Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

This course deals with interfacing the photovoltaic cells to applications and loads. The interface will be the primary topic of discussion and design in this course so it will primarily comprised of circuits power electronic circuits that will interface the solar cells to the radios loads however the central component in all these circuits and applications is the solar cells of thePhotowall type cell we will not be going much into the physics of the photovoltaic cell or the making of the photovoltaic cell

But we will be looking at it as a two terminal device and we would like to characterize and parameterize it as an electrical component just like any other component that we would buy off the shelves like the diode of the master target 80 however it will be interesting to look back and see how this photovoltaic cell came about a historical perspective about the photovoltaic effect of the photovoltaic cell will be in keeping with the discussions to follow and it will give us an insight into how the fore fathers thought about and how they discovered the principles behind the photovoltaic cells and gave us this wonderful gift.

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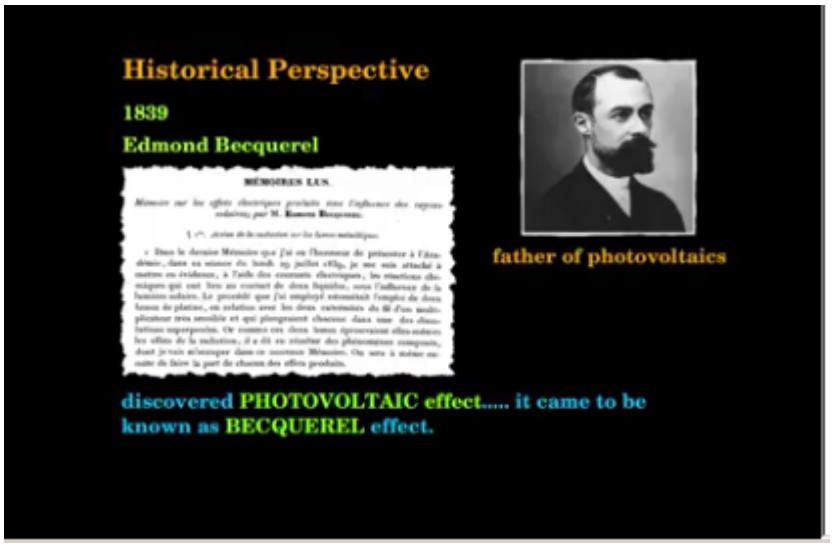

Which is the solar cell for whole time it began animation century in 1839 a young man called Edmund Becker a 19 year old boy discovered photo hold I can affect it came to be known as the back resurrect the age of 19 Edmund Cirrus was working in his father's lab he had the genes of his father his father was also a great his color Henry Becker who discovered his electricity and then later on radioactivity along with Curie he also got the Nobel Prize for that using belcher Becker L discovered that when light was thrown upon the electrons in absolution.

He started giving out a current and then he put on his diameters he piton the observations and I Myers and in July 1839 he published the first available literature born for all time if you we go back to the 19th century in 1839it began for foodie and boy of nineteen years old Edmund Decorah discovered the poor old I correct and it came to be known as the Baker claret he was working in his father’s lab where he discovered that the light was shown upon electrode dipped in an acidic medium current flows through the electrode.

He later on published the results in memory and this represents the very first publication on photovoltaic effect he came to be known as the father offotodiox and if you look at early photovoltaic cells made by the corrosive Edmund tackle it consists of a container and was painted black so that it traplight in the solution Patrick solution it had two electrodes and the electrodes were coated with silver chloride he placed a thin membrane in between and connected the external circuit to the two electrodes.

This fashion and then he should light onto the electrodes and he found that there was an erotic and going to the extra secure on the application of light he experimented with blue light

ultraviolet light and sunlight and recorded his observations of always things so this was the ugliest photo world type subletting and fine from 1839 to 1877 there was not much action in the on this topic not much of those work was carried on or at least not reported.

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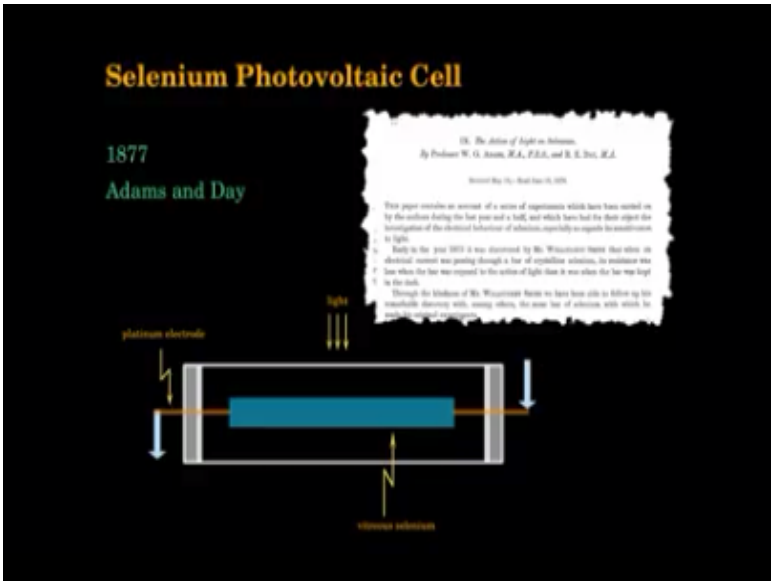

