

# FABRICATION OF SEMICONDUCTOR NANO STRUCTURED POROUS ALUMINA TEMPLATES BY ANODIZATION

Vishnu Palle<sup>1</sup>

<sup>1</sup>. Assistant Professor, Department of Physics, Jayamukhi Institute of Technological Sciences, Warangal, T.S, India.

## Abstract:

Photo voltaic Semiconductor nano structures are required to have high energy change efficiencies because of the expanded retention coefficients of semiconductor nano structures. Furthermore, the slender film permeable layout can be utilized for ideal surface finishing of sun powered cells prompting extra improvement in energy transformation effectiveness. A significant prerequisite for these applications is the capacity to blend nano structure varieties of various measurements with great size control. This task utilized nano permeable alumina layouts made by the anodization of aluminum slender moves stored on glass substrates for the creation of the nano structures and upgraded the interaction boundaries to acquire uniform pore distances across. An extra prerequisite is consistency or routineness of the nano structure exhibits. While consistent current anodization was seen to give controlled pore distances across, steady voltage anodization was required for commonality of the nanostructure clusters. Along these lines a two-venture anodization measure was researched and created in this task for improving the pore size circulation and pore periodicity of the nano porous alumina templates

**Key words:** *Nano Porous Alumina Templates, Anodization,*

## I. Introduction

Nanotechnology based daylight based cells can give extraordinarily high energy change efficiency and is seen as a real opportunities for future PV development. The immense energy change efficiency rise out of the going with influences: (a) nanostructure crystallite sizes are equivalent to the carrier scattering lengths, this basically diminishes the disseminating rate, thusly growing the carrier combination capability; and (b) nanostructures have strong ingestion coefficient in light of extended thickness of states.

Moreover, by moving the size of the nanostructures, the band opening can be tuned to ingest in a particular photon energy range. Regardless, to achieve these advantages at non-cryogenic temperatures, it is essential to make intermittent assortments of individual nanostructures with a uniform size under 20 nm. A critical obstruction to the progression of a nanostructure-based PV development has been the inability to produce enormous assortments of nanostructures with the fundamental periodicity and size control easily. The standard nanofabrication techniques of epitaxial material turn of events, electron-support point lithography and responsive molecule cutting are not sensible for photovoltaic applications in light of their prohibitively huge gathering costs. Different choice non lithographic creation techniques have been inspected, similar to declaration from a colloidal suspension of particles, joining of semiconductor bundles in regular polymers, circuit of semiconductor miniature crystallites in glass grids, strain-impelled self-composed improvement, etc In any case, most of these systems miss the mark on the fundamental control over nanostructure size movement, periodicity and the flexibility with respect to the choice of semiconductor material. We have developed a fascinating straightforwardness nano development for the production of irregular assortments of semiconductor nanostructures with marvelous size control ( $\pm 10\%$ ) and a serious degree of periodicity. This procedure uses electrochemical association of semiconductor nano structures on a preformed design that is made by electrochemical anodization of aluminum. Since this system uses procedures that are of all over use in the business electrochemical gathering industry, it is unassuming, trustworthy, fitting for huge scope assembling, and what's more allows the usage of a wide extent of substrate and semiconductor materials. This advancement is similarly clearly suitable for the game plan of multi intersection structures, which can moreover grow the photo change adequacy. The objective of this endeavor is to utilize

this non-lithographic strategy to develop an insignificant exertion development for the execution of high efficiency sun controlled cells

