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Homemade
SOLAR CELLS


PHOTO IS EXAMPLE OF A SILICON TYPE CELL

LEARN HOW TO MAKE YOUR OWN SOLAR CELLS

Written By Creative Science & Research!
Www.FuellessPower.com Phone: 1-812-945-5839

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This is new. ID numbers are located at the top of the plans and are also hidden in code within these plans. In paper form as well as adobe pdf format.

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Thank you
David Waggoner
Owner

Creative Science & Research
PO Box 557
New Albany, IN. 47151-0557

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E-mail: SalesDept@FuellessPower.com

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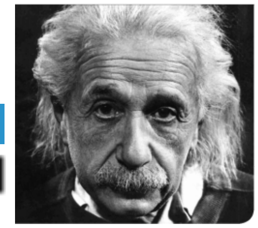

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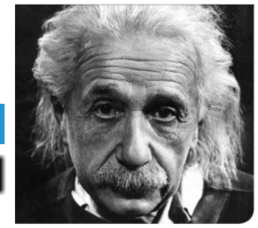
Introduction

Thank you for buying these plans. It will help us in our research efforts and to tell the world about this suppressed technology. Free energy motor and generator technology have been suppressed since the early 1900s. In this book we discuss 4 different types of solar cells and how they are made. The more common silicon type is by far the most powerful. The second is the 1996 screen printed type developed by **Matsushita Electric Industrial Company** in Japan. The Japanese US Patent uses a simple process that has been used for centuries. You can simply screen print the negative and positive layers and the contact layers onto a piece of glass plate, it does not matter how thick the glass is. The layers could also be sprayed on with a paint spray gun and an air compressor, but it is best to screen print them. Screen printing each layer will make your solar cells last longer and they will be more efficient. If you do not know what screen printing is or how to do it please purchase our Screen Printing plans order # 402 for $9.95 and our step by step screen printing video for $19.95 order # 402V. The video does not show you how to screen print solar cells, but it is all the same process. The video will show you how to screen print on T-shirts, how to prepare the screens, the inks you will need and much more.

You can also use the screen printing method to print the new and popular **Dye Sensitive Solar Cells**. I like this new technology because they are cheaper and easier to make. I am not sure if they are as powerful as the Japan solar cells (you may want to test them for yourself). But we have not had the time to do anymore testing on these cells because of our other more imortant free energy projects, such as our Fuelless Engine motors and our SP500 Generator. Our generator is super high efficient, and low rpm. **Great for many free energy projects!** Our Fuelless Engine plans are $70 order # 362-RC350 and our SP500 Generator plans are $70 order # Sp500. Any of our plans can be downloaded or sent to you on computer CD with password protection. The plans are much more step by step than our solar cell plans are. As a matter of fact, they make these plans look sick in comparison.

Making solar cells that can match the high power output of our SP500 AC or DC generator would be very difficult to do. You would probably have to make enough solar cells to cover your entire roof and garage and one of your neighbors roof tops as well. Plus the down side of using solar cell technology is that, the only time you can get free energy from the sun is when the sun is out. And your solar panels are exposed to the outside for any thief to come and still or destroy. The SP500 Generator and our Fuelless Engine motor can be safely hidden in your garage or basement and can run 24 hours a day - 7 days a week. But there are some people who still like using solar cell technology, and that's ok. That is why we made these plans. Once you learn how to make your own solar cells, you can print up as many cells as you want! You can even make money selling any unused electricity back to the electric company, which could pay for itself within one to two years. Our Sp500 Generator can be used as a direct 120 V AC source.

Screen printing solar cells is not new, and it is not limited to just printing on a glass surface. You can also apply it right onto aluminum or copper sheeting. Read and learn from the US Patent in the back of this book.



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How a Solar Panel Charging System Works

Example of just one solar panel.

First you make your own homemade solar cells. Each cell must then be soldered together in series and parallel to increase voltage and amperage. You then build a weather proof case to attach and glue the solar cells to. This can be wood or aluminum with Lexan clear plastic (bullet proof), or safe glass. The output of the solar panel is then connected to a 12v x 5 amp fuse using #12 or #14 AWG wire. You will also need to add a solar charge controller which you can buy at any online solar supply house, they are not that expensive. The controller will help keep the battery from over charging when the sun is out. From the battery to an inverter which changes the 12V DC to 110V AC or 120V AC x 60 Hz. You can then direct the 120V AC to your home.

One Solar Panel with 36 solar cells

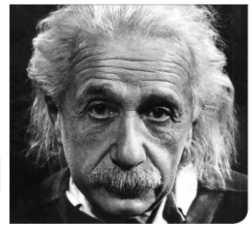
Fuse and ON/OFF SW
You may also want to add a 12 vdc charge controller so batteries won't over charge,

12 VDC Battery Bank
The more batteries you use the more amp hours. The higher the wattage of the inverter, the more electrical lights and appliances you can run.

115 VAC Inverter
x 60 hz

To breaker box sub switch

For 220 V or 240 V power inverters contact: http://www.invertersrus.com/pwri3k24012w.html 1-866-419-2616



Example of a large fork lift battery

Used for electric fork lifts

Tip: Fork lift batteries last longer than the smaller AGM or the smaller lead acid batteries. Up to 27 years.

If you use a 12 volt DC fork lift battery then you can use a 12 volt inverter to convert the 12 VDC to 115 VAC x 60 Hz.

If you use a 24 volt DC fork lift battery then you can must use an inverter that is rated for 24 volts DC x 115 VAC x 60 hz. If you try to hook up a 12 volt inverter to a 24 volt battery it could destroy the inverter.

To purchase a fork lift battery, new or used, check with your local yellow pages under fork lifts, or check with your local lumber yard, such as, Lowes lumber or Home Depot. They use them and may tell you the company they buy them from.

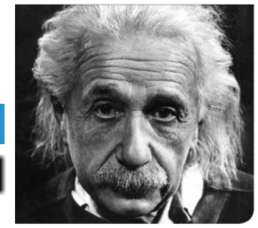
Battery Types Used in Solar Electric Systems AGM type MK

12 VDC x 105 AH
Model # 8A31DT
each battery would weight, about 69 lbs. You would need about 8 to 12 batteries. The more the better.
See: www.altestore.com

Detailed Description
These are completely sealed, absorbed glass mat, valve-regulated batteries with efficient recombination. UL Recognized components to UL MH17218. AGM batteries are recommended for battery backup standby power systems where batteries are in float service with occasional deep discharges. They can operate at temperatures from -40 to 140 F. Delivered from one of 20 MK warehouses across the US.

Www.AltEstore.com Expected life = about 5 to 10 years

TIP: Best to buy 3 - 4 12 VDC x 200 AH or more. The batteries are a little more heavy to lift, but are well worth it. They recommend charging no more than 4 batteries connected in parallel at one time.



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EXAMPLE OF A 8000 WATT INVERTER!

Wagan 8000 - The most powerful inverter on the market! Provides 69 amps to run Refrigerators, Microwaves, Computers, household appliances, Power Tools, Wet/Dry Vacuums, Air Conditioners, and more. Voltmeter and Ammeter.

8000 watts continuous power
16000 watts surge capacity (peak power)
AC Hardwire terminal block
Four AC receptacles
Voltmeter and Ammeter
Powerful internal high-speed cooling fans
High voltage protection
Low voltage protection
Overload protection
Low battery alarm

115 VAC
60 HZ

NOTICE!
You will need the Sp500 and the Fuelless Engine to keep the Batteries recharged or a very large solar electric system.

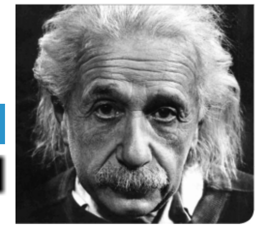
You can connect this into your power grid. Have an electrician install it for you if you do not know how. Or you can simply run heavy duty extension cords from the unit to your appliances.

Converts 12 volts **DC** to 115 volts **AC**

You can purchase these inverter's at: DonRowe.com
Http://www.donrowe.com/inverters/1000_5000_watt.html

$849.00 # WAG8000

Donrowe.com 1-800-367-3019 1- 800-367-3019
sales@donrowe.com



On A Budget?

Another option is to buy multiple 750 watt inverter's as your budget can afford. If you are on a tight budget you can keep adding them to your system as you go. For a 8,000 watt system you would need about 11 of these. They cost about $74 each. You can buy tem on line or at any Walmart or Sears store near you. Each one can be connected to your breaker box by breaker selection. Depending on which rooms you want to power first. Just one of these can power a refrigerator, one 40 watt light bulb and a small TV. The more of these you add the more of your house you can power. The nice thing about this is if one wears out you are only out of $74.00 to replace it instead of $800 or more. These inverter's are square wave and not sine wave. They will work on computers, lights TVS etc. But there maybe some equipment that needs pure sign wave such as some LaserJet printers.

Black & Decker 750 W Power Inverter

Chapter One

Silicon Solar Cell Technology

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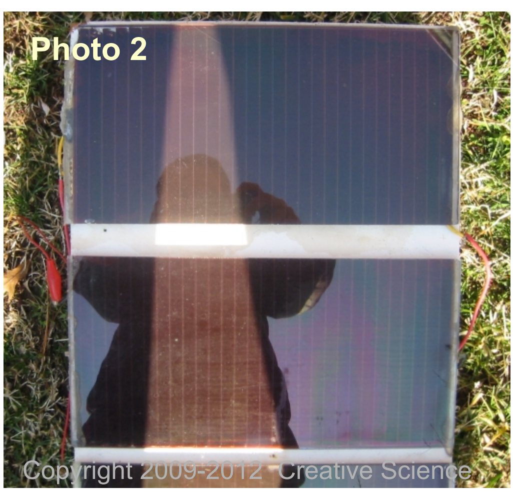
SOLAR CELL TECHNOLOGY

Example of one silicon solar cell



Example of screen printed solar cells

What is a solar cell?

A solar cell is a device that converts sunlight energy into DC electricity! It is also called the photovoltaic effect. If you know a little about electronics then you may know what a diode is made of. A solar cell is much like a one way diode, it has a P junction and an N junction, and can also be made up of silicon. There are many other materials that works as well such as heating up copper sheeting and using the red cuprous oxide that forms on the other side. Copper solar cells are cheap and very easy to make but they are not as powerful as the factory made silicon type.

A single silicon solar as seen in photo 1 can generate up to 0.5 volts dc in bright sunlight. Solar cell panels as seen on roof tops are made of many single solar cells connected in series and parallel. There are many other names for solar energy such as, solar panels, solar modules or photovoltaic arrays. *Photovoltaics* is the field of technology and research related to the application of solar cells in producing electricity for practical use. The energy generated in this way is called solar energy or also known as solar power energy. There are also the screen printed type as well as the new dye sensitive type solar cells.

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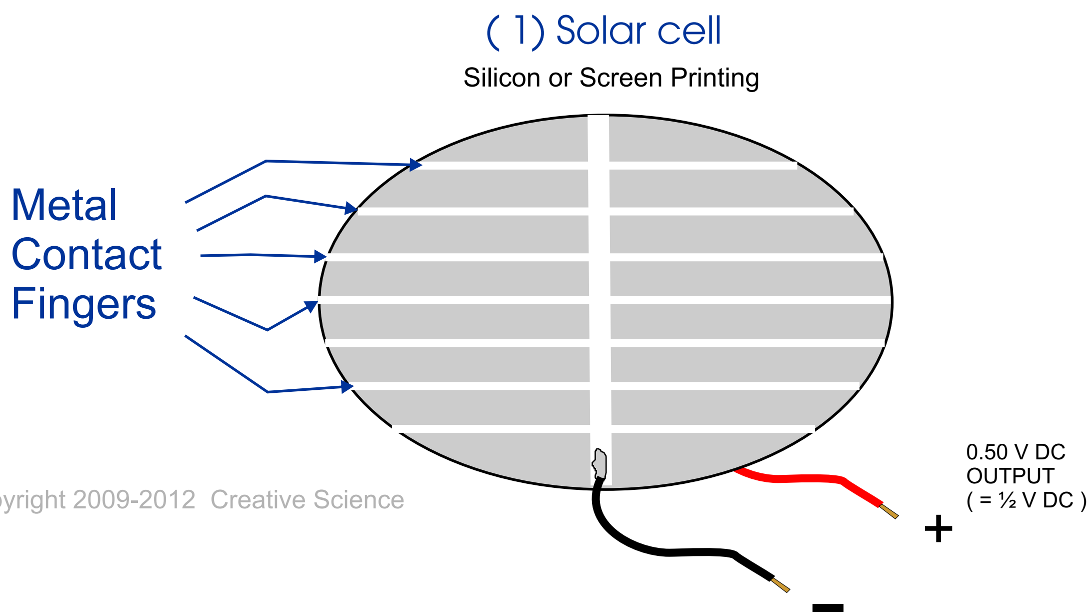
SOLAR CELL CONTACTS



Silicon or screen printed type solar cell disks or square type, are all screen printed with a top conductive layer of conductive ink. (Conductive means electricity can move through the ink material once it is dried. A non conductive material for example, would be paper or wood. Electricity can not travel through these types of materials.

Notice: Solar cells can only work and charge your 12 volt battery bank during the day when the sun is out. If you want a charging system that is more powerful and easier to make, I would strongly suggest our **Fuelless Engine** plans and our **SP500 AC or DC Generator** plans. You will need both of these plans if you are really wanting some serious wattage and juice to power your home with. The **SP500** can be built to run at 14 to 15 VDC x 100 to 200 amps, to keep a 12 volt battery bank fully charged. The battery bank is then connected to a inverter that converts the 12 VDC to 115 VAC, household current! You can also build the **SP500 Generator** as a direct 120 volt AC x 60 Hz generator. This can power your house directly to your electric panel. You do not have to be an electrical engineer to build the **Fuelless Engine** motor or **SP500 Generator**. We have made the plans easy to follow and step by step. You would be surprised at how many of our customers are just average people like yourself. This is information we are trying to quickly get into the hands of every American household!

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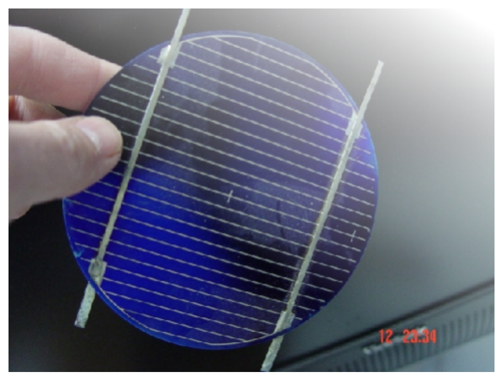
How Silicon Solar Cells Are Made

It is possible to make and grow your own silicon type solar cells at home. Although the information in these plans are for screen printing solar cells as well as the cheaper copper cells. I thought it would be a good idea to add this to the plans to give you a better idea of the difference between silicon solar cells and screen printed solar cells. Silicon cells are of a better quality than screen printed cells, but screen printed cells are easier to make. And cheaper to make. Dye sensitive solar cells are even better and can be made at home.



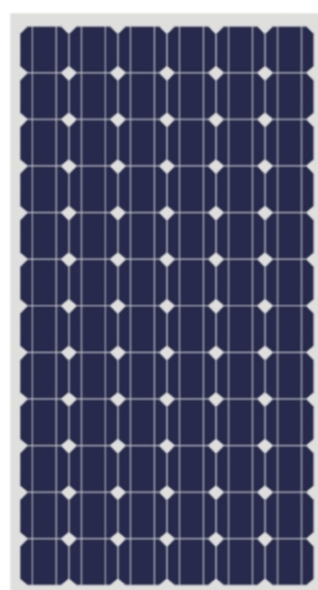
A Silicon Solar Cell

Silicon from Silicon Dioxide

1. You must first extract silicon from silicon dioxide material. The chemical compound silicon dioxide, also known as silica (from the Latin silex), is an oxide of silicon with a chemical formula of SiO_2 and has been known for its hardness since antiquity. Silica is most commonly found in nature as sand or quartz, as well as in the cell walls of diatoms. Silica is the most abundant mineral in the Earth's crust.

You will need to remove any impurities from the sand or silicon, and to do this you simply heat it in the oven at a very high temperature. (I am sure an oven the type glass makers use would work. you can purchase small melting pot ovens online, they also maybe called annealing ovens).

You need to keep repeating this process until you finish up with at least 99.5% pure silicon. This is the least you need to begin making your homemade solar cell with.



A Solar panel made up of 72
silicon solar cells, soldered together.

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How Silicon Solar Cells Are Made

Crystallize the Solution

2. Our next step would be to crystallize the solution. To make a successful crystallization of the silicon, you need to heat up the silicon until it melts, then once it does you want to add boron. You can find companies that sell boron chemicals or any other type of chemicals online, simply go to **www.google.com** and type in the keyword " **boron** " to search. I am not sure of how much boron you should add? You will have to find that out on your own by researching it. We have never tried the silicon type cells yet. Our expertise is mainly with the Fuelless Engine and Sp500 generator etc.

The addition of boron creates an electrical foundation. This then gets charged with a positive charge. Now pour the melted silicon/boron solution into a square block or a round block mold.

3. You should now have pure silicon in the shape of metal blocks or round cylinders. The next step would be to cut them into thin sheets. Find a very fine metal cutting saw such as a machine shop metal cutting machine, or have a machine shop cut it for you for a small fee. These thin wafers should be cut in the range of about 200-300 micrometers.

4. The thin wafer sheets of silicon cells are now dipped in water with chemical additives so that they can collect a negative charge. Sometimes companies add an anti-reflection material to each cell. This gives the solar cells a black appearance. this may help get the most from the sun's rays.

5. At last, the conductive paint or ink is added to the front surface and then to the back surface by using aluminum or silver conductive paint or ink. The ink can be screen printed on the front as a grid or mesh. The back can be rolled on or painted with a brush if screen printing is not desired. Connections are bonded to the photovoltaic cell to carry the electric current to your 12 volt battery bank, which is connected to a high wattage inverter that changes the 12 V DC to 120 V AC to be used to run your home lighting, TV, DVD player, computers, fans, tools etc.

END

Sand also known as Silicon

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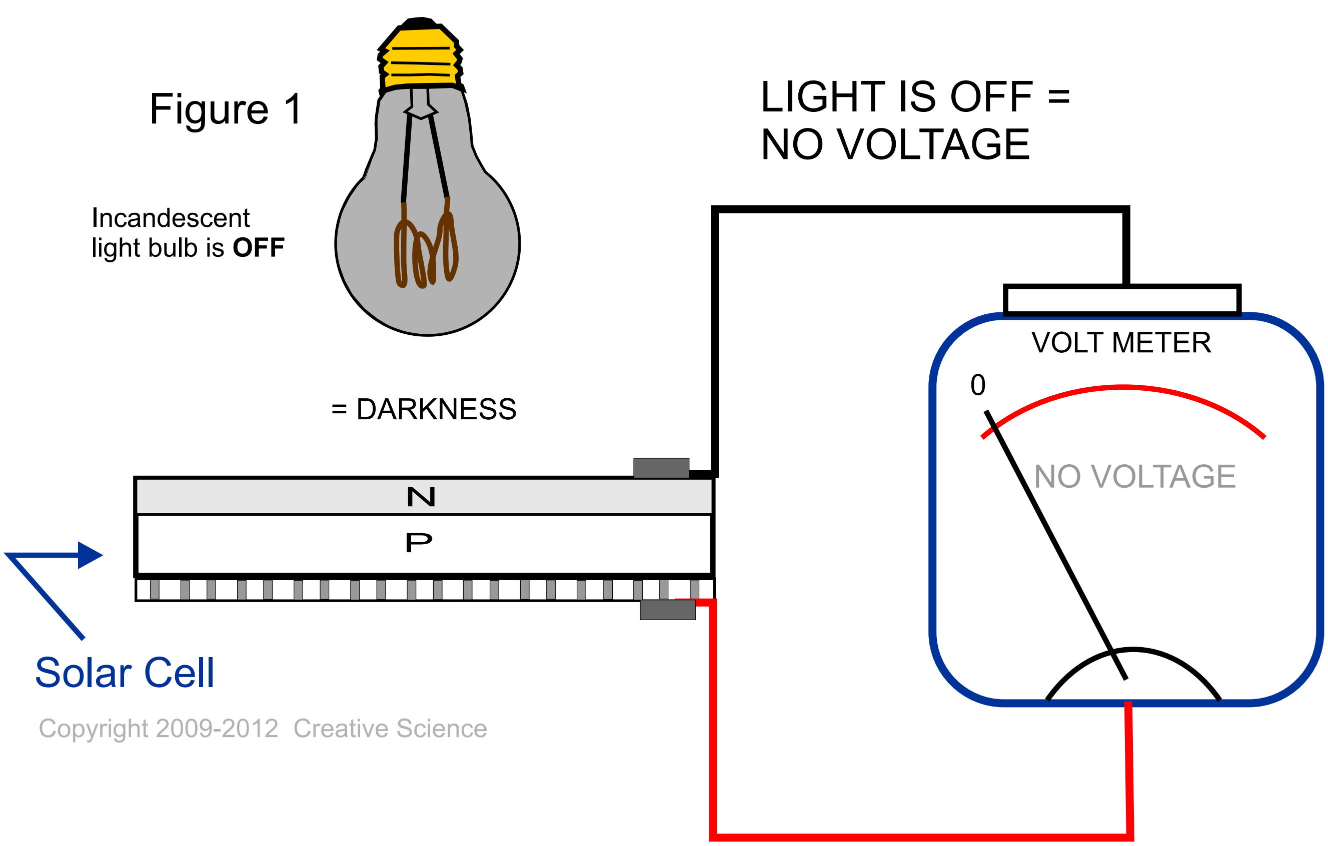
SOLAR CELL OPERATION



Solar cells are basically large **semiconductor diodes, and b**ecause of the photovoltaic effect, Sunlight or an incandescent light bulb will convert light into electrical current. In figure 1 the light bulb is off, there fore no light is converted to electrical energy because there is no light to convert.