So the first publication after 1839 was in 1877 35 years after the discovery of the photovoltaic effect Adams and day published in the Royal Society Philosophical Transactions of the Royal Society of London the action of light on selenium wearing it is described the selenium photovoltaic cell so they actually borrow on the discovery of Willow by Smith as a man electric current was passing to a bar of crystalline geranium which the resistance was left when the bar was exposed to the action of light.

That it was in the bar was kept in the dark whirring on this principle Adamson they made selenium photovoltaic cells so they used vitreous selenium and to that the electrodes the platinum electrodes were attached was encased in glass tube and the light was made tube incident on the selenium through the glass cube and observe the observe the current flowing through the electrodes and external cycle.

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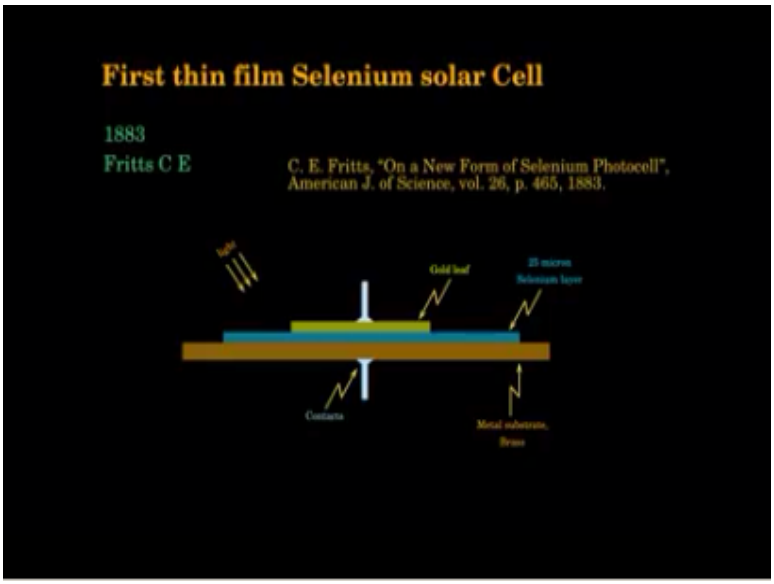

So this was the selenium photovoltaic cell in 1883 5 years later fritz published in theamerican journal of science on a new form of selenium photocell so this was the first thin filament selenium solar cell so he described this first pin fill in selenium solar cell a compass of metal substrate he used brass 35 micron selenium layer molten selenium was pressed in between two metal sheets and the top layer was a cold lead a very thin semi-transparent gold layer.

To which were attached the two contacts to which pH Thomas acute could be connected and when light was made to fall on the selenium through the semi-transparent metal there was electric current that flows through the contacts and the external circuitfritzsche tinkling selenium solar cell you know it was demonstrated and performed well the researchers was skeptical about it even though the experiments were reproducible and repeatable.

They were not clear about the theory because at that time the classical physics was not able to answer the underlying theoretical principles of the operation of the solar cell in 1900something revolutionary happened it was the first of quantum mechanics this on December 17 1907 physicist Max Planck he reported to a meeting for the Berlin Academy of Sciences Physical Society on the problem that he was facing in the thermal radiation issue.

He could not find any solution to his problem someway traditional classical physics and he tried to introduce a totally new concept the concept of one topaz Planck introduced this very famous equation now famous equation where energy is one type and here is proportional to the

frequency and H is the Planck's constant so at that moment at that point in time discretediscretization of energy or energy indiscrete form was not imaginable.