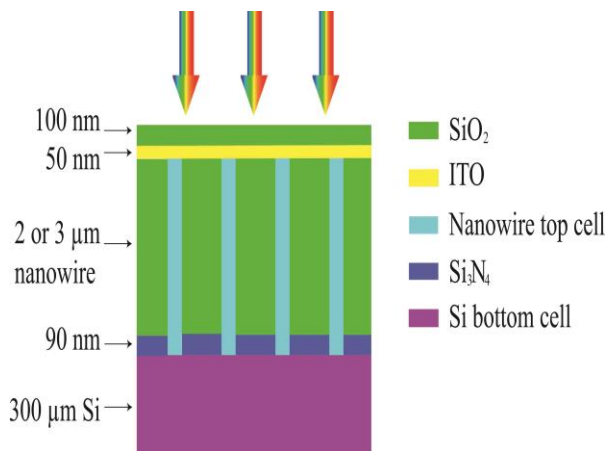


Figure 1: Schematic diagram

A schematic diagram of the nanostructure based daylight based cell is showed up in Figure 1. The development includes semiconductor nano wires embedded in an alumina framework created on a substrate containing the base electrical contact for the sun based cells the nano wires are reached at the top to shape the other electrical contact. The substrate is glass and the top contact is formed with a clear guide to allow full digestion of the sun situated radiation. Likewise, the base contact is furthermore preferred to be formed using a clear guide to allow future execution of multi intersection sun based cells. The photons from the daylight based radiation are consumed by the nano wires at modestly high capability due to the extended thickness of states of the lower layered developments. The innate electric field disengages the electron-opening pairs made as a result of photon maintenance which are assembled by the base and top electrical contacts. Due to the nano scale estimations of the unique material, it is typical that the implied electric field conveyed inside the nanostructures due to Fermi level staying at the surface will be sufficient to segregate the electron-opening sets made by the optical maintenance measure, consequently shedding the prerequisite for P-N convergence improvement. In any case, accepting the innate electric field turns out to be lacking, PN crossing points can be made by adding the fitting dopant materials during mix.

## II. Preparation of Nano porous Alumina templates

The manufacture method utilized in this venture depends on electrochemical blend of semiconductor on a preformed format. At the point when aluminium is anodized in a reasonable oxidizing corrosive (e.g. sulphuric corrosive), a two-dimensional hexagonal lacework of  $\text{Al}_2\text{O}_3$  cells with uniform rounded pores is framed as demonstrated in Figure 3. The pore distance across and the cell divider thickness rely upon the anodization conditions, like sort and ph of the anodizing corrosive, and the anodizing current thickness, and can be exactly controlled over a wide reach. The procedure can be utilized to make layouts with pore breadths going from 4 to 200 nm, pore length from 10 to 1000's of nm, and pore thickness in the  $10^9 - 10^{11} \text{ cm}^{-2}$  territories. What's more, such formats can be made on aluminium substrates, silicon substrates and glass (soft drink lime) substrates, and a pore measurement variety of  $\pm 10\%$  can be accomplished. Lately, scientists have detailed self-coordinated pore development prompting an almost awesome, thickly pressed hexagonal pore structure for a tight arrangement of preparing boundaries. A deliberate examination proposes that the reason for this self-requesting conduct is mechanical pressure which prompts a horrible association between adjoining pores. Such self-coordinated pore development permit much more severe power over the distances across of the nanostructures.

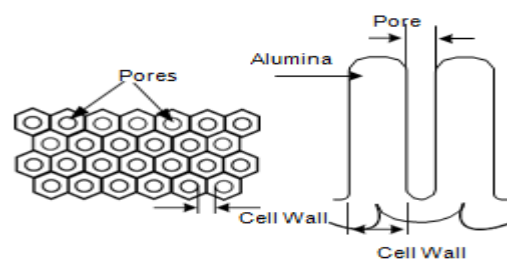
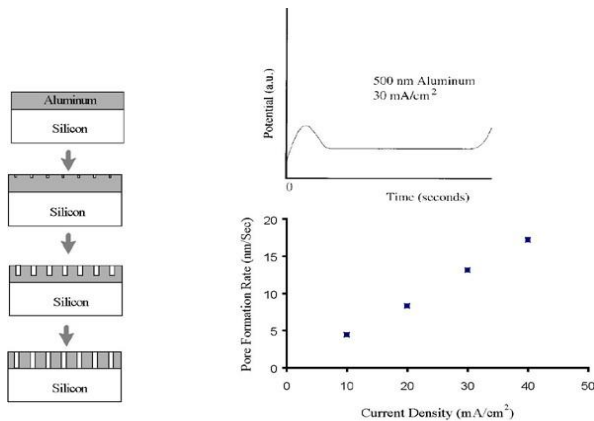


Figure 3. Schematic top and cross-sectional perspectives on pores shaped by iodization of aluminium.