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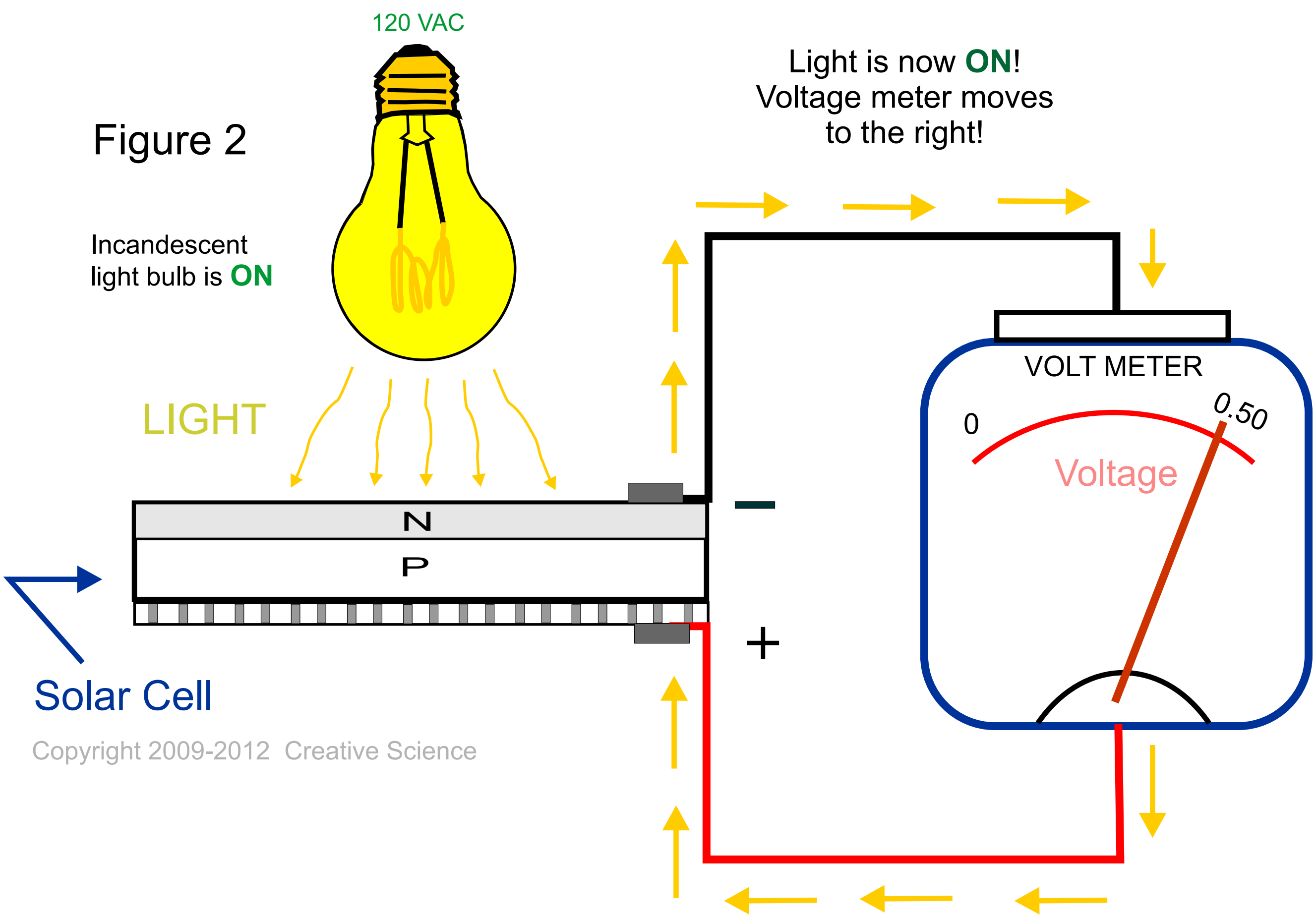
SOLAR CELL OPERATION



Now In figure 2 the light bulb is now ON, and there is now electrical current flowing through the volt meter converting light into electrical energy. The bulb can also represent the sunlight, which = free energy. Cells may also be P on N. Many different kinds of solar cells can be made. Often individual cells are connected in series or can be connected in parallel or both.

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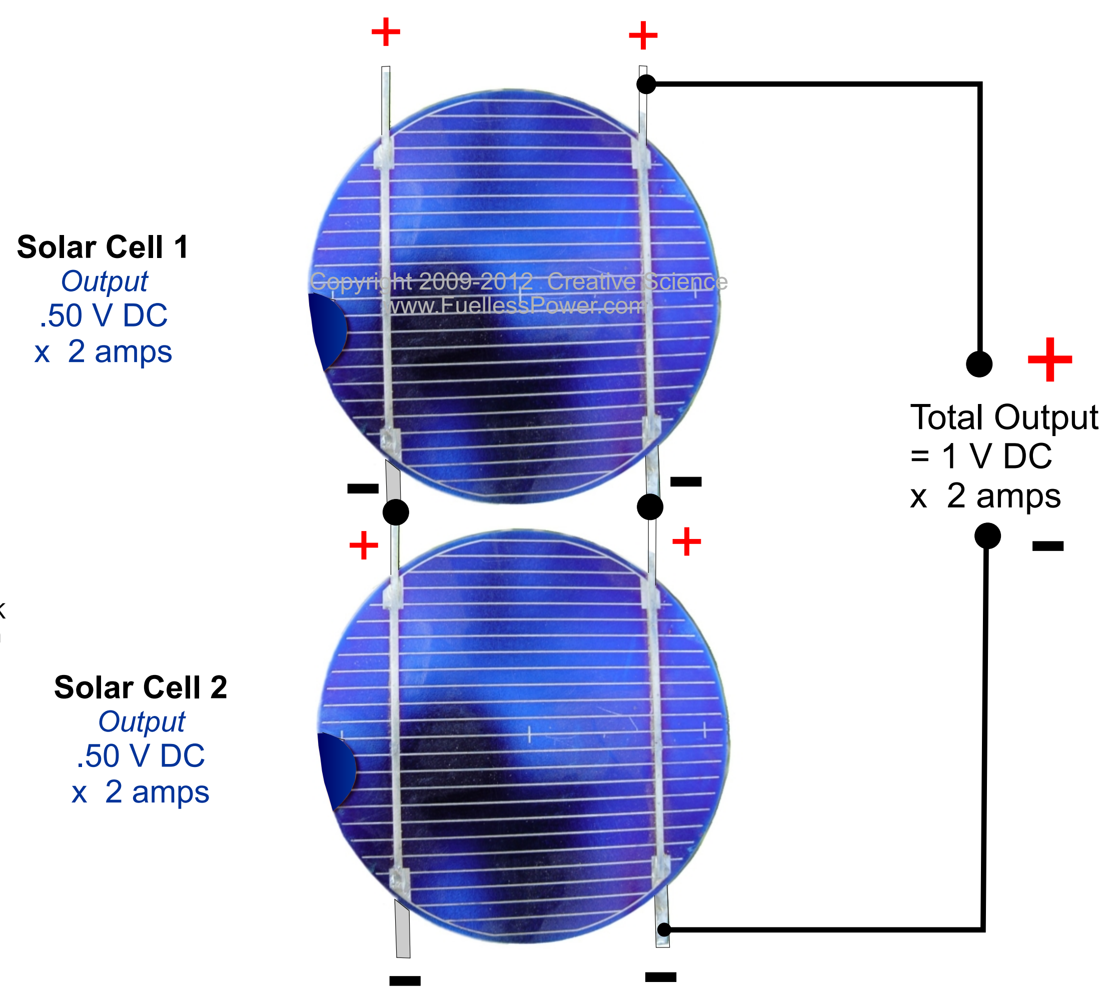
CONNECTING CELLS IN SERIES

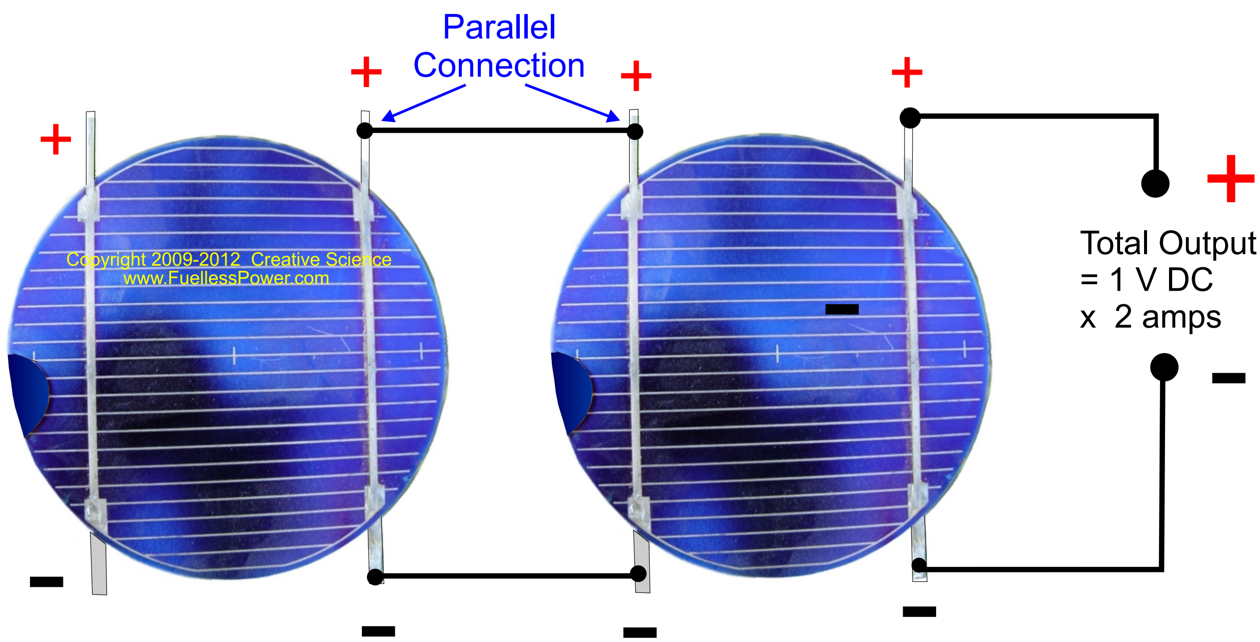


You will need a Weller 8200PK soldering gun and solder from Radio Shack or online

This is an example of how to connect solar cells in series. The voltage will double to 1 volt, but the amperage stays the same. The more solar cells you add in series the higher the output voltage will be. Each cell must be soldered together using solder. If you do not know how to solder you can learn very quickly. Soldering is very easy to learn. Soldering irons are sold online or at any Radio Shack store. Tip: You can buy solar cells online at Ebay.com or Amazon.com or use Google keyword search - “ Solar cells for sale “

CONNECTING 2 CELLS IN PARALLEL

Positive to Positive and Negative to Negative



This is an example of how to connect solar cells in series. The voltage will double to 1 volt, but the amperage stays the same. The more solar cells you add in series the higher the output voltage will be.

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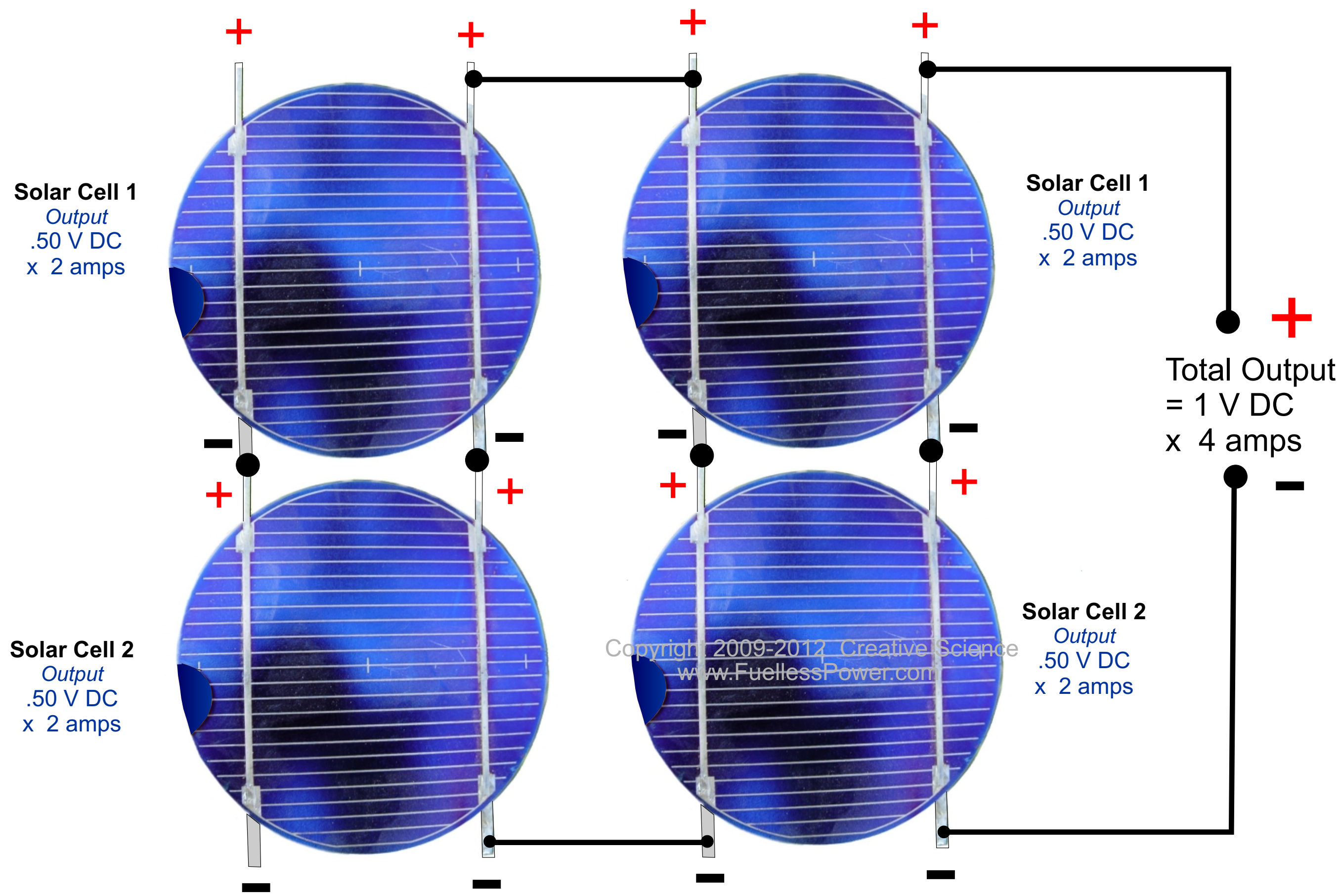
CONNECTING CELLS IN SERIES & PARALLEL



This is an example of how to connect solar cells in series and parallel. This increases the amperage output. So we have 1 VDC x 4 amps instead of 1 VDC x 2 amps. Depending on the output of your cells after you buy them or make them, and if your cells only put out .50 V DC each, you will need about 28 cells connected in series to get about 12 to 14 v DC x 2 amps. And one more set of 28 cells connected in parallel will increase the amperage to 4 amps x 14 VDC, To charge a 12 volt deep cycle battery or battery bank you will need 13 vdc or more for lead acid batteries. You will also need a charge controller to make sure that you do not over charge the battery(s). You can simply purchase a 8 to 10 amp diode from Radio Shack or any other online electronic supply store, and solder it on the positive side of the output solar panel. The Diode only allows the DC voltage and amperage to travel in one direction. This is so the battery will charge properly. Without a diode you can not charge a battery. Also if you do decide to charge with a diode, you will need a digital volt meter to make sure that you do not over charge the battery. You can purchase or make your own solar cells with higher voltage ratings.

Chapter Two

Dye Sensitive Solar Cell Technology

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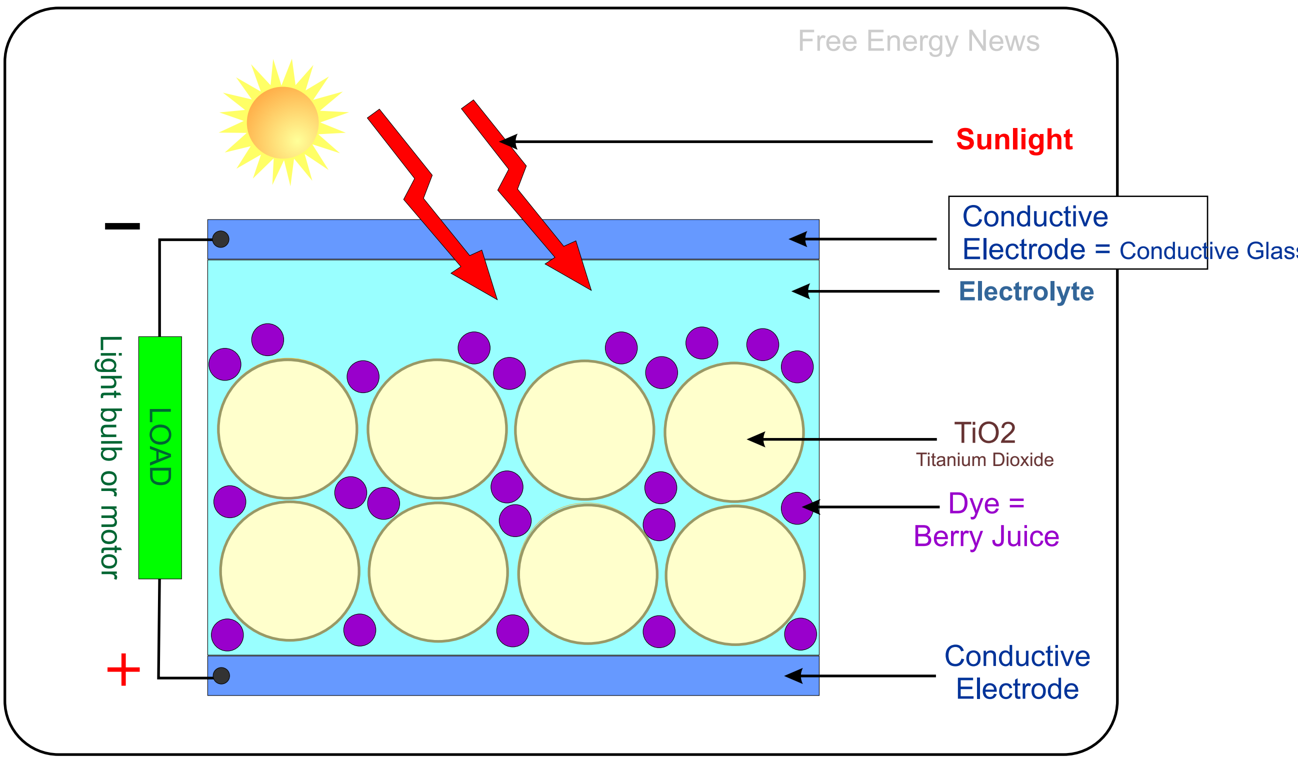
Dye Sensitive Solar Cells

Photo of a Dye Sensitive Solar Cell

YOU CAN MAKE THESE AT HOME USING BLACK BERRY JUICE!

