we have discussed in some detail. There are many promising nanotechniques which are also being used for proteomic applications.

So, there are various promising nanotechniques at various stages of development. They have received increasing in attention due to their higher potential for proteomic based investigations. Although the success of these nanotechniques is still very limited,

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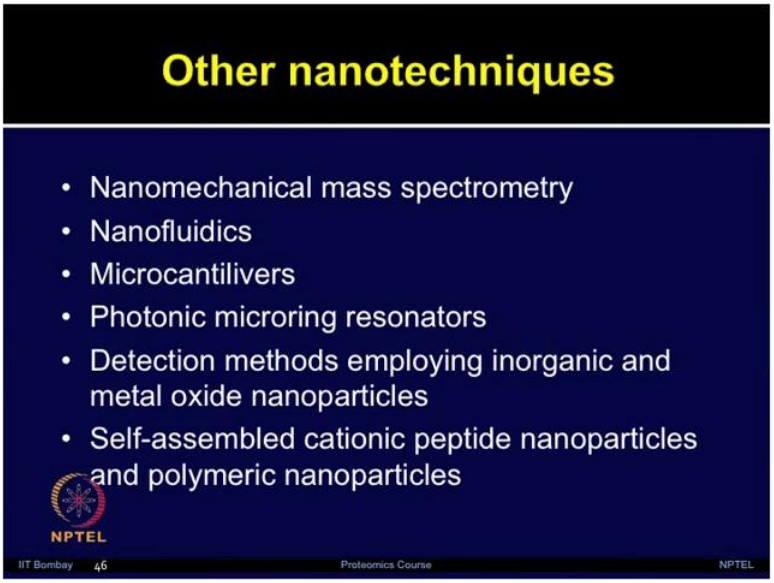

It has potential and significant impact for the future proteomic applications these other nanotechniques include Nanomechanical mass spectrometry Nanofluidics micro cantilevers Photonic micro ring rill resonators, various type of Detection methods which imploy inorganic and metaloxide nanoparticles. Self-assembled cationic peptide nanoparticles and polymeric nanoparticles.

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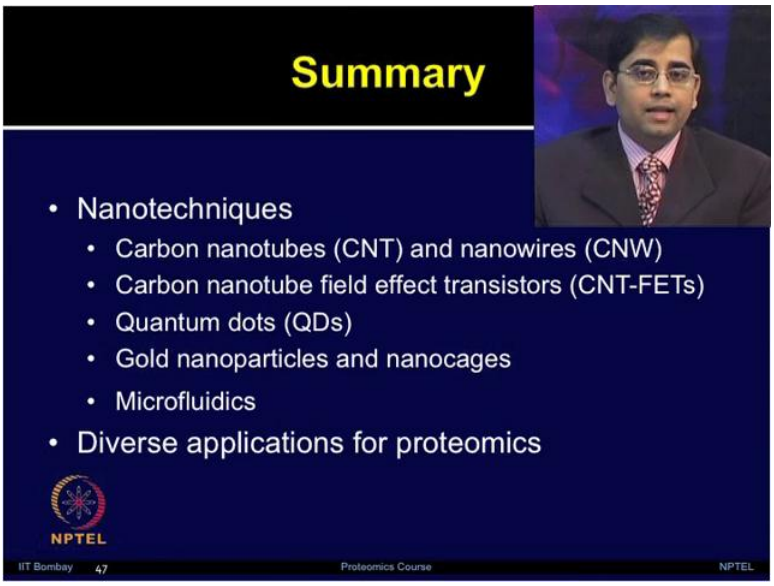

So, the study of proteomics which promises to provide solutions to several pathological conditions. It is still in need for possible new techniques to study the complex proteome. This has brought together the diverse field of proteomics and nanotechnology and offering a new field known as nanoproteomics. Over the last few years nanotechniques have made significant progress is starting from the proof of the concept designs to well established and reliable technological platform for handling the complex proteome. So, these nanotechniques have been used for several diverse applications such as biomarker discovery labeled free protein detection is studying various type of protein and bio molecular interactions as well as coupling them with mass spectrometry and protein microarrays.

Nanoproteomics field hold great promise to become a technically robust and user friendly platform for clinical and diagnostically studies. The advantages offered by various nanotechniques have allowed them to be successfully coupled with the rapidly expanding field of proteomics. In summary today we discussed about different type of nanotechniques such as, carbon nanotubes and nanowires carbon nanotube field effect transistors quantum dots gold nanoparticles and nanocages microfluidics. We have discussed merits and demerits of each of these techniques, as well as some of the potential applications. Now there is still remains many challenges associated with this field; however, by looking at some of these applications, it can be concluded that nanotechnique can offer significant advancement in the proteomics research. Thank you.