Pore arrangement steps and simultaneous potential-time attributes giving knowledge into pore development measure for negligible moves of aluminium. The potential-time bends and the aluminium film thickness can be utilized to decide the pore arrangement rate which is tentatively resolved to be relative to the iodization current thickness. Albeit the pore development instrument isn't yet completely comprehended, it is accepted to occur in the accompanying advances. During the initial 3-5 s of iodization, a slender non-permeable layer of alumina ( $\text{Al}_2\text{O}_3$ ) is framed on top of the aluminium layer. As anodization is preceded, a variety of pores creates on the alumina layer, and fills in width until arriving at the last measurement dictated by the anodization conditions. When the last breadth is reached, the distance across of the pores don't expand any further, and as the anodization is proceeded, the profundity of the pores expansion with respect to the anodization current. While the majority of the work in this space has been restricted to mass aluminium, we have stretched out this strategy to make  $\text{Al}_2\text{O}_3$  formats on silicon and glass substrates through the affidavit of an aluminium dainty film. This methodology gives the chance of nanostructure incorporation on silicon substrates, and gives us a device for definitely controlling the nanostructure profundity by observing the voltage-time qualities during anodization, as demonstrated in Figure 3. During anodization, the potential increments at first during the arrangement of the top layer of  $\text{Al}_2\text{O}_3$ , at that point diminishes during pore enlarging, and afterward levels of at the beginning of pore proliferation. Then, when the pores engender through the total layer of aluminium film, and contacts the silicon substrate, the potential quickly increments. Since the thickness of the aluminium film is precisely known, and the time from the start to the furthest limit of pore arrangement can be resolved from the likely profile, the pore development rate can be unequivocally

decided in this framework. Accordingly, as well as giving command over the width of the pores, our methodology likewise gives exact authority over the length of the pores.

### III. Procedure

One of the necessities for the execution of elite sun powered cells utilizing this innovation is the development of semiconductor nano wires with little size variety and of serious level of periodicity. Because of quantum restriction, the ingestion range of a nano wire is dictated by its distance across, consequently a variety in the breadth can bring about shifts in the assimilation spectra. While such moves can be profitably used to cover a more extensive scope of the sun powered spectra, an enormous variety in the measurements can take out the advantages of quantum containment impacts, for example, expanded ingestion because of higher thickness of states. Subsequently, a decent command over the nano wire width is vital. To distinguish the ideal size variety of the nano wires, the outcomes from a previous hypothetical displaying was utilized in this undertaking. The hypothetical model was produced for cadmium sulphide, which has very many like properties as cadmium telluride with a fairly bigger band hole. The re-enactment results appeared in Figure 4 show that a size variety of more than 30% can clean out the impact of quantum repression.

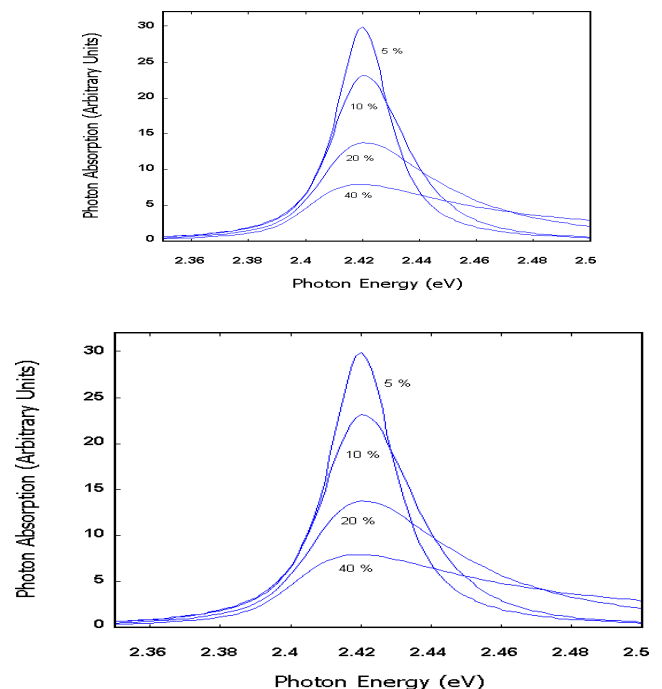


Figure 4. Reproduction results for the reliance of retention spectra on nano wire size variety and the assimilation spectra showing the diverse excitonic tops for a 16 nm width nano wire.