HOW THEY WORK



The bottom electrode can be made of metal, copper or aluminum etc..

More Suppliers

Dye Sensitive Solar Cell KITS

These kits are to help introduce you to this new technology and help you learn.

Http://ice.chem.wisc.edu/Catalog/SciKits.htm#Anchor-Nanocrystalline-41703
Type this link into your address bar of your internet browser or just type www.ice.chem.wisc.edu

Http://www.ecic.com/dssc.html?gclid=CLGroO6S2KYCFcNi2godJHePHA
Http://www.loop.ph/bin/view/Openloop/DyeSensitizedSolarCells

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Dye Sensitive Solar Cells

We can not forget to mention the new dye sensitive solar cell technology that everyone is now talking about. These solar cells are very easy and cheap to make but are not yet as powerful as the screen printed type. These solar cells can be made right at home using Titanium Dioxide (found in tooth past) and berry juice. There are many people right now researching this new technology to try and get them to be a more powerful and usable means of energy. Of course our Sp500 AC or DC generator is a better choice. It is a super high efficiency generator that we developed right here in our own labs. By connecting this generator to a free energy motor or a gasoline engine converted to run on water you can run your entire home 24 hours a day, 7 days a week. And can be safely hidden away in your garage or basement. (HHO or Hydrogen and Oxygen gases).

A dye-sensitized solar cell is a low-cost solar cell belonging to the group of thin film solar cells. These solar cells are based on a semiconductor formed between a photo-sensitized anode and an electrolyte. This type of solar cell was invented by Michael Grätzel and Brian O'Regan at the École Polytechnique Fédérale de Lausanne in 1991. Dye sensitive solar cells are made of low-cost materials and does not require elaborate apparatus to manufacture. Manufacturing these cells can be significantly less expensive than older solid-state cell designs. It can also be engineered into flexible sheets and is mechanically robust, requiring no protection from minor storms like hail or tree strikes. Although its conversion efficiency is less than the best thin-film cells, in theory its price/performance ratio is high enough to allow them to compete with fossil fuel electrical generation by achieving grid parity. This new type of technology may be the solar cells of the future!

Photo shows a group of dye sensitive solar cells being made in a lab. Materials used for this experiment were, Water, Titanium Dioxide, Berry juice, Clear tape and Conductive glass. Very easy to make but not very powerful. Our Fuelless Engine and Sp500 generator is what you really need. Our plans are step by step and easy to follow.

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Dye Sensitive Solar Cells Being Made

First the white Titanium Dioxide is coated onto the conductive glass. Tape off the edges and then mix the titanium dioxide powder with a few drops of dilute nitric acid or white vinegar to make a creamy paste. Drop a small amount into the top center area of the glass. Then use a metal rod or glass rod to apply it to the glass by moving it over the glass and the paste from top to bottom. This will apply an even coat. Remove the clear tape from the edges of the glass. Let it dry, then bake it in a small electric oven, hot plate or a heat gun for about 10 minutes.

Now dip the finished pieces of coated glass with the baked Titanium Dioxide on them into a bath of berry juice. You can try different types of juices to see which one works the best. The juice is the purple looking dye as you see in the photos above. See Youtube.com videos for more details. Place a 2nd conductive piece of glass on top of the finished dye glass. Place 1 or 2 drops of iodine or Redox Electrolyte between the 2 glass plates. Seal the edges with silicon glue so weather will not get in. And the solar cell should now be ready.

One glass plate gets the Titanium or also known as TiO2. And the other glass plate gets the black carbon. Or you may use graphite from a pencil by rubbing it across the glass.

You can buy conductive glass online or at:http://www.pgo-online.com/intl/katalog/ito.html?gclid=CITp8LjAzqYCFUHs7QodgEJ3HQ

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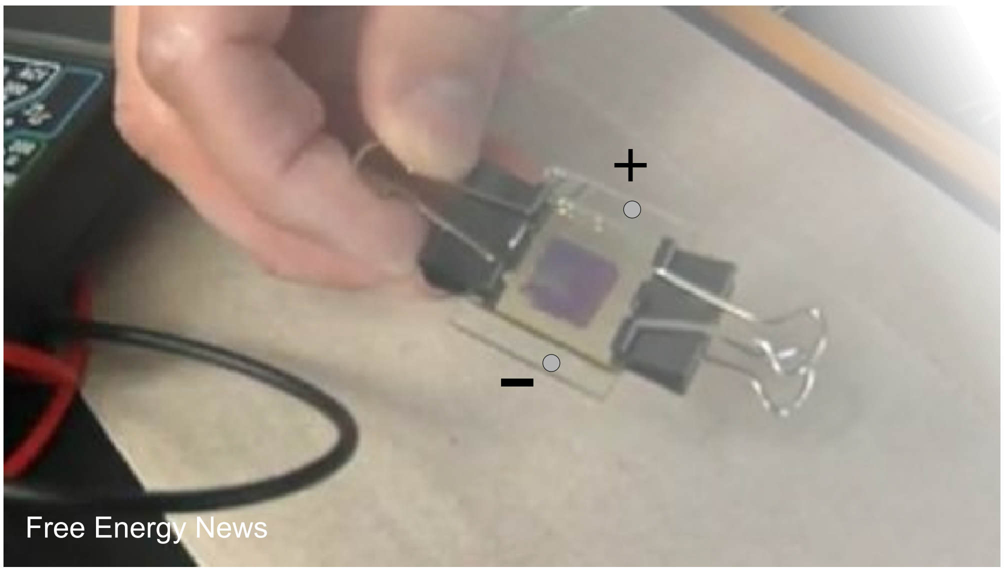
Our Sp500 AC or DC Generator will produce the power you need for your home and is easy to build!

Dye Sensitive Solar Cells



This is a finished lab prototype of a dye sensitive solar cell. Made from black berry juice. There are many ways to make these cells. But we will show you an easy way so you can quickly make one at home.

For this project you will need:

Conductive glass

You can purchase Low E window glass from a glass company or window company. Low E glass windows are conductive coated.
Wolfs Glass of New Albany IN
1-812-944-2264 Qty- 4 7" x 10" = $60.00

You can buy dye solar cell kits or if you are using just plain glass slides, an inexpensive approach is to coat the conductive sides with graphite. For this, a graphite pencil is most often used. Or you could screen print the entire solar cell. The TiO_2 paste could be screen printed onto a thin piece of metal or aluminum. Then after is cured and heated, the berry juice can then be sprayed on or the cell dipped in the juice. The top piece of glass (negative) can be screen printed with silver or nickel conductive ink as a grid pattern or stripes. The electrolyte or Iodine can then be applied onto the positive bottom plate and then the top glass plate can then be placed and glued onto the bottom plate. Or you maybe able to eliminate using glass all together and simply screen print the top conductive ink right on top of the bottom TiO_2 plate then adding the electrolyte and applying a clear spray painted covering or clear epoxy.

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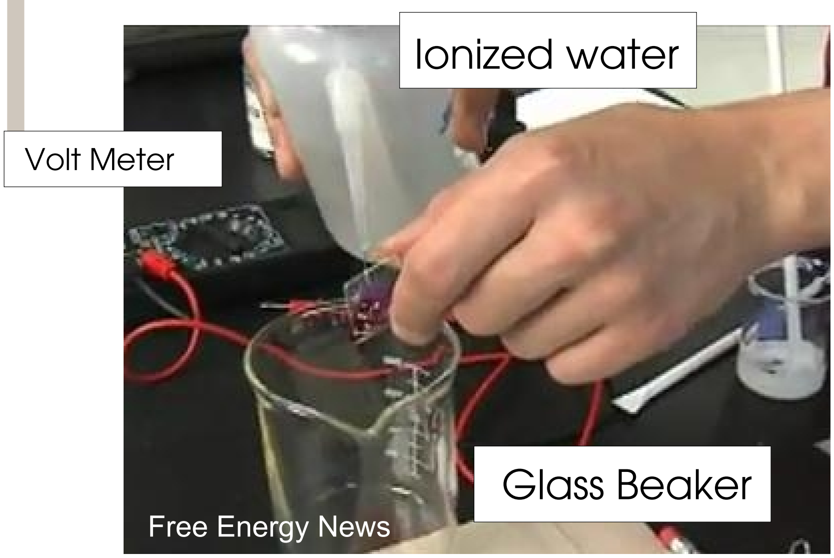
Dye Sensitive Solar Cells

Materials you will need

1. Qty - 2 Conductive glass plates
2. Qty - 1 (17 oz)Titania or Titanium Dioxide TiO2 power
3. Redox Electrolyte made from Iodine & Potassium iodide
4. Dilute Nitric Acid
5. Distilled white vinegar
6. Clear tape
7. Hot plate, heat gun or small electric oven to heat and cure TiO2 past
8. 100% Black Berry Juice
9. Eye dropper
10. Small glass beaker
11. Volt Multi Meter
12. Alligator test clips
13. Glass stirring rod
14. Pencil
15. Qty - 2 Binder clips
16. Ionized water
17. Isopropyl alcohol
18 Chem wipes or cotton wipes.
19. Stir sticks

Titanium Dioxide TiO2 powder



Redox Iodine

Hot plate


Where to buy TiO2 or Titanium Dioxide

Camden-Grey Essential Oils, Inc.
3579 NW 82 Ave.
Doral, FL 33122 (U.S.A.)

www.camdengrey.com

Ph: 305-500-9630
Fax: 305-500-9425

E-mail:
Customerservice@camdengrey.com

5 lbs. bulk ($25.00)

Direct Link:
Http://www.camdengrey.com/essential-oils/titanium-dioxide-bulk.html

Titanium dioxide, also known as titanium(IV) oxide or titania, is the naturally occurring oxide of titanium, chemical formula TiO_2. When used as a pigment, it is called titanium white, Pigment White 6, or CI 77891.

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Where to buy TiO2 = Titanium Dioxide Powder

Organic Creations
Quality Soap, Lotion & Cosmetic Crafting Supplies

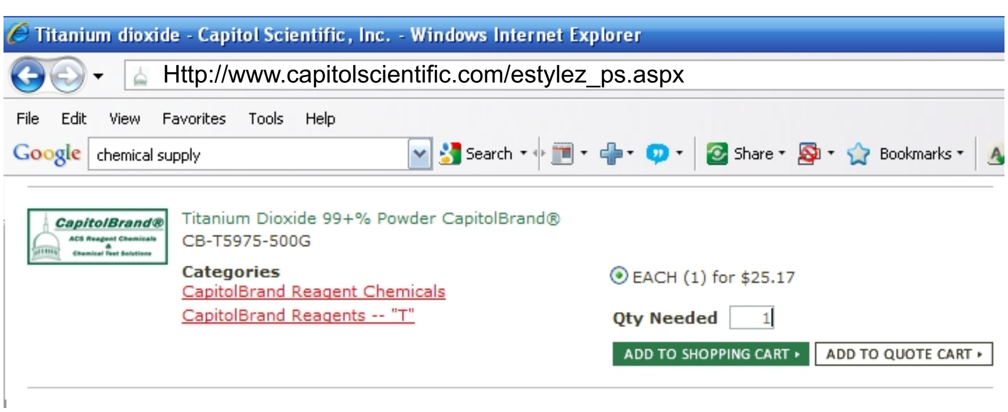
Www.organic-creations.com

Http://www.organic-creations.com/servlet/the-936/titanium-dioxide-natural-cosmetic/Detail

Organic Creations PO Box 101, Tenmile OR 97481 * (541) 679-4636

OR

This company also carries beakers and many other lab equipment.



500 G = about 17 ounces x 1.1 pounds cost $30.00
2.5KG = about 88 ounces x 5.5 pounds cost $59.49

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Dye Sensitive Solar Cells

MAKING THE PASTE

Step 1

Place the TiO2 Titanium Dioxide in the glass beaker, now add a few drops of nitric acid, or you can try distilled white vinegar. I have heard some researchers using vinegar, but I do not know how well it works.

Step 2

Now stir the nitric acid into the TiO2 power, add more drops of acid if needed. You want to make it a creamy consistency, not as thin as water and not as thick as a paste. Keep stirring until there are no small lumps. These plans may sometimes refer to the TiO2 as a paste but for this experiment it is actually a cream, much like thick paint. You maybe able to screen print this chemical as well.

WARNING! Adult supervision is required. Be sure to wear protective gloves and eye wear when handling acid as well as any hazardous chemical.

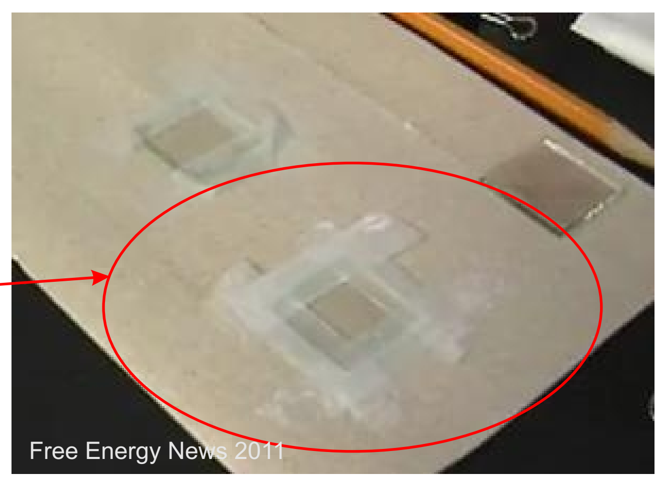
Dye Sensitive Solar Cells

APPLYING TAPE ONTO THE CONDUCTIVE GLASS

Step 3

With the conductive side up, tape all 4 edges of the conductive glass as shown.

When finished it should look like this,



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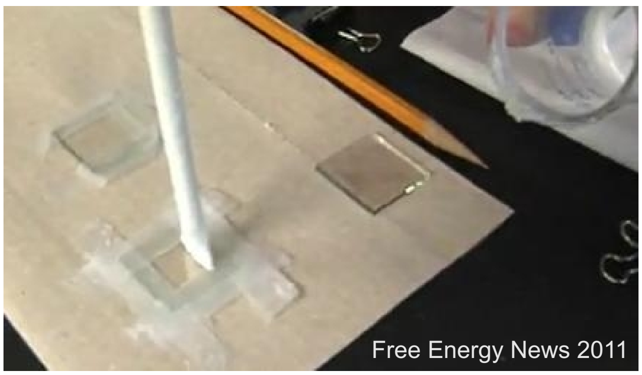
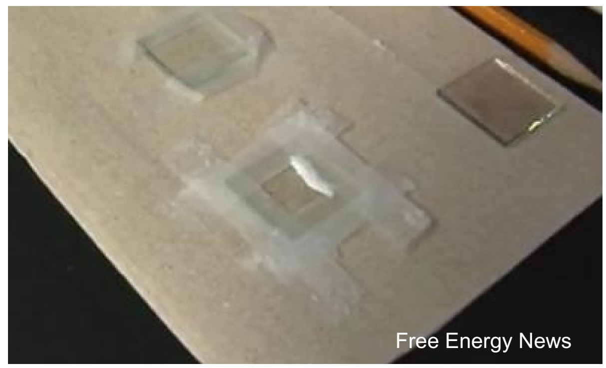
Dye Sensitive Solar Cells

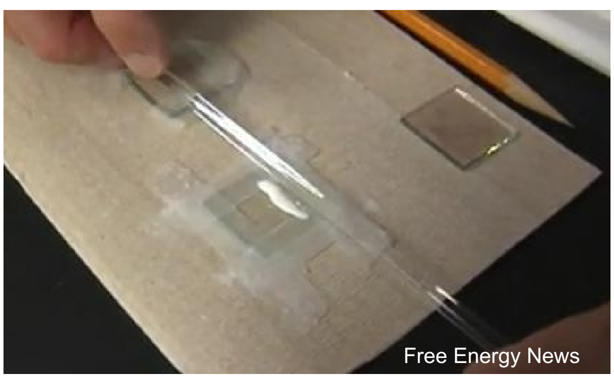
Applying the TiO2 past or cream onto the conductive glass

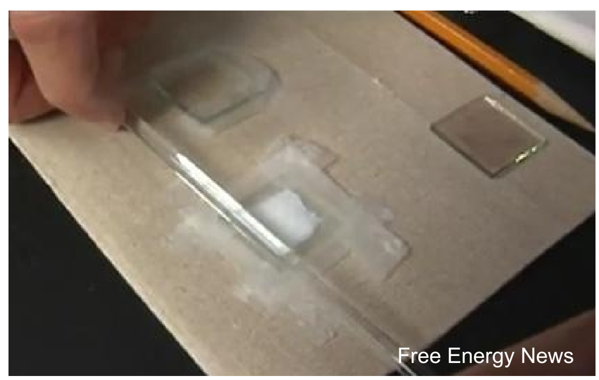
Step 4



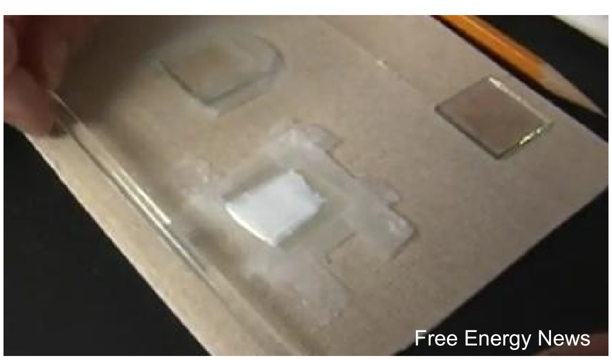


Apply a small amount of TiO2 past onto the top of the glass area.





Using a glass stir rod as a squeegee, slide it downward pushing the paste and covering the glass area.



Tip: You maybe able to use a large rubber roller for larger glass projects.

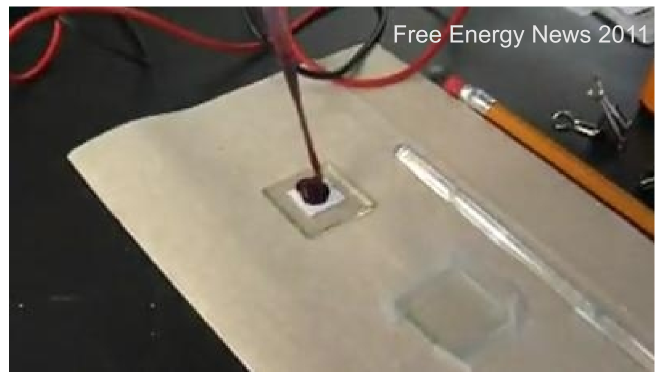
Let it air dry for about 5 or 10 minutes

Dye Sensitive Solar Cells

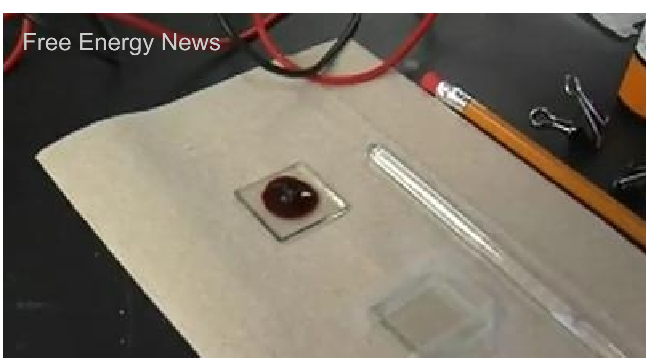
Step 5 Heat curing the cell

Remove the tape from the glass and using a hot plate or other, let it heat at about 450 C for 10 min. Or 842 Fahrenheit

Step 6 Dyeing the cell

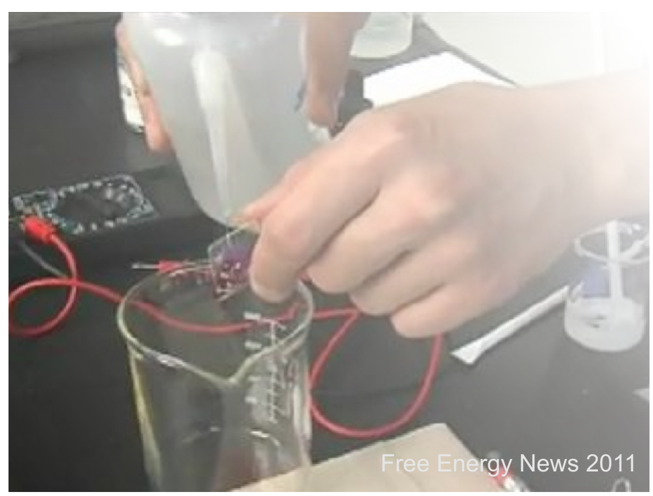


Once it has been heat cured you can now apply the black berry juice. You can also use Raspberry or Cherry juice. Using an eye dropper, apply the juice to the TiO2 glass.