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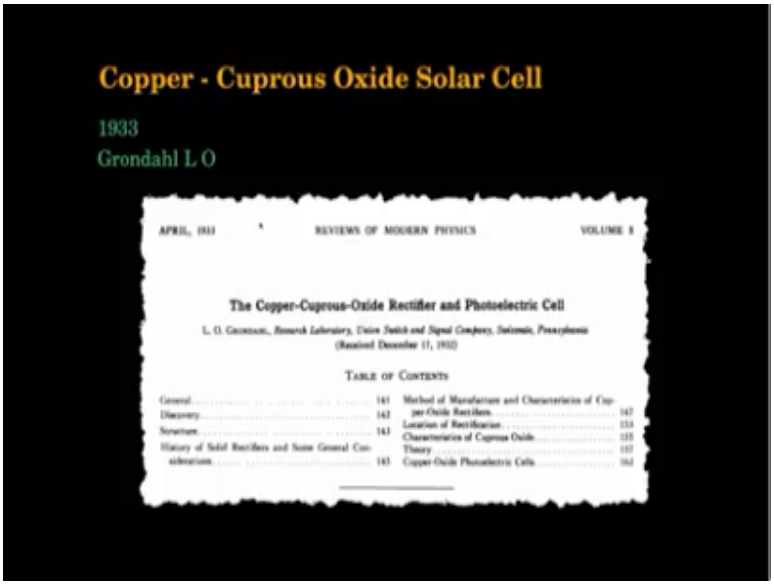

Classical physics would not allow it but Max Planck with the seminal ideas at that point in time introduced the concept of energy packets or the quanta and this was a starting point for amazing discoveries far beyond the imagination of even science fiction writers the work of Max plan foreshadowed all the development of physics for many years to come so this was the contribution of MaxPlanck he gave us a window to our totally new world of ultra spawn.

So we had this quantum mechanics the first ofponta mechanics right at the beginning of the 20th century sometime in nineteen not five at the time literally unknown person Albert Einstein published an article in theannalen deer physic and then he explains the concept of photon packets like packets of the light quanta calledphotonunder this mechanism platform he explains the photo world like principle in the bottle type mechanism completely and that lays are laid the foundation for even the semiconductor industry in1933.

Groaned on once and published many articles on copper cuprous oxide solar cell and he published numerous papers out of which this particular article in1932 the copper cuprous oxide rectifier and photoelectric cells you will great details into the manufacturing process or the photoelectric or the solar this copper cuprous oxide solar cell became quite popular because of its low-cost of production.

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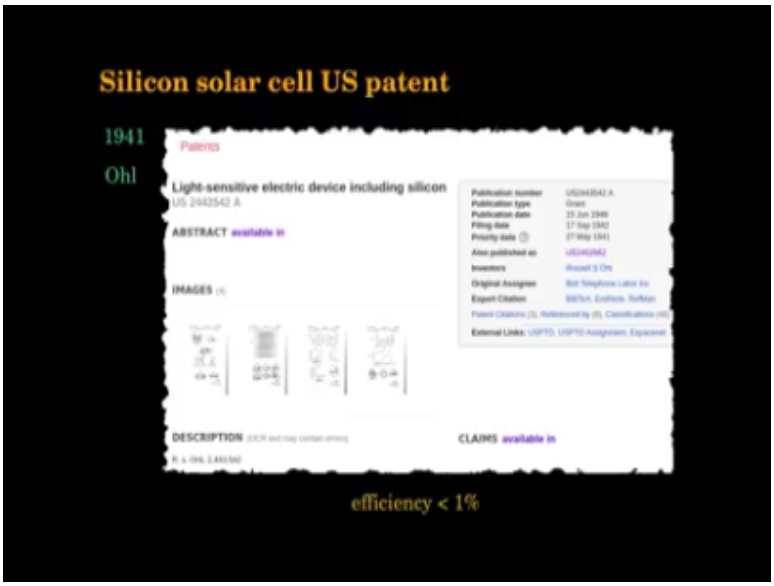

Then later in 1941Wars made the first patent for a silicon solar cell silicon solar reverse agent was made in 1941 so it was a licensed electric device including silicon this silicon solar cell had inefficiency of much less than 1% it did not have much commercial value commercial implication but it was landmark point as far as so lost a lot of prototypes as was concerned it was Avery important point in history in 1954chattin fuller and hear son published in the Journal of life disease solar cells.

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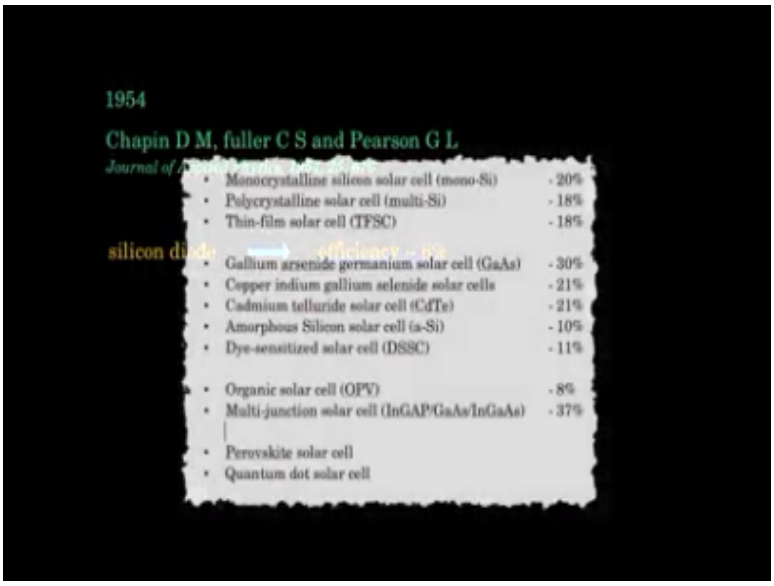