Recreation was utilized to affirm the quantum restricted nature of the ingestion spectra from the excitonic assimilation tops appeared in Figure 5. It was resolved that the size variety of the nano wires should be kept below 30%, and ideally between 10-20%. This will require the pore size variety of the nano porous alumina format to be inside the 10-20% territory. While the spatial dispersion of the nano wires don't straightforwardly influence the assimilation spectra, a layout with low level of pore periodicity can antagonistically influence the sunlight based cell execution as two firmly found pores can circuit to frame a bigger pore, which has been frequently noticed. Along these lines, another prerequisite for this task is to build up the cycle for the development of nano porous alumina layouts with great level of pore periodicity. The manufacture cycle in this undertaking comprised of : (I) the turn of events and improvement of the anodization interaction, (ii) the turn of events and advancement of the nano wire union interaction, (iii) creation measure improvement for the arrangement of ohmic contacts, and (iv) measure advancement for the surface finishing of sun oriented cells.

The main period of the task comprised of the turn of events and advancement of the cycle boundaries for the manufacture of nano porous alumina layouts with great pore size consistency and serious level of pore periodicity. This goal was cultivated by enhancement of the dainty film structure for the production of uniform varieties of nanostructures, the improvement of aluminium affidavit measure, recognizable proof of any cushion materials required, advancement of aluminium layer thickness, just as the examination and advancement of the two-venture anodization measure. The interaction improvement was at first completed on silicon substrates and once streamlined was moved to ITO covered glass substrates. The silicon substrate was an ideal stage for the advancement of the cycle because of its amazingly smooth surface profile.

Silicon substrates were first summa-cleaned, at that point inundated in a 1% HF shower, washed, and dried in  $N_2$ . At that point, a 100 nm layer of Al was falter kept on the rear of the wafer, trailed by toughening at 450° C for 30 minutes to

shape an ohmic back contact. Then, a 100 nm layer of Al was stored on the highest point of the wafer, which was then tempered at 400° C for 30 minutes to guarantee great bond. The wafers were then anodized in 20% sulphuric corrosive at various current densities. A portion of these wafers were then pore augmented in 5% phosphoric corrosive for one or the other 3 or brief lengths.

A picture of the anodization apparatus is shown in Figure 5, which also shows a close-up of the sample holder. The sample is mounted on the chamber so as to be liquid sealed; the chamber is cooled using a water bath circulating around it that is pumped through the pump. This ensures a constant temperature of the anodization bath as the porosity can be adversely affected by varying bath temperatures. All anodizations in this project were carried out at a constant temperature of around 10°C.

#### IV. Experimental Arrangement and Analysis

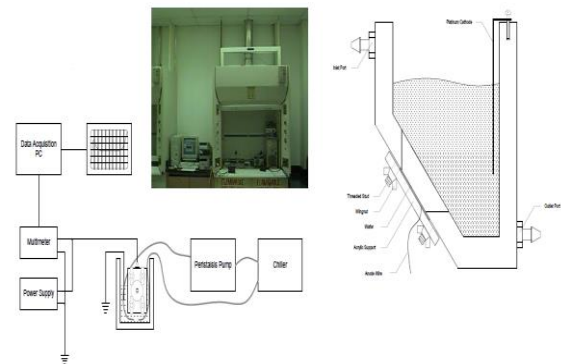


Figure 5. Anodization apparatus and chamber showing details of the sample holder

During anodization, the voltage-time characteristics is monitored to obtain an insight into the anodization process and also to obtain an end point for the anodization process. Figure 6. Shows a typical voltage- time characteristics obtained during anodization. The voltage-time characteristics show the steps of pore initiation, pore formation, pore propagation and termination of the pores on the substrate.