Let the juice stand on th TiO2 for about 5 to 10 minutes

Step 7 Rinsing the cell



Now rinse the cell using iodized water (is the best) or distilled water. The TiO2 cell will now have a purple dye look to it.

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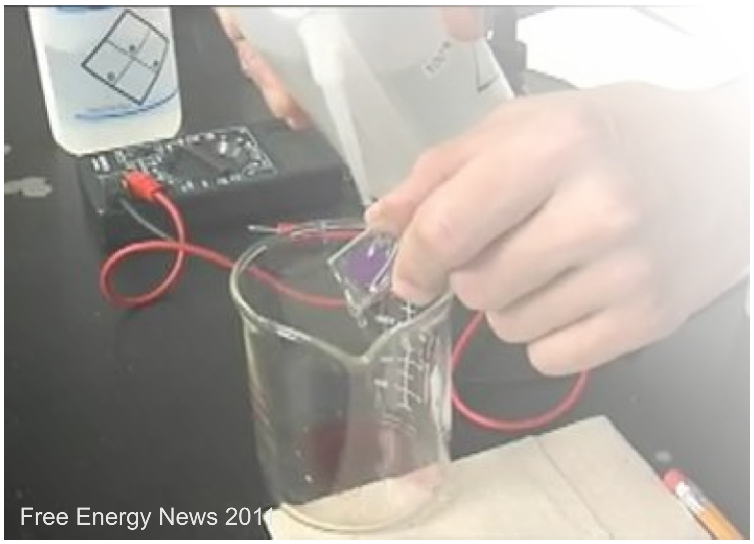
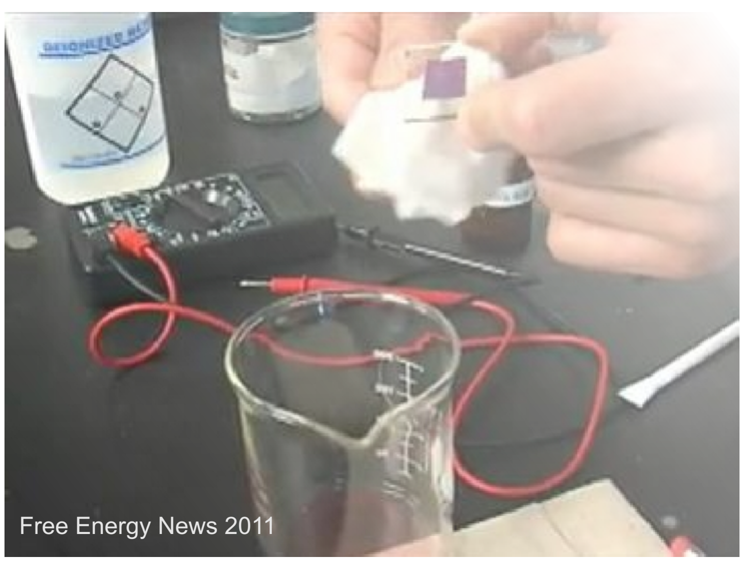
Dye Sensitive Solar Cells

Step 8 Rinsing the cell with alcohol



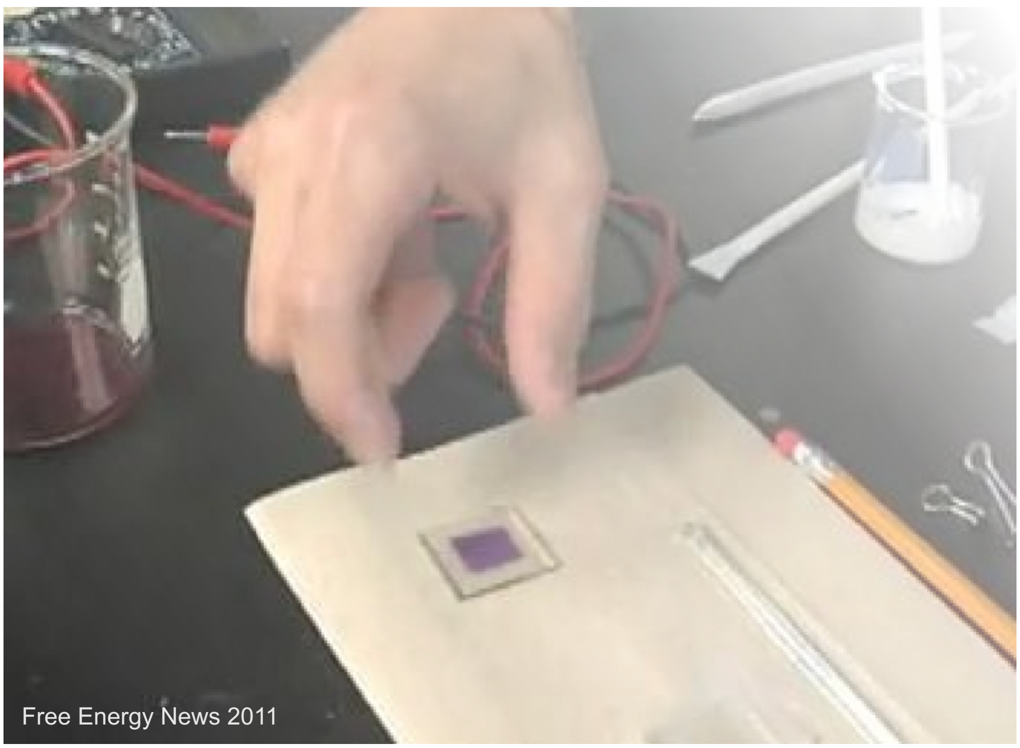
Now rinse the cell with isopropyl alcohol to help it dry faster.



Now blot it dry with a chem wipe or cotton wipe towel.

Dye Sensitive Solar Cells

The first side of the cell (the anode - positive) is now done.



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Dye Sensitive Solar Cells

Step 9
Preparing the 2nd glass piece, or the cathode -

Use the graphite from a pencil to etch it on the glass.

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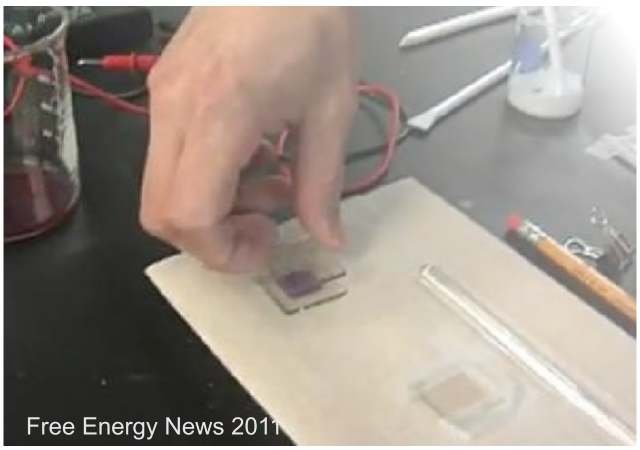
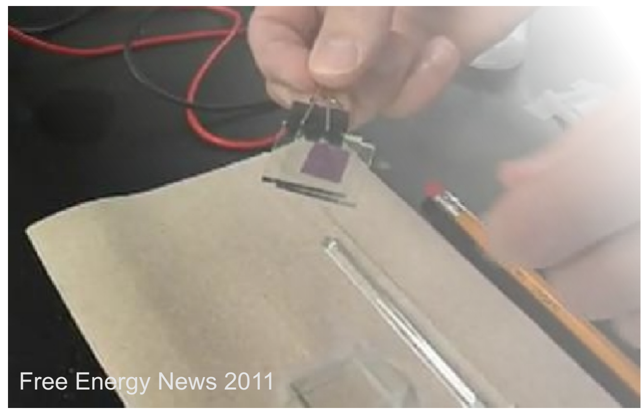
Dye Sensitive Solar Cells

Step 10 ASSEMBLING THE CELL



Place the pencil etched side of the glass to the face side of the TiO2 cell.

Step 11

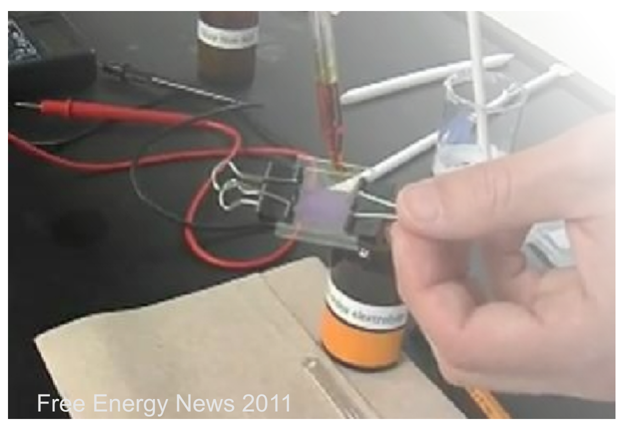


Make sure to off set the edges. Use binder clips keep the 2 pieces of glass together.

Step 12

Place a 2nd binder clip onto the other side. The cell is almost ready to use except for one thing. There is no conductivity between the two plates, so Redox or iodine must be applied.

Step 13



Now apply the Redox iodine to the edges of the two glass plates. Open and shut one clip at a time alternating so the Redox can work its way inside the middle of the two plates. He cell is now ready to go!

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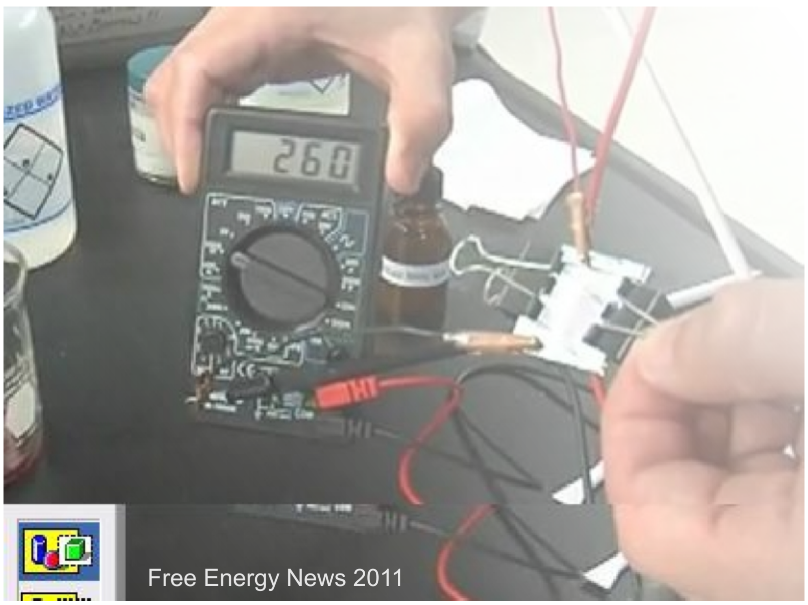
Dye Sensitive Solar Cells

Step 14 TESTING THE SOLAR CELL



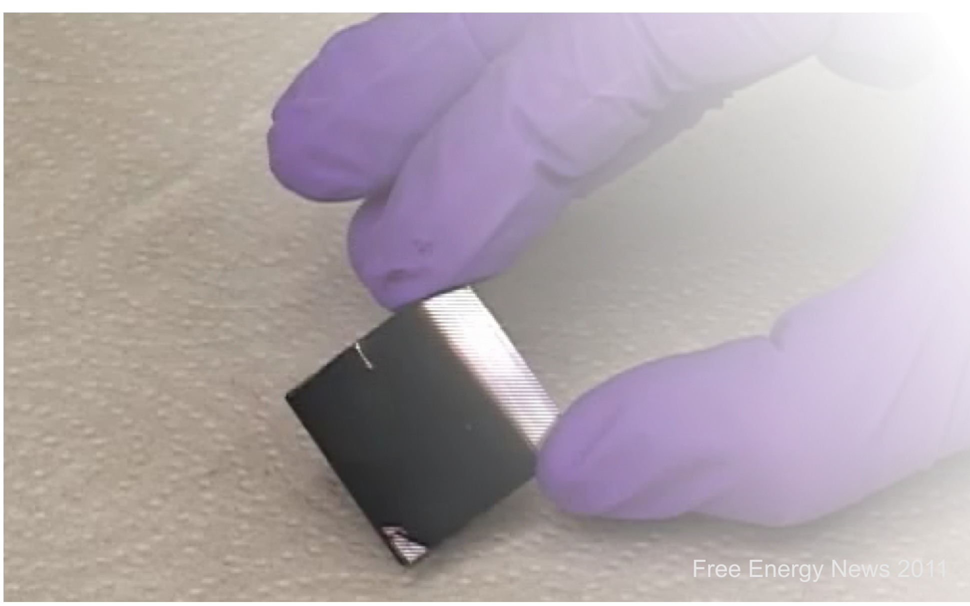
This is an inverter. It coverts a 12 VDC battery to 110 VAC or 120 VAC to run lights and appliances in your home or RV.

It is now time to test the solar cell. Place alligator clips onto the positive and negative volt meter probes. Red to red and black to black. Now place the red wire to the bottom edge of the TiO_2 glass this is the positive. Now place the black wire to the top glass this is the negative. At room light (depending on the type of light) you can get 260 milla volts and more. Place the solar cell close to a 100 watt *incandescent* light bulb and watch voltage rise. Using the cell out in the sun will give even better results. The cell can now be incased in clear silicon, plastic or clear epoxy. A more permanent solar can be screen printed onto glass or metal. If you do not know how screen print, it's easy. See our screen printing plans for only $9.95 order # 402. You can now make hundreds of these cells and solder them together in series and parallel to make *multiple* solar panels to help run your home. Use about a qty of (10) 750 watt inverters from Walmart or other to run your home. You can tapp each inverter into your breaker box for each room. Or you can put all you money in one basket and purchase (2) 4,000 watt pure sine wave *invertors*. So, the solar panels will be used for charging 12 volt golf cart batteries or one large fork lift battery (Fork lift batteries I think are the best choice, they last 27 years and longer, cheaper in the long run).

Of course nothing can hold a candle to our Fuelless Engine motor and our Sp500 AC or DC Generator. Each set of plans are $70 each you will need both $140.00 total. Our engine and generator blow solar cell technology out of the water (just my opinion - *David Waggoner*).

Here is another idea for the cathode side

Take the 2nd piece of conductive glass and using a candle move it back and forth over the flame until the entire bottom side is completely covered with black carbon on the conductive glass side.



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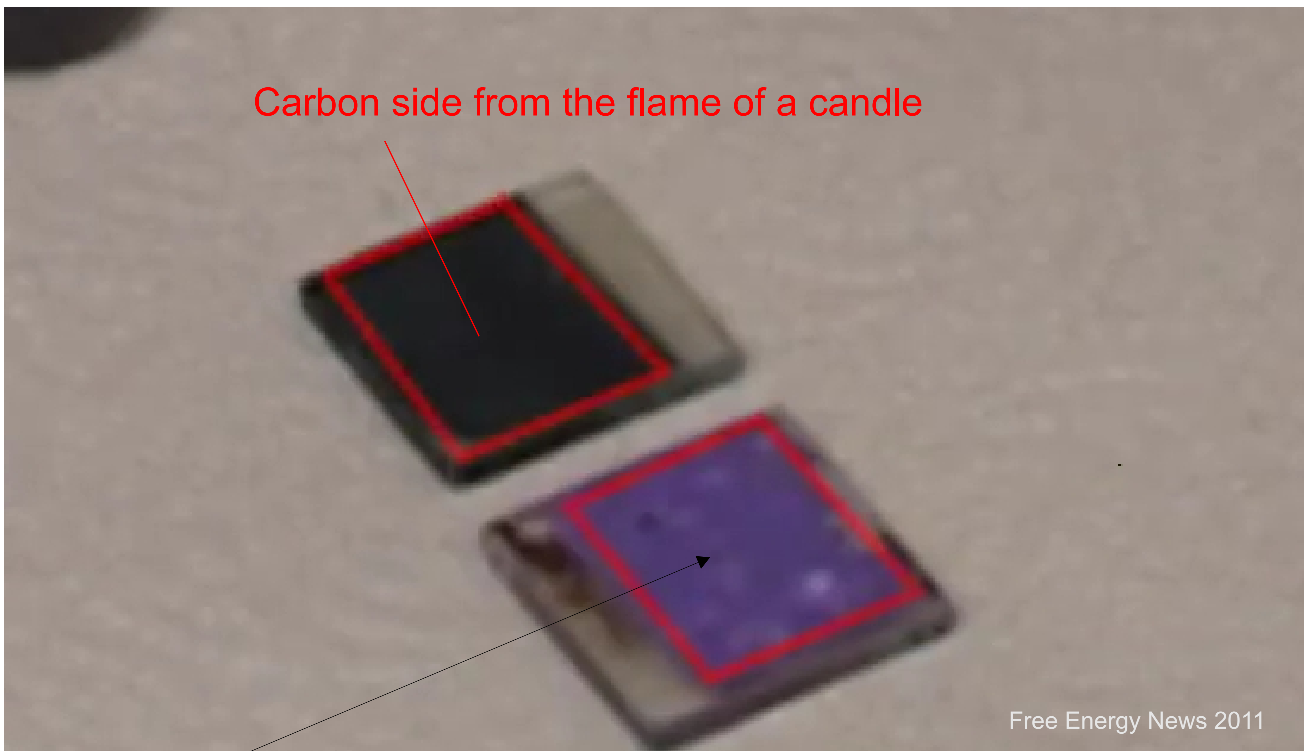

Titanium Dioxide dye side. Both of these will be placed together, face to face to make the solar cell, carbon side to the dye side.

Chapter Three

Copper
Solar Cell Technology

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Homemade Copper Solar Cells

As you have already seen, there are many ways to make solar cells. Another way is to make from copper sheeting. The high-efficiency type solar cells you can buy at Radio Shack and other stores are made from highly processed silicon, and require huge factories, high temperatures, vacuum equipment, and lots of money. But Dye sensitive and Copper solar cells as well as screen printed cells can be made at home.

Copper Solar Cells:
If we are willing to sacrifice efficiency for the ability to make your own solar cells in the kitchen out of materials from the neighborhood hardware store, The you can learn to make a working solar cell in about one hour. A copper solar cell is made from cuprous oxide instead of silicon. Cuprous oxide is one of the first materials known to display the photoelectric effect, in which light causes electricity to flow in a material.

Materials you will need

1. A sheet of copper flashing from the hardware store. This normally costs about $5.00 per square foot. You will need about half a square foot.

2. Two alligator clip leads of approximately 12” in length for each solar cell. You want to leave enough slack in the clips so that connections can be made without tipping the solar cell.

3. A sensitive micro-ammeter that can read currents between 10 and 50 micro amperes. Radio Shack sells small LCD multi meters that will do, but I used a small surplus meter with a needle.

4. A small propane torch. But you can use an electric stove, or a small one-burner electric hot plate to heat the copper with. A 1100 watt burner hot plate may be best.

5. Muriatic acid or nitric acid to remove the black oxide from the copper after it is cooled. Or you may not need the acid if you use a burner and let it cool slowly. The black Oxide should fall right off. There are acids that you can buy from a hardware store that work as well.