Silicon solar cells semiconductor solar cells having an efficiency of 6%who doesn't even were employees of the labs this was an offshoot of an observation that the bell at silicon diode produced significant amount of current voltage in the presence of lights this was brought forth into commercial product when the first silicon photovoltaic cells with inefficiency of 6% was developed so this was the beginning of the silicon photovoltaic cell from then on there were rapid improvements and then you had host of solar cells.

That have been developed so if you see the top three these are the mainstays the Monachusline Pollex line tinkling silicon solar cells see the moment crystalline silicon solar cell has an efficiency of 20%today they are the most efficient althea supplying solar cells reaching about 18% so also the thin film solar cells another group of cells here which are at the research level not in commercial installations Ailey must mine germanium solar cells having efficiency of up to 30 %copper indium gallium serenade solar cell 21% efficient cadmium telluride

Solar cell again 21 .% amorphous silicon solar cells having efficiency of 10 .% but very low production costs dye sensitized solar cells from 11 person you also how organic solar cell having efficiency of each person they are low-cost cell multifunction solar cell indium galliumphosphide gallium arsenide indium gallium arsenide they have a very high efficiency of 37 .% again all these at the laboratory report HW in future I think one should look out forperovskite solar

cellspero skies is a material which is coated on top of silicon solar cells to improve the efficiency.

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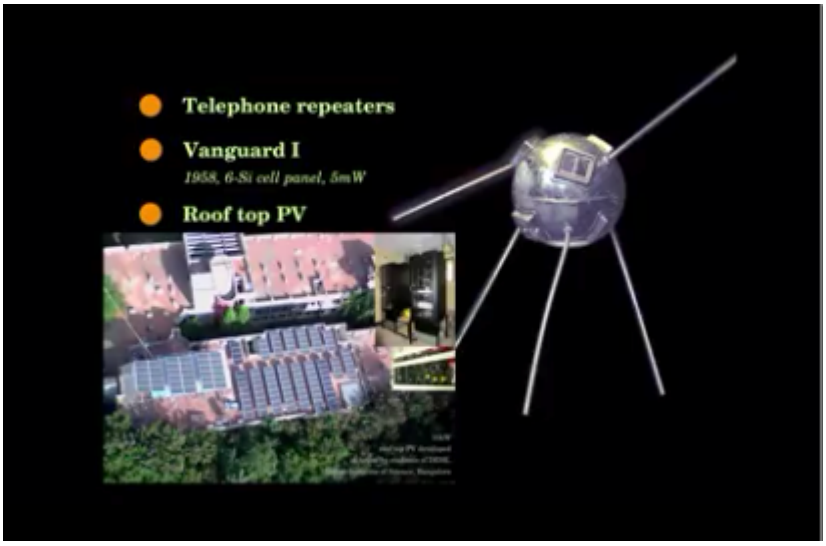

It is improved by another5% quantum dot solar cells these are something that will start coming in the near future and they are supposed to be high-efficiency solar cells the army solar cells were used for telephone repeaters and ugliest popular application was space application the Vanguard 1 satellite in 1958 was launched with six silicon cell panels of having the power of 5 mille watt the silicon cells were placed here in these noises one two three four five and six one the back through the one got satellite when the battery stopped operating after two months the pave source continued to operate the transmitter forever six years life of the satellite.

This in fact was a very great successor photovoltaic cell nowadays the photovoltaic cell is being populated on rooftops to power the whole buildings and communities this is one of the more recent applications of the photovoltaic cell this was a place in Tamil Nadu this is the world's largest solar array at the time of this recording so this is phenomenal 648megawatt solar power plant it's been a long journey for the photovoltaic cell about 180 years from 1839.

From the time Edmond Becquerel discovered four volt like I said till today when we see high-efficiency semiconductor silicon solar cells powering many roofs many communities and as you

see here the six forty megawatt stations so now the photovoltaic cell is spoiled to power our to become the electric power supply for this planet.