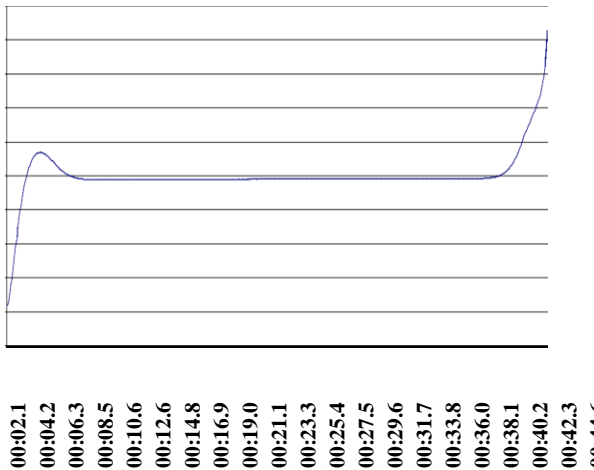


Figure6: Typical voltage-time characteristics obtained during the anodization of aluminum under constant current condition.

One of the main undertakings in this task was to recognize the aluminium statement measure and furthermore the thickness of the aluminium layer as the last thickness of the nano wire will be dictated by the thickness of the nano porous alumina format. In light of our examination and count it was resolved that a thickness of 100 nm of aluminium would be adequate for this undertaking. Two distinct procedures for the testimony of aluminium was explored: faltering and electron bar dissipation. While faltering has the advantage of giving quicker statement rate and is an assembling cycle, electron shaft dissipation was found to give improved film quality and better anodized layer. Figure 7 shows the checking electron magnifying instrument pictures of the outside of anodized layers for aluminium saved by faltering and electron pillar dissipation, which unmistakably show the advantage of the last interaction. One of the issues with getting top perspectives on the pores was the high resistivity of alumina which caused charging during electron microscopy.

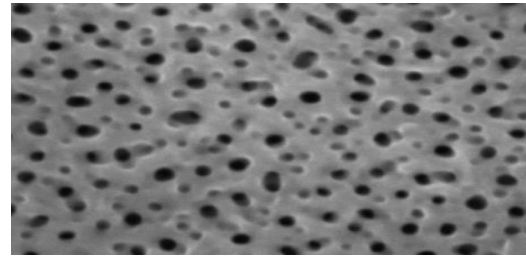
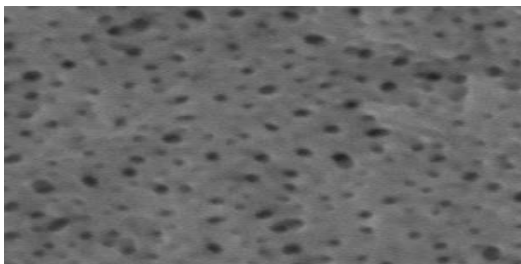


Figure7. Scanning electron microscope images of the surface of alumina template created from sputter deposited and electron beam evaporated aluminium

To recognize the ideal anodization boundaries, a definite examination was completed on the underlying reliance of the nano porous alumina on the diverse anodization boundaries like the current thickness, electrolyte temperature, and voltage and anodization time. Specifically, an extraordinary convention was created to recognize the finish of anodization of the slim film. On silicon substrates such end-point assurance is cultivated through perception of a critical ascent in voltage because of oxidation of the silicon substrate. For dainty film aluminium saved on glass substrate, such assurance is more muddled since at the aluminium-glass interface, the voltage-time conduct is unpredictable. The example of voltage-time was observed for various examples and the normal segment was distinguished. Such end-point assurance is vital to control the pore size of the nano porous alumina layout.