Homemade Copper Solar Cells

Materials Needed:

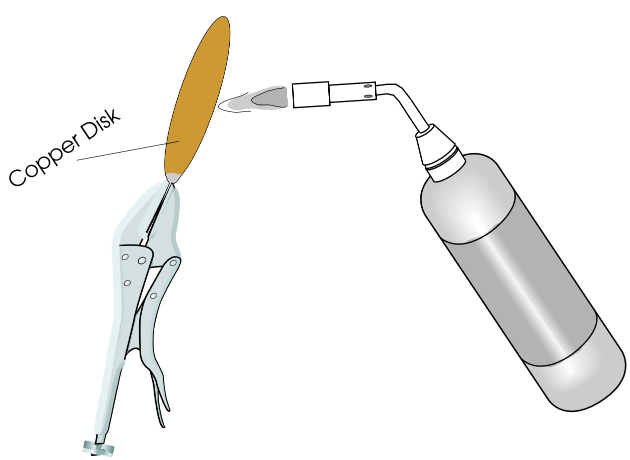
6. A large clear plastic 2-liter bottle that you can cut the top off of to leave a cylinder in which the salt solution and solar cells can be contained. Glass jars will Work as well.

7. Two tablespoons of table salt, preferably NaCl reagent grade. I haven't had the chance to compare regular table salt with reagent grade salt in its effect on solar cell output. Common table salt has minute quantities of NaI and glucose mixed with the NaCl for stabilizing the NaI.

8. A source of tap water

9. Fine grit sandpaper (00)

10. Sheet metal sheers to cut the copper sheeting into the size you need for the solar cell.



Homemade Copper Solar Cells

A small carefully made solar cell of approximately 2 ½”diameter, will produce around 5 milliamperes of current in direct sunlight. This is enough to drive a sensitive light meter or an extremely sensitive replay. By making a bank of these and connecting them in series and parallel you can run small electric motors. Experiment with the procedures described and you may stumble onto a method of making a solar cell that can produce far more then what we have. Be careful, some of the chemicals described here can be dangerous if abused or mishandled. You build at your own risk. We are not responsible for anything in these plans.

There are an estimated 80 trillion kilowatts of solar electrical energy (free energy) available in the northern hemisphere.

Many Different Types of Chemicals Have Photoelectric Properties!

There are a number of elements and chemical compounds that can be used to make a solar cell. They include: Titanium dioxide, selenium, thorium, cuprous oxide, and metals of the alkali group such as, sodium, potassium, rubidium, lithium, cesium and francium.

I think the best substances to use for homemade solar cells are Titanium dioxide, Cuprous oxide and selenium.

You should have no trouble building the copper solar cells described in this chapter. But, be cautious. Use good judgement and common sense in handling the chemicals and heating process described. You will find that a simple solar cell can be constructed by a persistent student. Copper solar cells as well as dye sensitive solar cells can make outstanding science fair projects as well as our Free Energy From The Earth Plans! If you plan on building our Fuelless Engine and Sp500 Generator for a science fair project be sure you do not reveal all our secrets to the open public. If you know of anyone that wants to build and use these devices please tell them to go to our website at: www.FuellessPower.com or our 2nd website at: www.FuellessUSA.com and purchase our plans. Thank you.

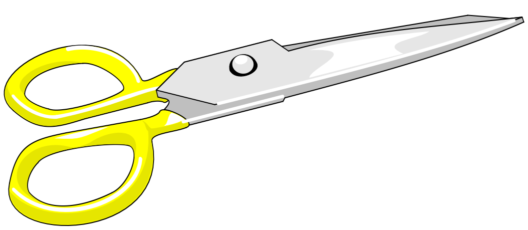
The electrical output from homemade copper solar cells are a bit below that of modern commercial cells, but the cost to make these cells are very low. If you serious about running your entire home, then I would suggest that you build our Sp500 AC or DC Generator the output in amperage and wattage is enormous, compared to solar cell technology! The Sp500 and our Fuelless Engine is not that hard to build. We make it as easy as possible for just about any to learn and build.

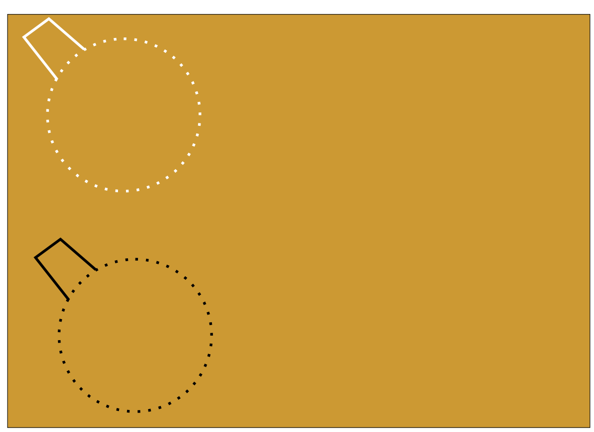
Homemade Copper Solar Cells

Note: The dark red cuprous oxide has photoelectric properties but black cupric oxide does not. The black oxide that forms on the outside of your cell must be removed because it is opaque and will not allow light to reach the cell's active surface.

Building Your Solar Cell

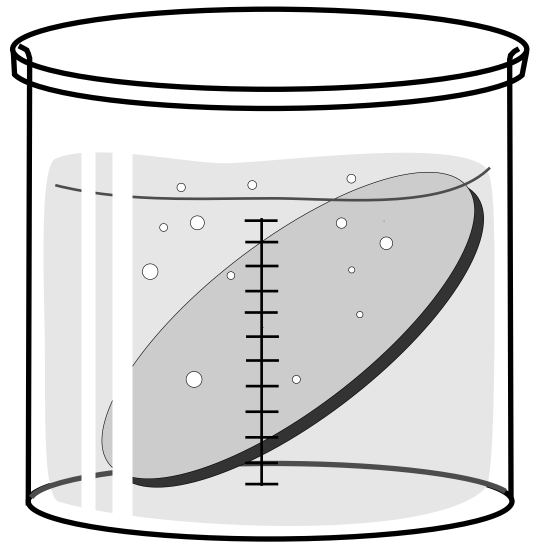
Step 1. Cut a piece sheet copper into the size and shape you wish for your cell. Although .025 inch thick copper was used for the cells described here, just about any thickness will do. Copper is a soft metal and can be cut with tin snips or even with an old pair of scissors. Cut your cell with a diameter of 2 1/2 inches, **You may want to make it 1 inch or less to learn with,** a smaller cell is much easier to work with. The larger the heat source the bigger the size copper you can use to create your solar cell. After you get the hang of it you can then build larger cells. As you cut the copper, be sure to leave a "handle" so that you may grip the cell with pliers without marring the cell's active surface.





Thin Copper sheet

Step 2.
The surface of the cell must be made extremely clean. Prepare a solution of nitric acid or other by carefully mixing 20 parts nitric acid and 80 parts distilled water. Remember to wear protective goggles or other suitable eye protection and to work in a well ventilated area when ever you work with chemicals.



Copper disk, scoured & polished and dipped in acid.

IMPORTANT! ALWAYS ADD ACID TO WATER! NEVER ADD WATER TO ACID!

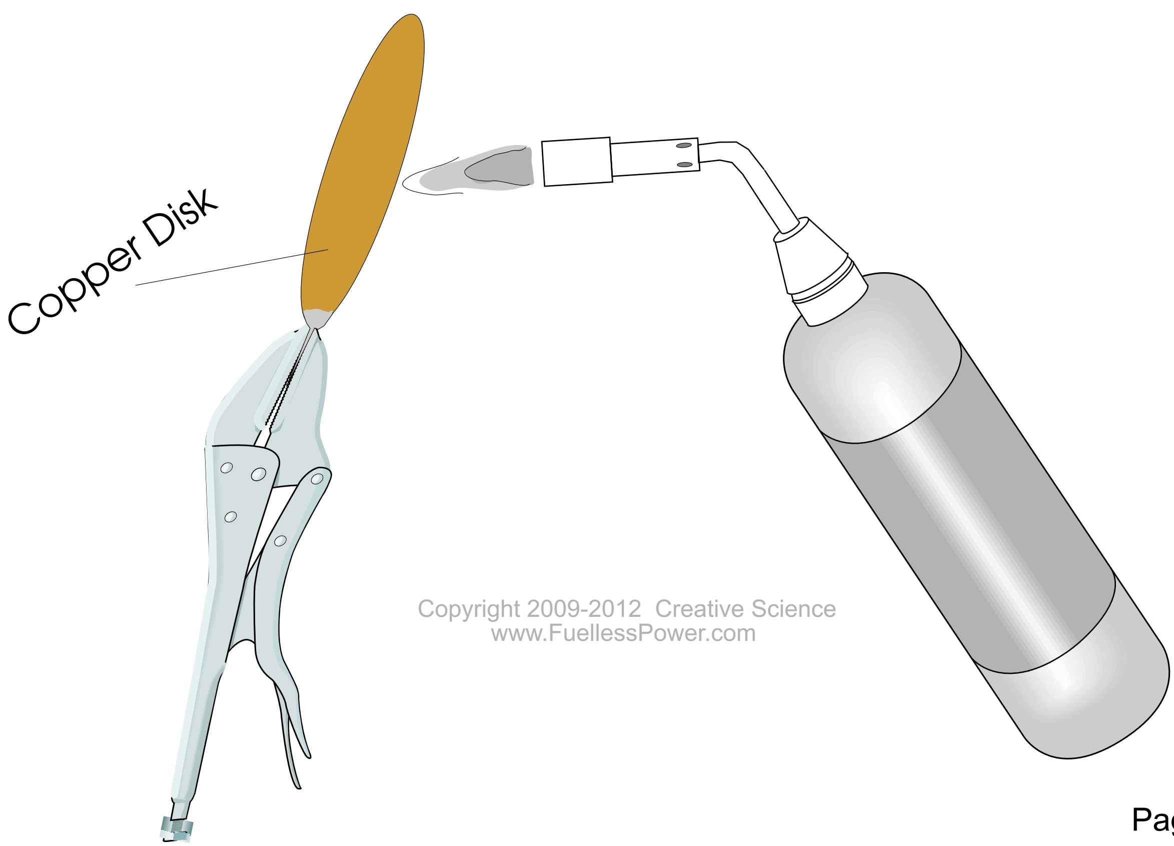
Begin by carefully polishing the face of the cell with a fine grade of steel wool until it shines brightly. Then place the cell with the shiny side up, in the solution of nitric acid.
Soon, tiny bubbles will form on the copper disk. Stir the solution occasionally. When the disk seems shiny and well cleaned, remove and rinse it under cool running water.
WARNING! Never to allow your skin to touch the acid, and that no acid remains on the cell. The cell will sometimes work without the acid cleaning if it is simply well polished by the steel wool. However, we strongly recommend the acid cleaning. Nitric acid and the other chemicals mentioned in the text can be easily ordered online at number of chemical supply companies.
Clean - rinse off the acid with water.

Step 3. The cuprous oxide is now formed on the disk by heating it over a Bunsen burner, or propane torch. A gas stove can be used, but results may be unpredictable. The amount of time the disk must be heated varies greatly depending on the heat of the torch, and the thickness and size of the copper piece. Using a standard propane torch from the hardware store and a disk of the described size, I found 2 minutes and 40 seconds to be ideal. If you heat it too long, you run the risk of burning off the oxides. Heating for to short a time may prevent the oxides from forming fully.

Homemade Copper Solar Cells

The copper is heated on one side only until it is glowing red hot! Again copper must be kept at an even exposure to the flame all over it's surface for about 2 minutes and 45 seconds by moving the copper over the torch in a round motion. The side of the cell that is not exposed to the flame will become coated with the black cupric oxide.

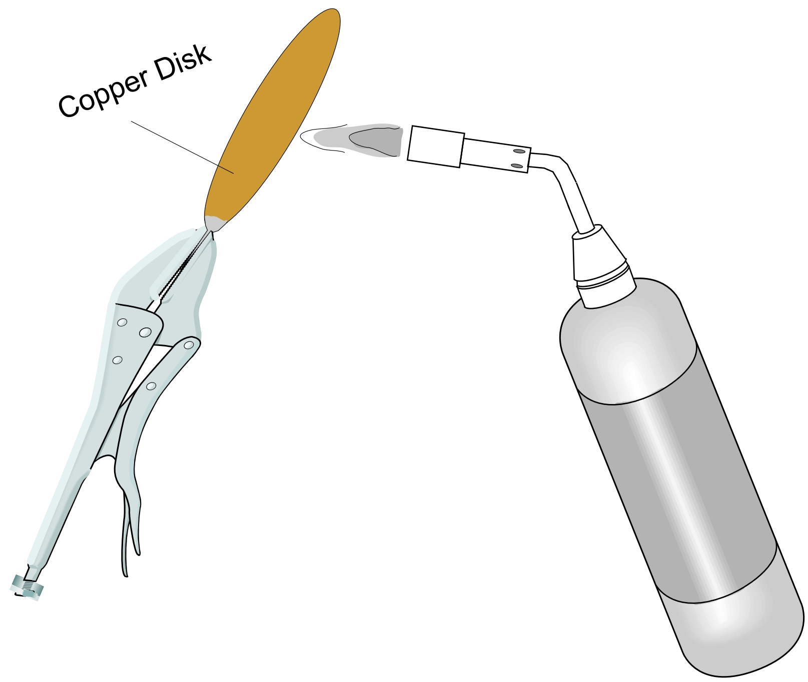
Now just beneath this black oxide is the photo sensitive red cuprous oxide. This red cuprous oxide can be purchased in powder form and mixed with a liquid solution and heated. The oxide can then be applied by a sgeegee or sprayed on, rolled on or screen printed onto the copper surface. After heating your cell for the prescribed time, it must be carefully cooled. There are two ways to go about this. You can cool the copper quickly by either placing it face down on a flat metal surface, or by waiting a few moments and then quenching it in cool water. The advantage to cooling the cell quickly is that the unwanted black cupric oxide will often flake off the cell due to the difference in contraction rates of the oxides. Unfortunately, I have had bad luck with this method despite extensive experimentation with different temperatures and procedures.



Homemade Copper Solar Cells

Step 4

What has worked very well for me is to bring the cell's temperature down as slowly as possible making sure the black oxide does not crack at all. Once completely cool, the cell is immersed in the nitric acid bath. You must wait while the acid begins to dissolve the black oxide. Then you remove and rinse the cell. A very weak solution of sodium cyanide can also be used with good results. However, you should be extremely careful when using it. Cyanide is an extremely poisonous chemical, and if accidentally mixed with an acid can create deadly fumes. At this point the black oxide covering the cell can be rubbed away with steel wool and a little elbow grease. After all of the Black oxide has been removed, your cell should have a uniform coating of deep red on one side.



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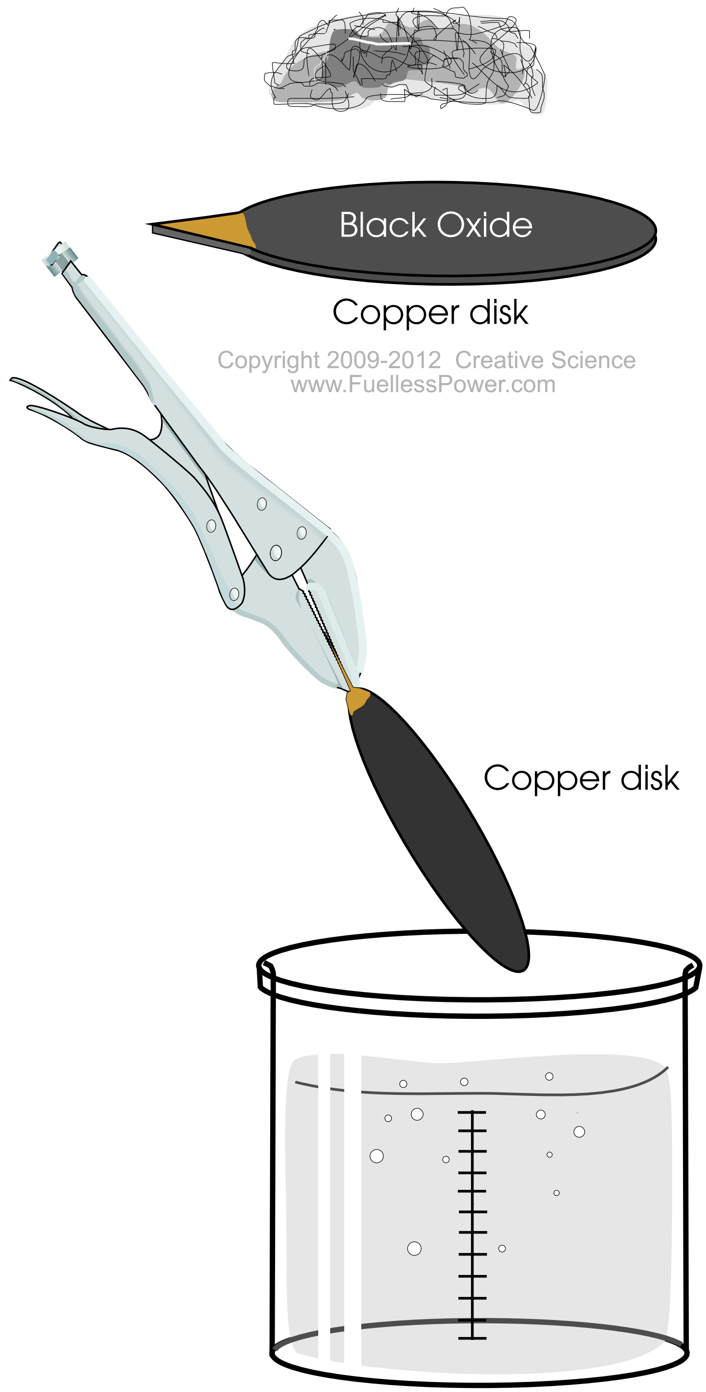
Homemade Copper Solar Cells

Don't worry if the very outside edges of your cell don't have the coating, this is due to uneven cooling and is normal. Keep in mind that the red coating must not be scratched or scraped away to reveal the bare copper plate beneath. If this happens the cell might short in the final step and not work at all.

Step 5 Testing:
There are now several ways that you can test you solar cell. Even though it is not finished the cell is ready to generate power. If you are building the cell for a science fair project or, you may want to stop and use the cell at this point while the cuprous oxide is still visible. If you hold the cell near a source of bright light, a current will be generated between the cuprous oxide coating and the copper plate. The copper will form the positive terminal and the cuprous oxide the negative.

Making contact with the copper portion of the disk is very easy. Simply sand a small bare spot on the back of the solar cell and attach a wire. Attaching the wire and making a good contact with the cuprous oxide is more difficult, it is hard to solder and attach anything to it. But it can be done by pressure gluing or other methods such as described in the dye sensitive solar cells.

Fine steel wool



Nitric acid or other
to remove black oxide

Homemade Copper Solar Cells

Step 6

A method of making a good contact with this large of a surface area is by attaching a wire grid to it. A better way is to apply a very thin layer of silver or gold called a transparent. Or an easily fabricated but temporary transparent electrode can be made from salt water. Or as seen in our chlorine cells, a container glued to the cell and the liquid applied. A solution of salt or acid will conduct electricity and also pass light to the cell. Drip a small amount of salt water on to the center of the cell. Make sure that the water rests only on the red cuprous oxide and does not touch any of the solar cells copper surface or it will short out and will not produce any free electrical energy at all.

Now, attach one wire from a galvanometer or voltmeter using the milliamp or low voltage setting to some exposed portion of the cells copper surface. Usually the back or the edges have some exposed copper. Touch the other meter lead to the surface of the water. The meter will spring to life. Next, bring a bright source of light such as a 100 watt bulb near the cell. The meter should show a smaller voltage as the light approaches. Your cell will produce best in sunlight! The cell is changing some of the light into electricity but is having to counteract the current generated by the saltwater, hence the drop in voltage. The salt water actually acts as an electrolyte and with the oxide generates its own current just as a small battery would. Another way that you can test your cell is by making a wire electrode for the surface. This is done simply by coiling some 30 gauge silver-plated wire or aluminum wire and by holding it against the (cells) cuprous oxide surface with a sheet of glass. A good way is to coil the wire around is to use a cone shaped dowel or other object first in order to make good even spirals. Make sure that the wire touches the cuprous oxide only, and none of the bare copper. You will always have some bare copper around the edges of the cell, so it is best to paint with enamel paint.

By simply attaching one wire of your meter to the silver wire, and one to the cell's exposed copper, you will be able to register a small current when a light is brought near. In this form, the cell can be operated indefinitely and makes an excellent Science Fair Display.

Step 7

Making the silver solution: The final step in making your own solar cell will be to make a permanent transparent electrode. When properly applied, this will give your cell a beautiful semi-mirrored finish and allow you to make electrical contact with the whole cuprous oxide face of the cell. This step is probably the trickiest in the production of the cell. But just as with the last steps, it becomes somewhat easier with practice.

Making the silver solution:

Using distilled water, make ten percent solutions each of ammonia water, potassium hydroxide and potassium sodium tartrate in separate test tubes. A ten percent solution can be created by mixing 10 parts by weight of solute in 90 parts of water. Please remember that the test tubes can become warm or even hot when the water is first added, so be sure to use Pyrex glass test tubes. Also, make certain you have ample ventilation when mixing the ammonia solution. Dissolve in 1 oz. water a single crystal of silver nitrate. The crystal should be somewhat larger than the head of a match. Begin adding drops of the ammonia solution to the dissolved silver nitrate until the water first becomes brown, and then just begins to clear. Add a drop of potassium hydroxide to this solution. Then again begin adding drops of ammonia water until the solution just begins to clear. The solution will remain somewhat cloudy. Too much ammonia in the solution can dissolve the cuprous oxide coating and can damage or ruin the cell. Stir the mixture while adding a single drop of the potassium sodium tartrate solution. The mixture is now ready and should be used immediately.

Applying The Solution

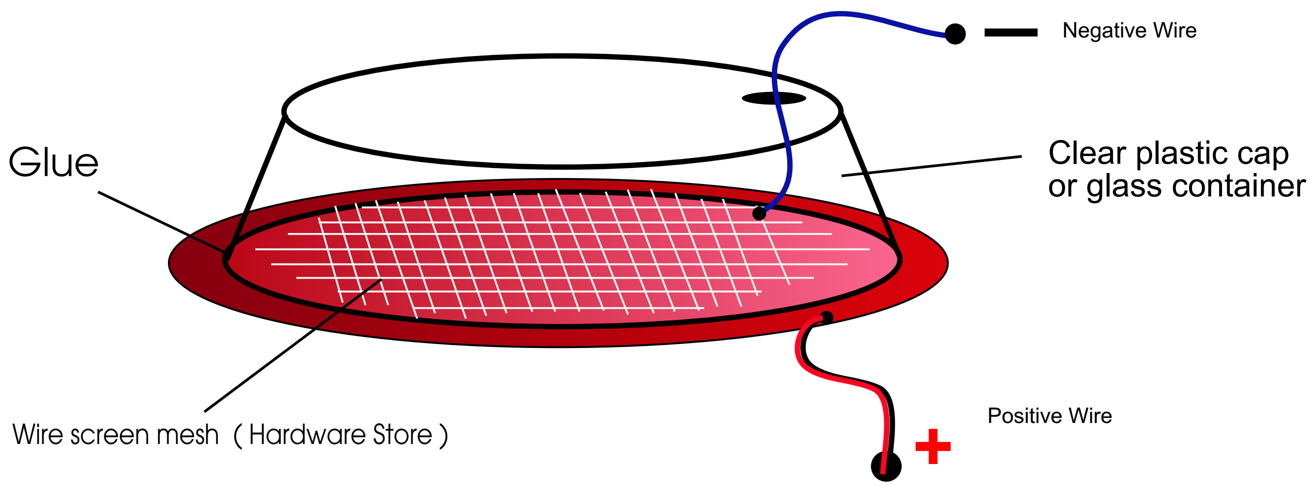
Temperature and variations in the chemical mixture can change dramatically in the time required to complete the silvering process. The best way to complete this step is by simple visual examination of the process as it proceeds. With the cell on a flat surface, begin by carefully pouring the silvering mixture on to the center of the cell. Remember to avoid letting this mixture contact any exposed copper.

Continue pouring until the liquid has covered as much of the surface as you can .
If all the exposed copper on the surface has been properly protected with the lacquer, you can actually pour the solution until it comes right to the edge of the cell. Very soon, a thin film of silver will begin to form over the cell's surface. The liquid should be poured off when the red oxide is still slightly visible beneath the silver. allow the silvering process to go a little too long rather than not long enough since some of the silver coating can be polished away. You should now have a smooth silver coating through which the red oxide is barely visible. It maybe much easier for many people to build our 6,000 watt Sp500 AC or DC Generator again the plans are $70.00 plus $9.95 shipping.

To complete the Solar Cell contact can now be made to the cuprous oxide face of the cell by means of a ring of lead or silver-coated wire which is slightly smaller in diameter than the disk itself. With the ring held firmly against the disk, a protective coating of thin lacquer can be applied. Make certain the lacquer does not come between the wire and the disk. With wires attached to the disk's copper back and the lead or silver ring, the cell is complete. The disk can now be housed behind glass, mounted to a sheet of plastic, cast in a clear resin or housed in any other enclosure you desire!

Option 2

The Copper Chlorine Solar Cell



Cut out a second piece of 2" diameter copper and repeats the steps to heat and prep it (see the previous pages to repeat those steps). After you have heated and removed the black oxide from the copper, clean off all the acid with warm water for about 3 to 5 minutes. Allow the cell to dry. You can now make a cell known as the Copper Chlorine (bleach) Solar Cell. If there are any scratches on the oxide exposing the copper, make sure you paint them all with a lacquer or enamel paint, using a very fine paint brush. If there are any exposed copper areas that will be under the water and bleach solution, the cell will not work, or the voltage and amperage will be lower when exposed to sunlight.

There are many different ways to construct these homemade solar cells, using a bleach and water mixed solution is just one of them. The above drawing shows a wire screen mesh that you can buy at any and hardware store. Using wire mesh makes a much more powerful cell, than just using one strand of wire. Before assembly, attach the wire mesh to the red copper side. Use a small weight in the center of the wire mesh and using clear silicon, glue down the edges, (make sure you don't get any glue in the area where the plastic cap is going to sit.) Now let that sit over night to dry or cure. Now glue on your clear plastic cap or cup onto the red copper side of solar cell. Add pure tap water to test it, or if you like go ahead and add the chlorine bleach solution. Mix 95% water and 5% Clorox bleach.

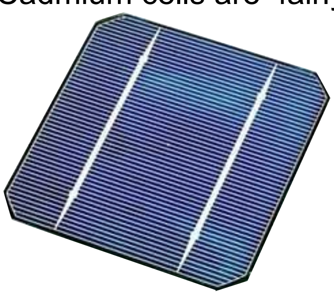
After you have poured in the Chlorine bleach and water solution, then place a copper or steel wire through the hole and onto the bottom. The wire must be submerged in the solution. Now tape or glue the hole up with the wire in it. The copper solar cell is now finished. Now test the cell in the sun using a DC volt meter attach + to the copper or backside of the cell, and negative wire to the steel wire coming out of hole. If using a multi volt meter, set the meter to milliamps or milli volts. You will now see the meter move showing a voltage! Now block the sun with your hand and watch the voltage drop. (If the cell is not working try soldering the copper wire to the steel mesh).

These solar cells make a great science fair project! Adult supervision is required.

A Cuprous Oxide Solar Cell
You can buy cuprous oxide (Cu^O) powder from a online chemical supply company. You maybe able to mix this powder in the same way as you would titanium dioxide powder for dye sensitive cells. I am also wondering if black berry juice could be applied to this as well. Never tried it yet, but if you do please let us know your research results. Cuprous oxide (Cu^O) power is redish brown in color.

Another material you may want to experiment with is Cadmium Sulfide!

Cadmium sulfide is probably the most promising low-cost solar cell second only to silicon. If you have an interest in electronics, you will undoubtedly recognize cadmium sulfide (the common "CDS" cell) as the material used in light detecting circuits. Although inventors have realized for some time that a number of materials such as cadmium sulfide change their electrical resistance in the presence of light, it has only been in fairly recent times that it was realized they could also be used to generate power also. The most important attribute of cadmium sulfide is that it could be mass-produced efficiently using a thin-film procedure wherein very thin layers of its photosensitive components are evaporated onto a base metal or screen printed. Cadmium cells are fairly efficient (3-5 typical) making them a good rival for amorphous silicon cells.



Selenium found in its natural form.

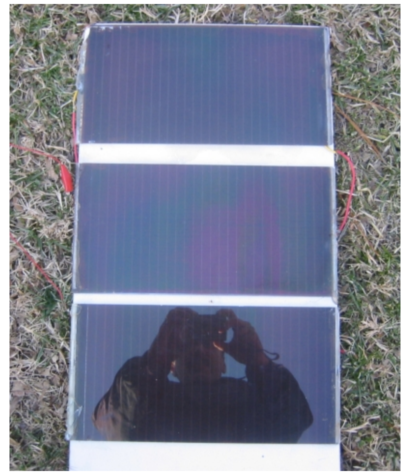
Selenium Makes More Efficient Solar Cells?

Selenium was also used extensively in the production of commercial solar cells before silicon. Although it can be somewhat difficult to find a supplier and it is a toxic heavy metal, it is relatively inexpensive and can often be found in old model radio sets, where it was used in the rectifier of the power supply. A selenium photocell is made from a metal plate (usually iron) with one side being covered with a layer of selenium. A very thin layer of silver or gold is spattered over the selenium layer forming a layer of current carrying material that allows light to pass through it. This layer is called a transparent electrode. A metal electrode called a collector, rests on the gold or silver near the edge of it. Wires are attached to the collector and the iron plate to deliver the electric current to the load. Although not as great an output as more modern cells, a selenium photocell can produce as much as eight milliamperes for each square inch of surface area exposed to bright sunlight.

A team at the Lawrence Berkeley National Laboratory in Berkeley, California, embedded selenium in zinc oxide, a relatively inexpensive material that could be promising for solar power conversion if it could make more efficient use of the sun's energy. The team found that even a relatively small amount of selenium, just 9 percent of the mostly zinc-oxide base, dramatically boosted the material's efficiency in absorbing the light. Natural sources of selenium include certain selenium-rich soils, and selenium that has been bioconcentrated by certain plants. Anthropogenic sources of selenium include coal burning and the mining and smelting of sulfide ores.

Turning Sunlight Into Electricity!

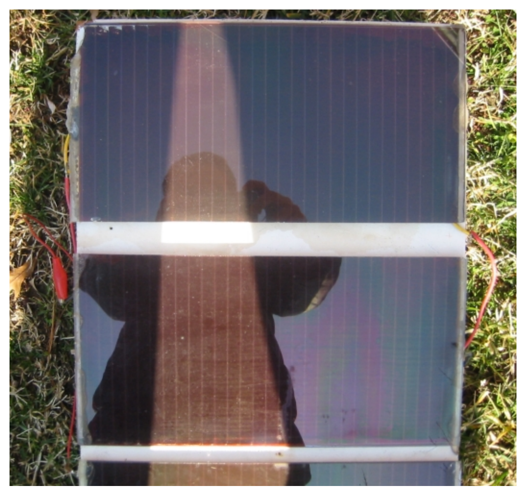
Solar Cells convert light energy into electricity at the atomic level. It was first discovered in 1839, the process of producing electric current in a solid material with the aid of sunlight wasn't truly understood for more than a hundred years. Through out the second half of the 20th century, the science has been refined and process has been more fully explained. As a result the cost of these devices has put them into the mainstream of modem energy producers. This was caused in part by advances in technology, where PV conversion efficiencies have been improved.



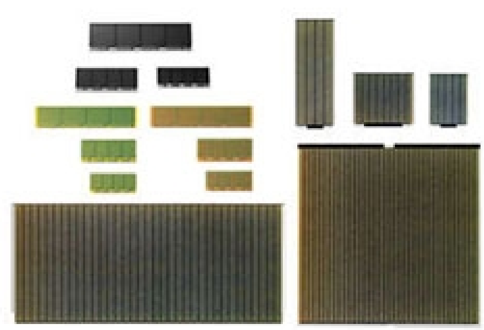
12” x 18” 12 vdc
Screen Printed Solar Cells

Solar Cell Materials

The most important parts of a solar cell are the semiconductor layers, this is where the electron current is created. There are a number of different materials available for making these semiconducting layers, and each has benefits and drawbacks. Unfortunately, there is no one ideal material for all types of cells and applications. In addition to the semiconducting materials, solar cells consist of a top metallic grid or other electrical contact to collect electrons from the semiconductor and transfer them to the external load, and a back contact layer to complete the electrical circuit.



Then, on top of the complete cell is typically a glass cover or other type of transparent encapsulant to seal the cell and keep weather out, and a anti-reflective coating to keep the cell from reflecting the light back away from the cell. A typical solar cell consists of a cover glass, a anti-reflective layer, a front contact to allow the electrons to enter a circuit and a back contact to allow them to complete the circuit, and the semiconductor layers where the electrons begin to complete there voyages!



Chapter Four

Screen Printed Solar Cell Technology

CREATIVE
401
SCIENCE NEWS

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Screen Printed Solar Cells

A Screen printing press, the wood frame is the screen

Scientists in Arizona are using screen-printing, a technique developed for printing fabrics, paper and to produce plastic, glass and metal solar cells. The basic materials of a photovoltaic cell (solar cell) are inexpensive. The organic manufactured by Ghassan Jabbour and colleagues at the University of Arizona in Tucson have about 11/4 of the efficiency of commercial silicon solar cells, which turn 10-20 per cent of light energy into electricity. But, being cheap to produce, they can make up the loss in quantity what they lack in quality. Now the Japan screen printed solar cells are even better than that!

For more info contact: Matsushita Electric Industrial co. LTD, Osaka. Japan

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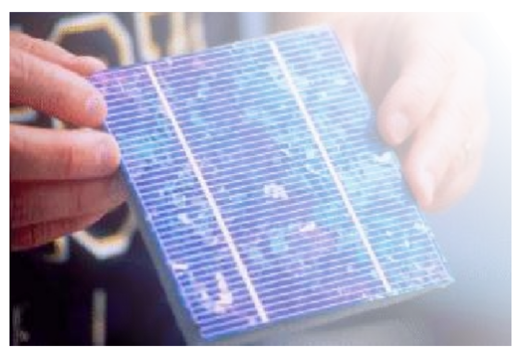
In conventional Screen printing, a taut piece of screen mesh fabric is stretched over a wood frame, you can buy the screens already made and the materials from any screen printing shop or screen printing supply company in your area or on the internet. You may also want to check with your local art store, sometimes they have screen printing kits. The screen is then masked off using masking tape, For example: a 5" x 5" square area. the screen outside of the masking tape is then coated with a block out liquid or paint, this is so when you apply your semiconducting ink that you mix, it will go through just the area that you masked off when you apply a rubber squeegee to it. The screen can then be placed on any table top and hinges attached to the back of the wood frame and the table, this will insure the screen can move up and down. Then get a small wood paint stick and using a small nail, hammer one end to the front side of wood frame. This will be your kick leg and will help keep your screen in an upward position when needed.



An example of a Silicon cell

Take a 5" x 5" piece of glass and place it right under the open 5" x 5" area of the open screen mesh. When the leg is flipped back the screen comes down and you grab your rubber and wood handled squeegee and with the ink in front of your rubber squeegee pull toward you applying pressure so ink will go through screen, once you have passed by the 5" x 5" area then flip the screen back up and reverse squeegee to flood the screen for the next print.

Screen Printed Solar Cells

The Japan Made Solar Cell US Patent

This is a unique method of manufacturing your own solar cells. Some of the chemicals used are hazardous. But if it is handled with care and caution you could produce your own screen printed solar cells right in your own garage. First a layer of n-type compound semiconductor is formed, then a layer of p-type semiconductor compound is formed or screen printed with electrode layers onto a glass. Please Note: these plans are not step by step like our Fuelless Engine and Sp500 Generator plans, therefore it is advised to carefully study the US Patent that we have provided later on in this chapter. Screen printing your own solar cells can be done at home if you are careful. About four months ago we receive a call from an elderly man which purchased our solar cell info and US Patent. He said he successfully learned how to screen print solar cells using the US patent information that we provided. He said he went on to make as many solar cells as his heart desired.

One of the steps of forming a layer of the compound semiconductor, is by preparing a paste which can be mixed with a semiconductor raw material and a viscous agent, having a thick, sticky consistency between solid and liquid = having a high viscosity. Now the paste is then applied to the glass. Right after a print is made, the printed glass is placed onto the homemade vibrator to vibrate any and all air bubbles out of the ink. This greatly improves the solar cells efficiency! The paste or screen printed past or ink is then dried to harden it.

You may be able to use an outside grill to bake or heat cure the screen printed layers. It is a good idea to make the solar cells about 7" x 7”. We may want to try placing the cell inside a large roasting pan, and then put the roasting pan inside a preheated grill and shut the lid.

Once you successfully print one working solar cell it will be much easier to make hundreds more. We suggest that you bake or heat cure these cells outside. You don't want any fumes in the house. An outside grill maybe the best and most readily available oven there is.

The US Patent calls for heating them or baking them in a nitrogen atmosphere. I am not sure, but you may want to first try it without the nitrogen. But, if it looks like you do need it, you may be able to get nitrogen from a gas companies that makes speciality gases. Look online or in your yellow pages phone book. You maybe able to make nitrogen yourself. Nitrogent is a nonflammable gas.

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February 10, 2011

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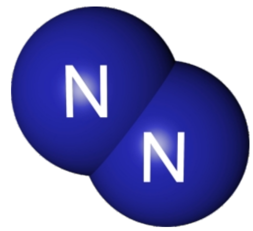
NITROGEN Specifications



Scientific Grade - Min. Purity 99.9995%
O_2 <0.5 ppm
H_2O <1 ppm
$CO + CO_2$ <2 ppm
THC <0.1 ppm
H_2 <1 ppm

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THC <0.5 ppm
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THC <0.5 ppm

Oxygen Free - Min. Purity 99.998%
Certified oxygen content <0.5 ppm

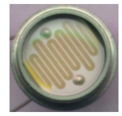
Prepurified Grade - Min. Purity 99.998%
H_2O <5 ppm
O_2 <5 ppm

You can buy nitrogen in refillable containers. Or one time use containers.

7
N
Nitrogen
14.0067

Atomic Number: 7
Atomic Weight: 14.0067
Melting Point: 63.15 K (-210.00°C or -346.00°F)
Boiling Point: 77.36 K (-195.79°C or -320.44°F)
Density: 0.0012506 grams per cubic centimeter
Phase at Room Temperature: Gas
Element Classification: Non-metal
Period Number: 2 **Group Number:** 15 **Group Name:** Pnictogen

Nitrogen was discovered by the Scottish physician Daniel Rutherford in 1772. It is the fifth most abundant element in the universe and makes up about 78% of the earth's atmosphere, which contains an estimated 4,000 trillion tons of the gas. Nitrogen is obtained from liquefied air through a process known as fractional distillation. Nitrogen gas (N_2) makes up 78.1% of the Earth's air, by volume. The atmosphere of Mars, by comparison, is only 2.6% nitrogen. From an exhaustible source in our atmosphere, nitrogen gas can be obtained by liquefaction and fractional distillation. Nitrogen is found in all living systems as part of the makeup of biological compounds. The French chemist Antoine Laurent Lavoisier mistakenly named nitrogen azote, meaning without life. However, nitrogen compounds are found in foods, organic materials, fertilizers, etc. Nitrogen, as a gas is colorless, odorless, and generally considered an inert element. As a liquid (boiling point = minus 195.8oC), is similar in appearance to water. Nitrogen gas can be prepared by heating a water solution of ammonium nitrite (NH_4NO_3).



Example of a small Cadmium Sulphide solar cell

Supplies you may need

1. Cadmium Sulphide in powder form = Cds
   http://www.2spi.com/catalog/chem/cadmium-sulfide.shtml

2. Cadmium Chloride + Cdcl 2 (Powder or liquid form)
   Http://www.labexpress.com/

3. Propylene glycol + pg in liquid form Http://www.labexpress.com/

4. Carbon Powder: If you can not find none make your own wood carbon powder or try using Activated Charcoal from a health food store.

5. Cadmium = Cd Http://www.labexpress.com/

6. Tellurium = Te Http://www.labexpress.com/

7. Silver powder
   http://www.saltlakemetals.com/Silver_Powder.htm

   Borosilicate Glass: 7” x 7” or you can try any size you wish to experiment with. This is a special heat resistant glass, also known as barium borosilcate glass. This glass is very popular and widely used in, Solar cells, Cooking supplies, such as tea pots, etc... oven ware, fireplace glass doors. It is also found in aquarium heaters. You maybe able to buy this special glass at a glass supply store in your area, If they do not have it in stock, I am sure they can order it for you.