Introductory cycle advancement for improvement of the nano porous alumina films was completed on silicon substrates because of the level surface properties of silicon substrates just as the capacity to connect on the silicon substrate for the anodization interaction. Since metallic aluminium doesn't have great bond to silicon, a layer of platinum or tantalum was commonly stored first. When the cycle was streamlined, it was moved to glass substrates just as ITO covered glass substrates. The issue with utilizing aluminium straightforwardly saved on glass was that the full thickness of aluminium couldn't be anodized as the aluminium layer is additionally utilized as the anode. Cycle advancement was likewise completed on ITO-covered glass substrate which has the advantage that the ITO layer could be utilized as the back contact for anodization just as for sun oriented cell contact. A particular example holder was planned and produced for the anodization of aluminium layers saved on both glass and ITO-covered glass substrates as the contact must be produced using the front and not from the back. Figure 8 shows the schematic of the example

holder created just as a common voltage-time attributes got during the anodization of aluminium saved on ITO-covered glass. This unique example holder was additionally utilized for the electrochemical affidavit of CdTe inside the pores of the alumina formats.

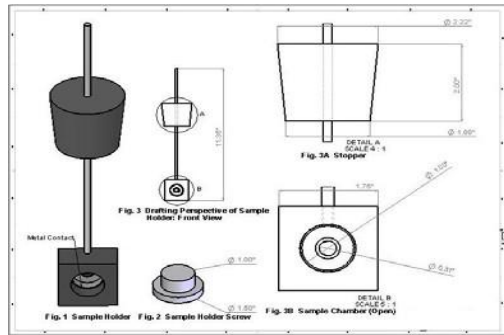


Figure 8. Special holder developed for the anodization of aluminium deposited on glass and ITO-coated glass substrates. Right hand side figure shows a typical voltage-time characteristic obtained during the anodization of aluminium deposited on ITO-coated glass.

The voltage-time qualities for glass and ITO-covered glass substrates show comparative attributes with a quick ascent when the substrate is reached because of oxidation of the substrate by the anodizing arrangement. To eliminate the oxidation, a tin film of platinum was at first stored on the ITO-covered glass, notwithstanding, it was tracked down that the end-point assurance was more troublesome. It was resolved that the oxide at the base could be eliminated via doing a pore broadening step in phosphoric corrosive.

During anodization measure advancement, it was seen that while the anodization current thickness greaterly affected the pore distance across, the anodization voltage assumed a pivotal part on the pore size consistency. For sun powered cell execution, since the format pore size and consistency decide the nano particle size and consistency, it is important to control the measurements just as the pore size consistency. Since either consistent current anodization or steady voltage anodization won't give authority over the two boundaries, a blend of consistent current and steady voltage anodization is required. Towards this objective, a two-

venture anodization measure was researched and created. Two-venture anodization is ordinarily performed on mass aluminium tests where the aluminium thickness is in mm measurements. The principal anodization step is done for over a time of 10 to 20 hours, when 100s of microns of aluminium is anodized. The anodized alumina is then carved off and the subsequent anodization step is completed. The 'impressions' had behind by the principal anodization step gives seed focuses to the pore commencement giving more pore size periodicity and consistency. For slender film aluminium tests, for example, for our situation, such two-venture anodization is extremely difficult since the absolute thickness of aluminium film is not exactly a micron. Hence, uncommon interaction steps, more exact contrasted with mass examples, should have been produced for the two-venture anodization of aluminium slim movies. Since the quantum wire distance across in this undertaking is controlled by the pore width of the nano porous alumina format, thus the requirement for the enhancement of the interaction boundaries for different pore measurements in the two-venture anodization measure.

The particular boundaries that were resolved are the voltage to be utilized for the main anodization step, anodization time for the primary anodization step, drawing time, etchant fixation, scratch time, current thickness for second anodization step, and second anodization time. It was noticed that as the anodization voltage was changed for the primary anodization step, the centralization of the etchant must be adjusted to do the drawing with the fundamental thickness control. This was confounded by the way that diverse anodization acids were utilized to acquire distinctive pore breadths. Towards this objective, anodization of aluminium meager movies was done at various voltages covering the reach around 15 nm that were assessed to be required for this undertaking. For 15 nm pore breadth, it was concluded that phosphoric corrosive is the most reasonable anodization corrosive. For pore measurements in the scope of 15 - 20 nm, the ideal boundaries were resolved to be as per the following. The primary anodization step was done for 30 seconds, trailed by a scratching step. The subsequent anodization was then done under a consistent current thickness of 30 mm/cm<sup>2</sup> to acquire the ideal pore size.

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