8. Qty- 3 Glass beakers: For mixing the solar cell inks.

   Glass stir sticks

9. A vibrating table: This is for laying the printed cell on after printing to get the air bubbles out of the print before drying or heating. You can buy them already made or build your own. You can also buy a vibrating motor at: www.historystones.com
   Phone: 360-834-7021

Glass Beaker

Silver Powder

Vibrating Motor from www.Grainger.com
Grainger Item # 2PUX4 $40.00 USD

Free energy news

This is a homemade vibrating table made by Historystones.com, very easy to make they also sell the motors. See photo’s next page. This company makes stone figures. They use their vibrating table to get all the air bubbles out of the concrete. In our case it would be the solar cell inks.

Http://www.chemistrystore.com

Anti-Pirate Customer ID # 40127001

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SCIENCE NEWS

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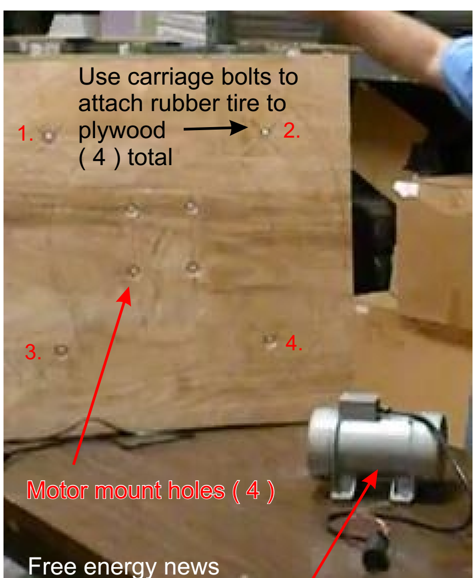
Make your own vibrating table

Very important in the making of solar cells! To remove air bubbles in solar cells after printing and before drying or heat curing.

Old Rubber Tire

3/4"plywood attached to tire

Variable resister / motor speed controller
You can buy these at hardware stores or online. Www.Grainger.com



Vibrating motor

Contact www.historystone.com or see their youtube video

Cadmium Sulphide (CdS)

Cadmium sulfide is the inorganic compound with the formula CdS. Cadmium sulfide is a yellow solid.[2] It occurs in nature with two different crystal structures as the rare minerals greenockite and hawleyite, but is more prevalent as an impurity substituent in the similarly structured zinc ores sphalerite and wurtzite, which are the major economic sources of cadmium. As a compound that is easy to isolate and purify, it is the principal source of cadmium for all commercial applications. But is a bit expensive. You can try purchasing it from China.

Crystal properties

Crystal growth method:	Seeded vapor phase growth
Crystal growth orientation	(0001)
Maximum size	Up to 50mm diameter
Variations:	Doped crystals (on request)

Crystallographic properties

Crystallographic structure:	Hexagonal
	a= 0.4135nm, c= 0.6749nm
Defects structure	Inclusions with < lOu. in size
Color:	Red

Physical properties

Density:	4.82 g/cm3
Melting point:	1748 °C
Hardness:	4 Mohs
Thermal conductivity:	15.9 W m -1 K-1
Dielectric constant:	8.28 C, 8.64 | I C
Band gap (@ 300 K):	2.53 eV
Specific resistivity:	~108 (Ohms cm)
Emmission wavelength:	600 nm @ 300 °K

Optical properties

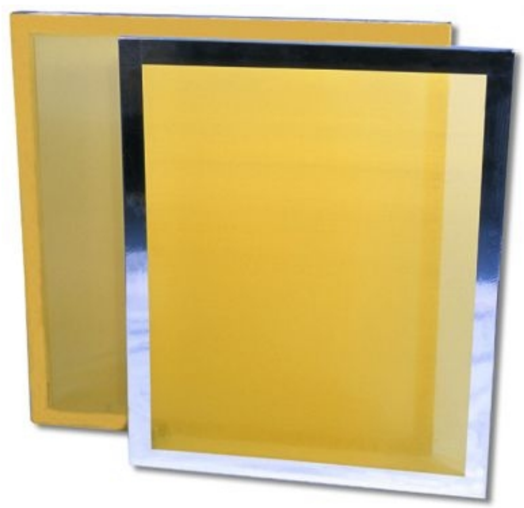
Transmission range:	0.5 um -15 urn (2mm thick)
Refraction index:	No = 2.517, Ne = 2.548

Screen printing supplies you will need!

You can buy all your screening printing supplies at:
www.advancedscreenprintsupply.com Phone 1-877-509-7600

or www.printersedge.com or www.gogsg.com

Qty- 1 Sgueegee
For moving and pressing the ink through the screen mesh and solar stencil design onto the glass or other.



Qty- 2 20” x 24”Aluminum
Screen printing frames, 200 mesh
www.printersedge.com or phone:
1-800-467-3343 $15 each

Screen Printing Frame Hinge/Clamps
Qty-2 These are connected to a wooden table and are used to clamp the aluminum or wooden screen frames in place, during printing of the solar cells.

Http://www.enasco.com/product/7200101

$23.00 each

Anti-Pirate Customer ID # 40127001

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Screen printing supplies

www.atlasscreensupply.com Phone: 1-800-621-4173

Photo Emulsion Coater

Photo Emulsion being coated onto a screen

Photo Emulsion

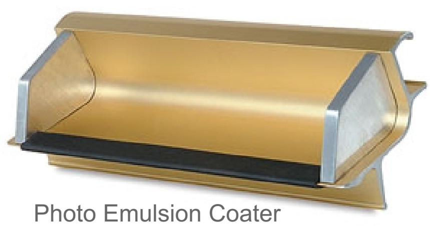


Photo Emulsion Coater

Qty- 1 28 oz of Emulsion or also known as photo emulsion. To apply to screen with a screen coater. Once it is dry you can then apply the amberlith film postitive to the back side of the screen and expose to sunlight or other light source. You then take off the amberlith positive from the screen and wash the unexposed emulsion from the screen using a water hose sprayer. See our Screen printing booklet for more details, or go to youtube.com and type in learning how to screen print.

Qty-1 18” length -Emulsion coater. They are designed for easy and comfortable handling while providing a smooth layer of photo emulsion onto your screen. The coating angle is designed on a perfect angle. It's calibrated to give you a perfect coating of emulsion every time. See our Screen printing plans - learn how to screen print and or our Screen printing video at: www.Fuellesspower.com

X-Acto Knife

The film positive is hand cut by you, using an exacto knife and amberlith or rubylith film. For example cut a perfect 6.5 “ square, then peel all of the outside of the film off leaving the 6.5” square (red amberlith or rubylith). You can purchase these cutting films at any online arts supply store. See Amberlith masking film made by Ulano.

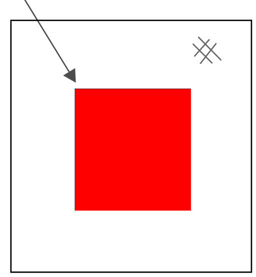
Ulano Aberlith or rubylith

Www.ulano.com/knifecut/masking.htm

Www.hyatts.com/sign/ulano-screenprint-film-3.8714

1-800-234-9288

Aberlith cut to 6.5” x 6.5” = Film positive to be placed on back of screen and exposed to sunlight.



NOTE: You may also want to get emulsion remover in case you mess up and need to redo the screen. You maybe able to use pure bleach to remove the emulsion.

You will need 2 amberlith or rubylith film positives

You can cut this your self using an X-acto knife. You can purchase all of these supplies at most local art supply stores or on the internet. You will need two amberlith film positives as I like to call them. The first positive is for printing the silver contact lines. This can be the first print on the glass or the US patent may have you do it a different way. Study the US patent carefully before attempting to print your own solar cells. Just to let you know, the Cadmium Sulphide is a bit expensive unless you buy it from China in large bulk.

When cutting the amberlith don't use to much pressure on the knife as to cut through the clear Mylar plastic or to dent it much at all with the blade,. You want just enough pressure on the knife to cut through the film only. Once you cut the film you can then begin to pull off all the film that will not be used in the positive. You can do this by taking the knife blade under one edge of the film and lifting up, grab the edge with your fingers and begin pulling the un wanted film up and off of the clear plastic. Cut your first film positive to a 6.5" x 6.5" (inch) square. Then using a ruler, cut 1/16" thick -thin lines into the square as seen in Fig 1. Then make your 2nd film positive as shown in fig 2, with no lines. Make it 6.5" x 6.5" as well. These film positives will be used to make a photo image in the light sensitive photo emulsion that is coated and dried on the screen. Use a thick piece of flat foam board or foam cushing type material to lay on the inside of the screen. Turn the screen over with the foam board in the middle and lay them both flat on a table top. Now place one of the film positives on the back side of the screen using a heavy piece of glass to cover them. This will keep the film positive flat to the screen so the sun will not get under the red film. See figure 3 next page. Lay out in the sun for about 5 to 10 minutes, time varies depending on the type of emulsion and how much sun is out.

Figure 1

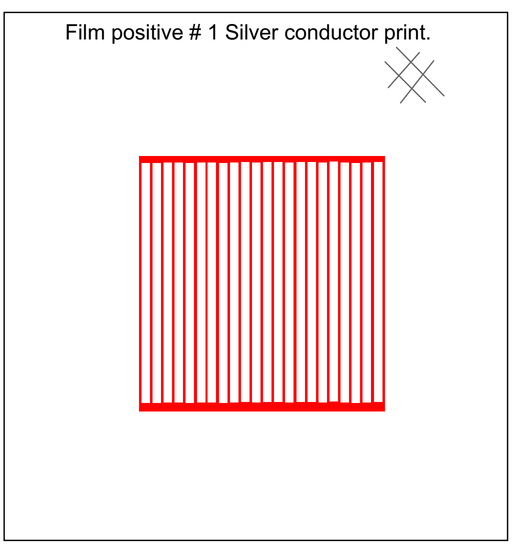
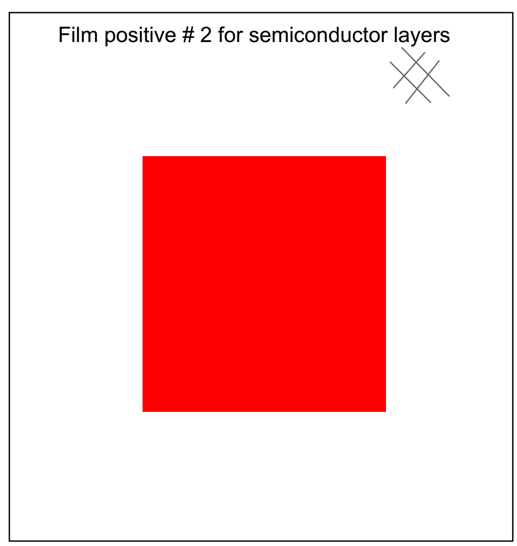
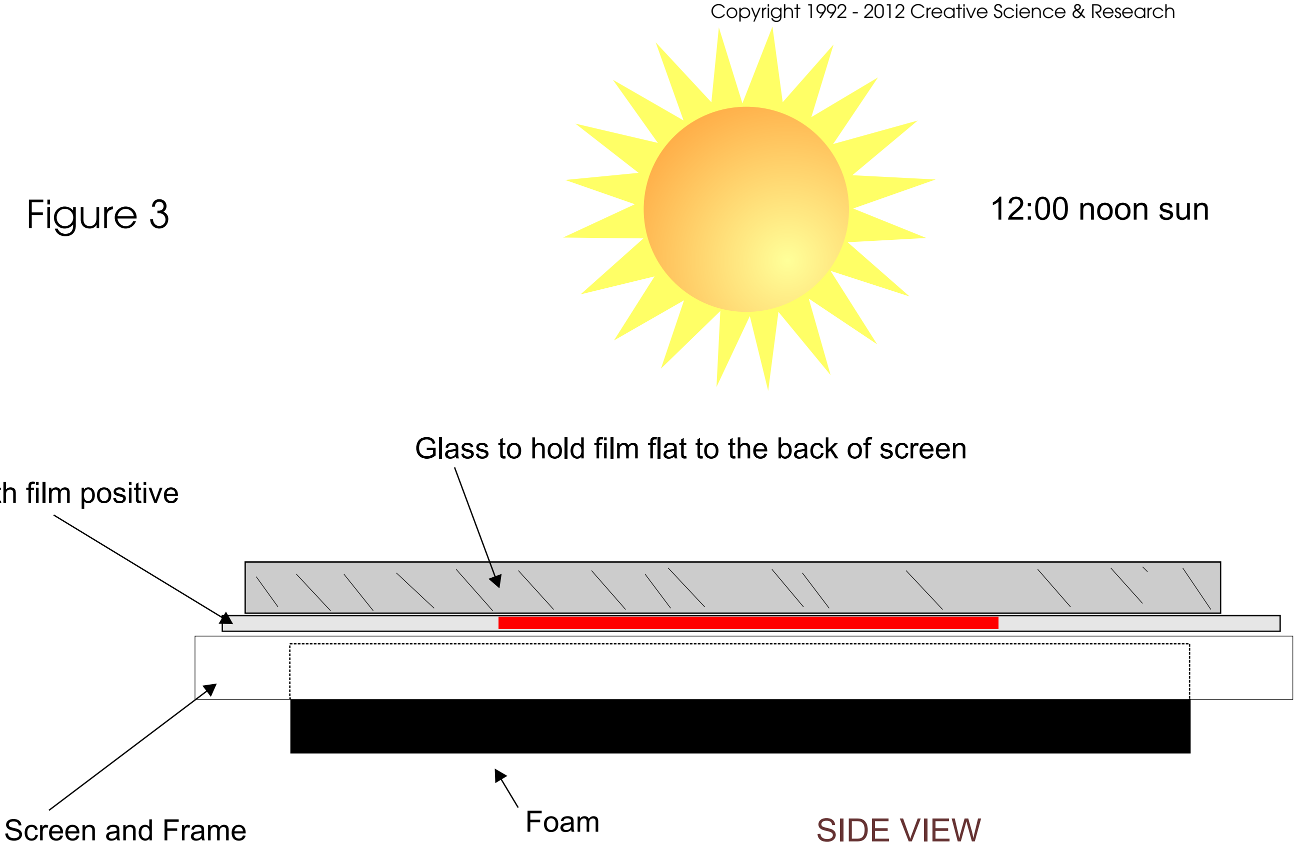


Figure 2

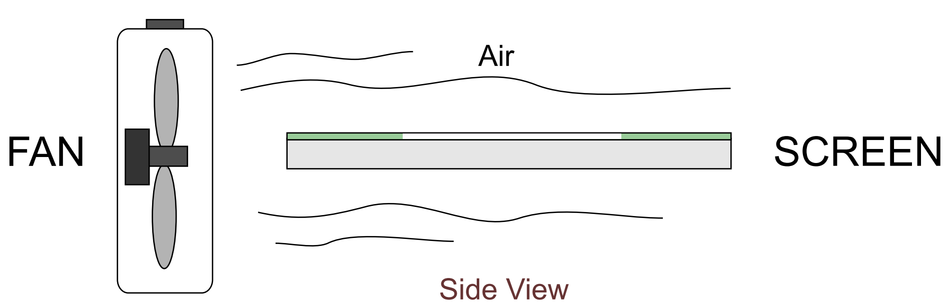


Amberlith cut to 6.5" x 6.5" = Film positive to be placed on back of screen and exposed to sunlight or a strong light source of some kind.

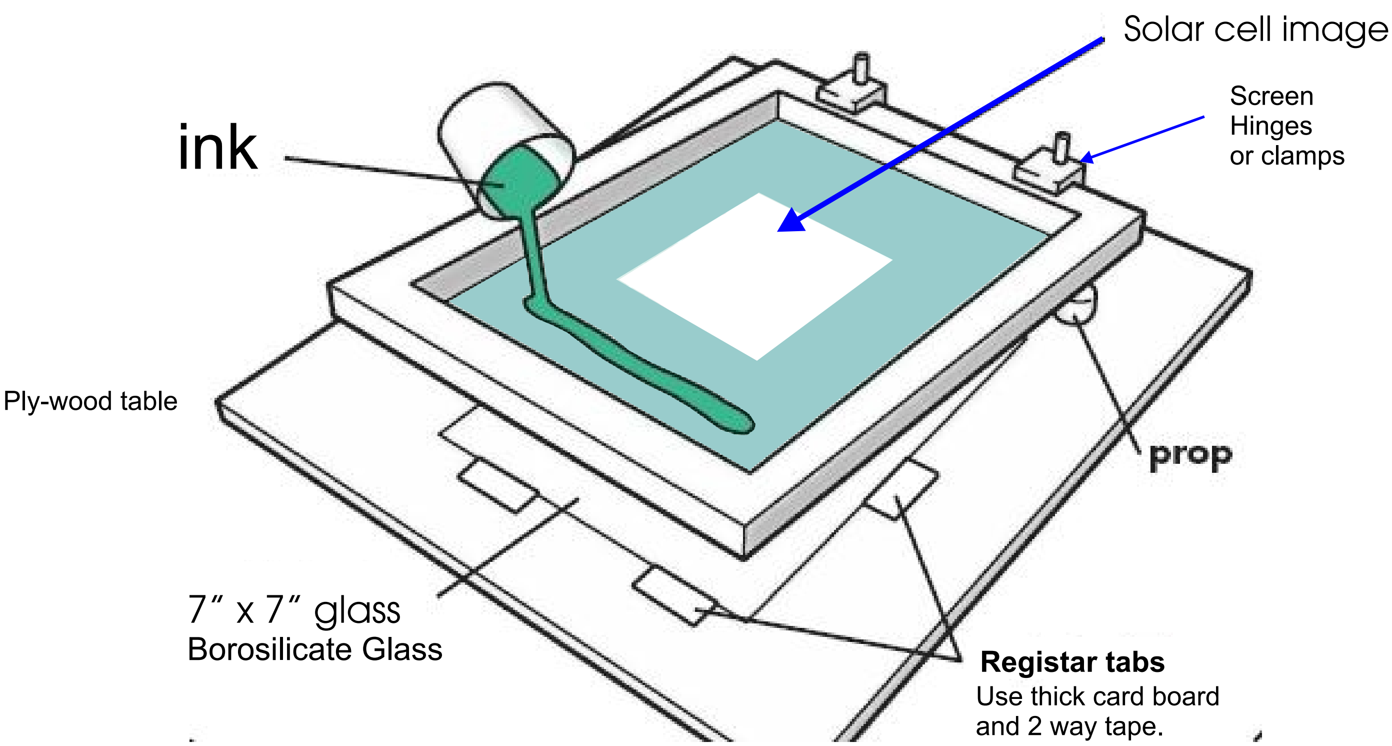


After the screen with the light sensitive photo emulsion is exposed to the sun, you can remove the glass, the amberlith film positive, and the foam board, Then quickly take the exposed screen out of the sun into a low light room a room using a red light bulb. The areas of the screen that were exposed to the sun will be hard and will not wash out with water (unless the screen was under exposed) If the screen was under exposed you may still be able to use it, but only if a few miner pin holes washed out. If the exposed areas washes out more than this, you will need to start all over again. Any pin holes can be filled in later with a brush and some photo emulsion.

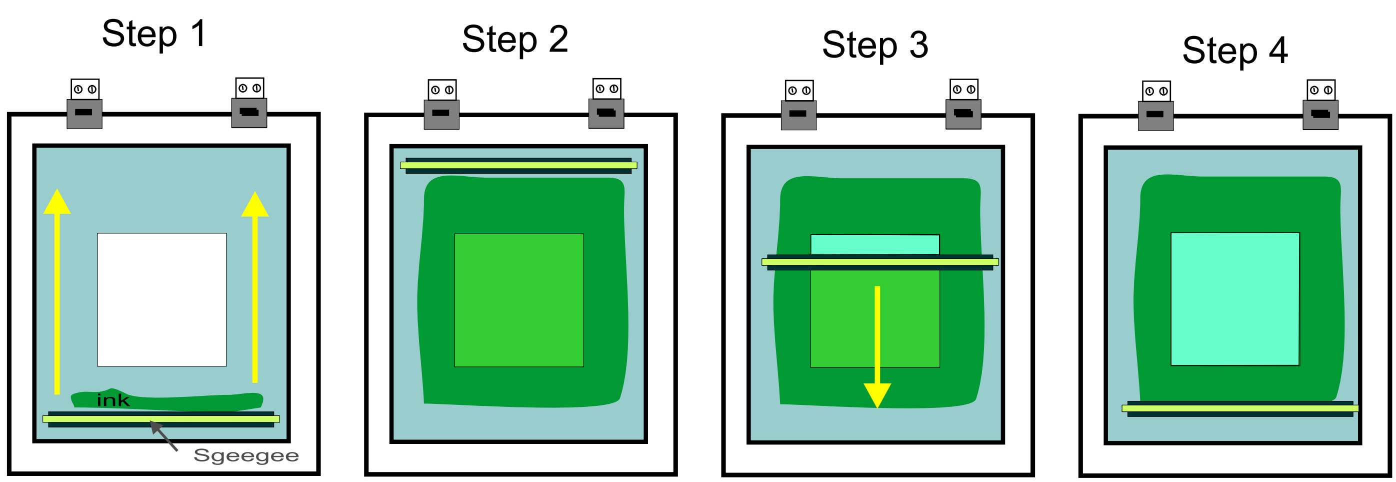
Now the 6.5” x 6.5” area that was not exposed to the sun will wash out with water using a light spraying action from a water hose sprayer. Once you see that all the emulsion from that one area is all washed out. You can now blot the screen dry using newspapers. Start with the back side blot it 2 or 3 times with 3 dry news papers. Now go to the front side and do the same. If the news paper sticks to much to the screen and emulsion, then the screen was under exposed. If it is not to badly under exposed you may be able to set the screen side up into the sun for about 5 to 10 minutes longer. No film positive, foam or glass would be needed at this point. If you have a low powered air compressor, you can blow out the image area with a bit of air to remove any moisture and or minor emulsion left in the area. Use a very low air pressure setting. Place the screen in a horizontal position in front of a fan to let it dry.



A quick example of how a screen printing set up would look like.



See our screen printing video for more details on how screen print.
Order 402V Screen printing video cost $19.95



While the screen is up off of the table. The sgueegee is moved to the back moving the ink over the image. This is called flooding the screen. You can hold the screen up by hand or use a wooden kick stand.

The screen is now placed down flat onto the table and is ready to print on the glass.

Placing both hands on the sgueegee, press down and pull forward. The ink is now being applied to the glass.

The first layer of print is done you can slowly pull the screen upward. If the screen sticks to the glass, it maybe best to add cardboard build up under the frame so the screen will pop away during printing. Remove the glass and place another one into place if you are going to make more than one solar cell.

Screen Printed Solar Cells

The US Patent

Prepare your ink or paste or (Cds) by mixing the fine powder of cadmium sulphide with cadmium chloride (CdC12) with Propylene glycol (PG). You want it to be a creamy paste. If it is to thick it will not go through the screen mesh or will be to hard to print with. If it is to thin it will not print correctly and it will bleed. Experiment with it. Try different thickness's until you find the perfect working thickness. The US Patent is not clear how much cadmium chloride to mix with the cadmium sulphide (no doubt it is a trade secret), I would experiment on your own to find the perfect amounts to mix. Please study the US patent very carefully.


Cadmium Sulphide

www.americanelements.com
Ph: 1-310-208-0551


Cadmium Chloride

www.Hengsource.com
Phone: 086-312-8921375 (China)

Propylene Glycol

www.durvet.com
Phone: 1-816-229-9101

Http://www.makingcosmetics.com/Solvents-amp-Stabilizers/Propylene-Glycol-p152.html

Phone: 1-425-427-9116

WARNING! Before opening and working with any of these chemicals be sure to read all warning notices on handling etc. Make sure the chemical company or Osha supplies you with safety and handling instructions before attempting to work with these chemicals. Wear rubber gloves and protective safety goggles. Use in a well ventilated area. Cadmium pigments are a class of pigments that have cadmium as one of the chemical components. They are highly toxic and can produce cadmium poisoning. Most of cadmium produced worldwide is used in the production of nickel-cadmium batteries, but about half the remaining consumption, is used to produce colored cadmium pigments. The principal pigments are a family of yellow/orange/red cadmium sulfides and sulfoselenides. Cadmium yellow is cadmium sulfide (CdS); by adding increasing amounts of selenium, colors ranging from orange to nearly black (the color of cadmium selenide) can be produced. Cadmium yellow is sometimes mixed with viridian to give a bright, pale green mixture called cadmium green.

Screen Printed Solar Cells

Where does Cadmium come from? CdS

Cadmium sulfide (also known as sulphide). It is also known as the mineral greenockite. It is a hexagonal, yellowish crystal, and is a rare mineral on Earth, and is the only real ore of cadmium. It is a much sought after mineral because of its nice color and crystal habit. Did you know it has the same structure as that of zinc iron sulfide wurtzite? It is an amazing mineral!

The structure of Greenockite is composed of SCd4 tetrahedrons, which are stacked in a layered structure with every other layer exactly the same in an AB AB AB ... hexagonal sequence.

Color is honey yellow, orange, red or light to dark brown. Luster is adamantine to resinous. Transparency crystals are transparent to translucent.

The US Patent

Now lets look at the first page of the US Patent on how to screen print a solar cell.
See the **N** type layer # 2**,** this is what the patent says to print first. Or you could try printing the metal grid lines first onto the glass and then the semiconductor layers. Also please note that you do not have to print on glass if you do not want to. You can print onto a metal surface. If you decide to print on metal instead of glass, then the metal surface would be # 5 then the first print would be # 4, let it air dry and then bake or heat cure at about 600 degrees for 3 to 5 minutes.
Each printed layer can be done this way.

Now returning back to the US patent.
The second print would be # 3, then you let it air dry, then bake in the oven (You may be able to heat cure them on a hot plate). Next you will want to print # 2, let it air dry then heat cure it as well. Now use the printing screen that has thin lines in the image, set it up the same way you did the first screen. Then you must print a metal line over # 2 then let air dry, (you don't have to bake the metal conductive print.) This will be your negative contact, # 5 will be your positive contact. So what the US patent seems to be showing us is to reverse the printing layer steps as is common in many other screen printed solar cells. If you have never seen a solar cell the metal conductive lines can be seen on the front of the solar cell printed on the backside of the glass. This is the way I would do it. I am not sure why the US patent is not doing it that way? You can buy a special metal printing ink or mix it yourself as the patent says. The ink is simply made up of nickel or silver. Nickel is the cheapest should work just fine.

U.S. Patent Jul. 23, 1996 **5,538,903**

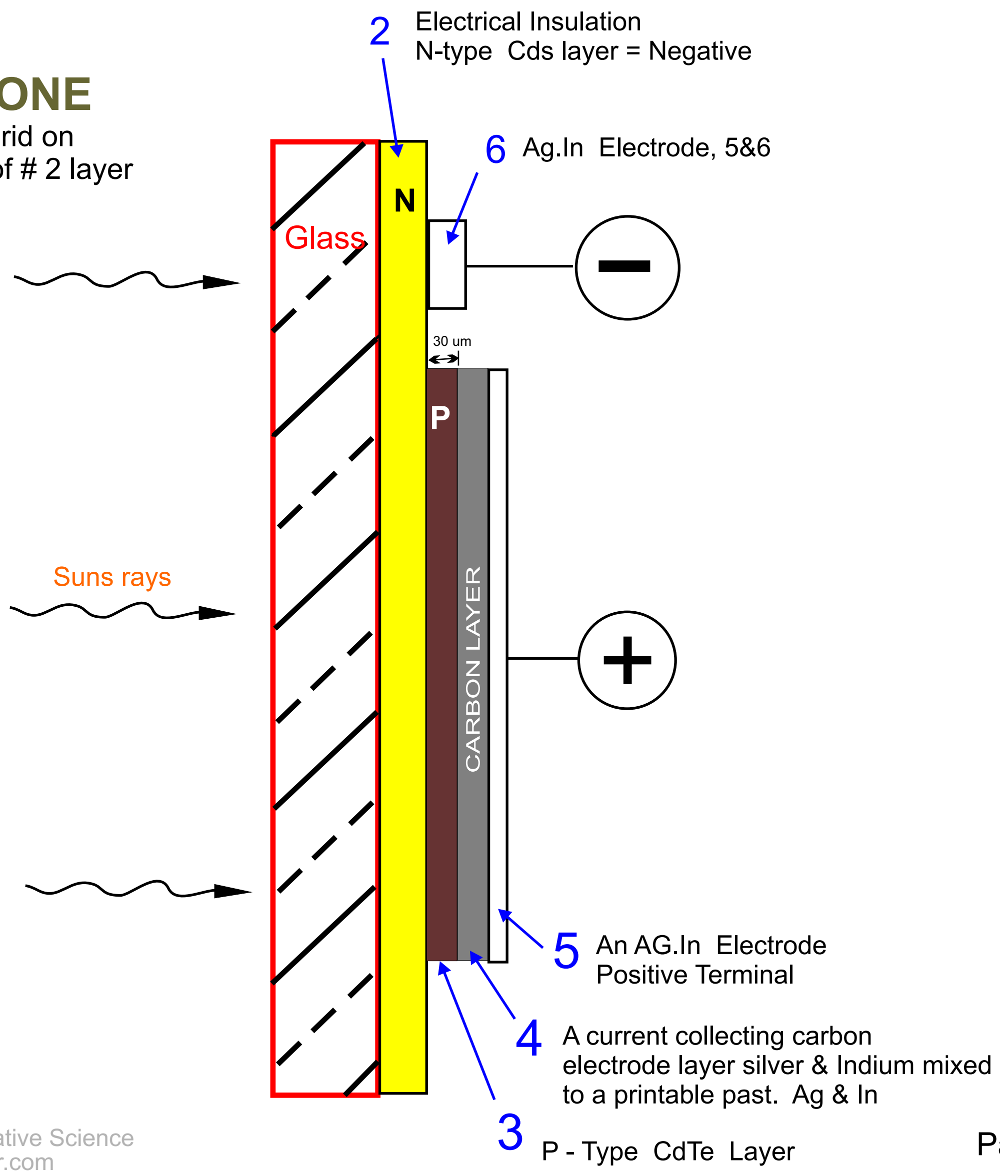
Method of manufacturing solar cell

Abstract

A method of manufacturing a solar cell, comprising the steps of forming a layer of n-type compound semiconductor, a layer of p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor layer comprises preparing a paste by mixing a semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it, and firing the dried paste, and vibrating said substrate during or after the application of the paste, to remove the bubbles in the paste, resulting in a semiconductor layer which is smooth, dense, and having good adhesion, thus realizing a solar cell with improved and uniform characteristics.

OPTION ONE

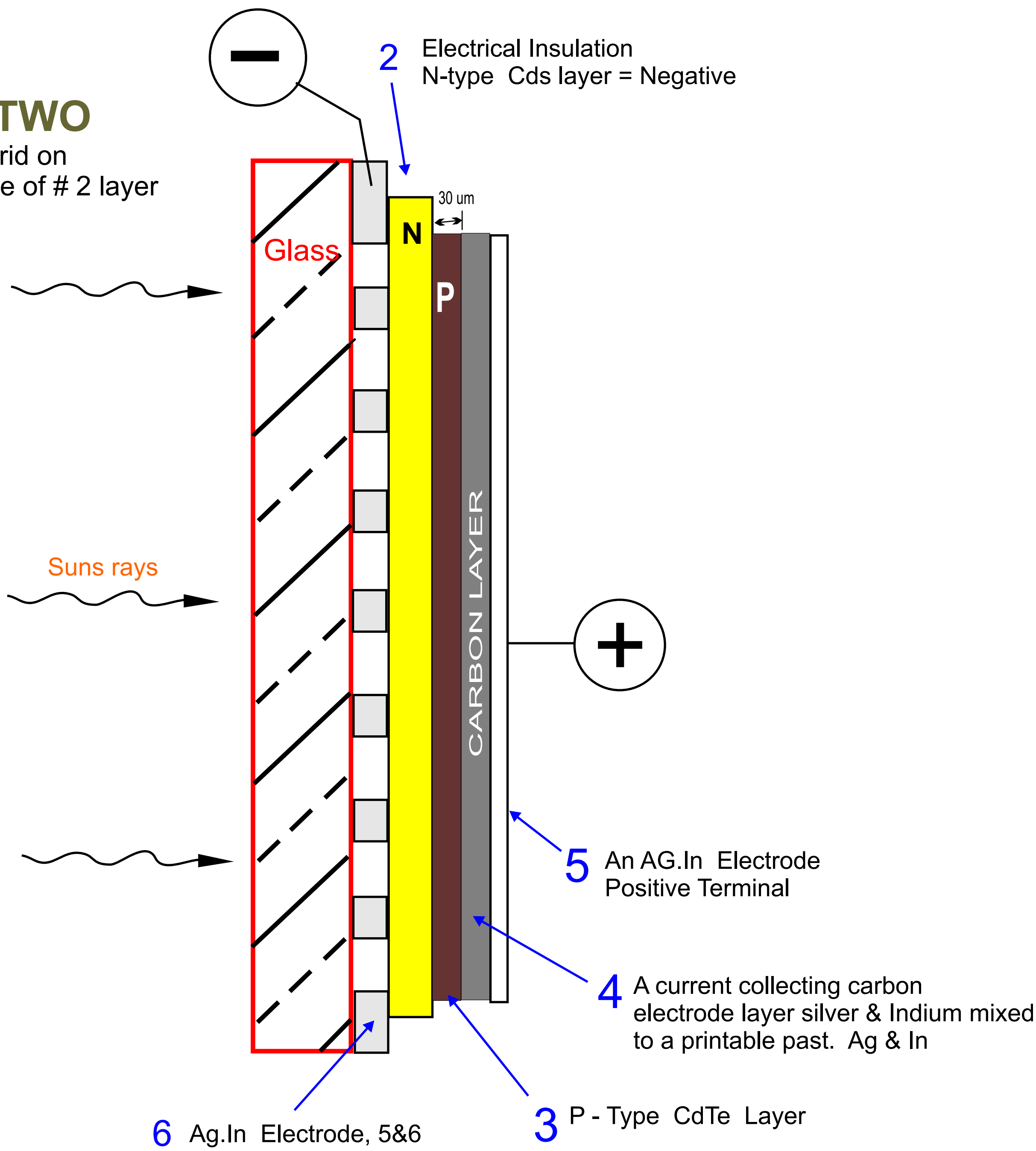
6 electrode grid on the back side of # 2 layer



U.S. Patent Jul. 23, 1996 **5,538,903**

OPTION TWO

6 electrode grid on
the FRONT side of # 2 layer



U.S. Patent Jul. 23, 1996 **5,538,903**

What is claimed:

1. A method of manufacturing a solar cell, comprising the steps of forming a layer of n-type compound semiconductor, a layer of p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor comprises:

preparing a paste by mixing a powdered semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it, and firing said paste, and vibrating said substrate during or after the application of the paste.

2. A method of manufacturing a solar cell according to claim 1, wherein said vibration is of an ultrasonic pulse form.

3. A method of manufacturing a solar cell according to claim 2, wherein the application of the paste is performed by a method selected from the group consisting of screen printing, nozzle printing, relief printing, intaglio printing, and spray printing.

4. A method of manufacturing a solar cell according to claim 3, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

5. A method of manufacturing a solar cell according to claim 4, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

6. A method of manufacturing a solar cell according to claim 3, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and CuInSe.sub.2.

7. A method of manufacturing a solar cell according to claim 6, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

8. A method of manufacturing a solar cell according to claim 3, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

U.S. Patent Jul. 23, 1996 **5,538,903**

9. A method of manufacturing a solar cell according to claim 2; wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

10. A method of manufacturing a solar cell according to claim 9, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

11. A method of manufacturing a solar cell according to claim 2, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and CuInSe.sub.2.

12. A method of manufacturing a solar cell according to claim 11, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

13. A method of manufacturing a solar cell according to claim 2, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

14. A method of manufacturing a solar cell according to claim 1, wherein the application of the paste is performed by a method selected from the group consisting of screen printing, nozzle printing, relief printing, intaglio printing, and spray printing.

15. A method of manufacturing a solar cell according to claim 14, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

16. A method of manufacturing a solar cell according to claim 15, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

17. A method of manufacturing a solar cell according to claim 14, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and CuInSe.sub.2.

18. A method of manufacturing a solar cell according to claim 17, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

19. A method of manufacturing a solar cell according to claim 14, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

20. A method of manufacturing a solar cell according to claim 1, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

21. A method of manufacturing a solar cell according to claim 20, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

22. A method a manufacturing a solar cell according to claim 1, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and CuInSe.sub.2.

23. A method of manufacturing a solar cell according to claim 22, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

24. A method of manufacturing a solar cell according to claim 1, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of manufacturing a solar cell of compound semiconductors by way of coating and firing.

2. Description of the Prior Art

In recent years, expectations for solar cells as a clean energy source have been raised, in view of the global warming, acid rain, ozone layer destruction, and other such environmental destruction. For the wide usage of solar cells to occur, improvement of the photo-electric conversion efficiency and reduction of the cost are most important. that purpose, solar cells made of compound semiconductors of Group III-V materials such as GaAs, InP, Group II-VI materials such as CdS/Cu.sub.2 S, CdS/CdTe, and Group I-III-VI.sub.2 materials such as CuInS.sub.2, CuInSe.sub.2, as well as crystalline and amorphous silicon solar cells, have been investigated in many countries of the world. Among these, solar cells made of compound semiconductor heterojunctions of n-CdS/p-CdTe have been produced commercially, with relatively low material cost, conversion efficiency as high as 10%, less deterioration over long time periods, and a relatively simple manufacturing process suitable for mass production consisting of printing, drying, firing (sintering or baking), resulting in a high density arrangement on a glass plate and realization of high voltage without outer wire connection, as well as large area cells.

A typical solar cell of Group II-VI semiconductor, of which a sectional view is shown in FIG. 1, comprises a glass substrate 1 of high light transmittance and electrical insulation provided on one surface thereof with an n-type CdS layer 2, a p-type CdTe layer 3, a current collecting carbon electrode layer 4, an Ag.In electrode which is the positive terminal 5, and an Ag.In electrode which is the negative terminal 6 formed by laminating with printing and baking of each layer. Usually, although not shown in the figure, the thus prepared solar cell element is provided, on both the Ag-In electrodes, with a copper paste layer deposited, dried, and baked for easy soldering of lead wires. The cell is then covered all over with a passivation layer of a thermosetting resin such as epoxy and baked.

Light, including that of the sun, falls on the surface of the glass substrate 1 opposite to the surface having the above solar cell element layers, to generate electrical power by photo-electric conversion.

As the substrate, a heat-resistant barium borosilicate glass is employed, which has very low alkali metal content and a high softening point.

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In the manufacturing of the compound semiconductor solar cell by the coating and firing method, it is important that each of the n-type compound semiconductor layer, p-type compound semiconductor layer, and electrode layer have uniform thickness, a smooth surface, and no pin-holes. Especially, if the n-type CdS semiconductor layer formed directly on the substrate is uniform, smooth, and non-porous, the adherence of the layer to the substrate is improved, resulting in an increase of the light transmittance, decrease of the sheet resistance, and, further, an increase of the photo-current and improvement of the characteristics of the cell.

Conventionally, to obtain such a layer, a paste made of the powdered compound semiconductor or elements therefor, an eletroconducting agent, and a viscous agent mixed together was kept under reduced pressure to remove bubbles therein and, after the deposition, the substrate was held horizontally at about 50.degree. C., which was lower than the drying temperature of the viscous agent, to reduce the viscosity of the viscous agent and uniformly precipitate the raw material powders in order to obtain a high density layer. However, if the bubbles were removed from the paste before coating, it sometimes happened in the coating process by screen printing that bubbles were introduced from the surrounding atmosphere, resulting in uneven deposition or pin-holes. Also, with the heat treatment only after coating, the raw material powders did not always uniformly precipitate, and the bubbles were not sufficiently removed, resulting in the layer not being flat, or of uniform thickness. The pin-holes left after coating and firing of the layers caused an increase of the sheet resistance. Especially, if pin-holes were formed in the p-type CdTe layer, the carbon particles of the carbon electrode layer formed thereon penetrated into the pin-holes up to the CdS layer under the CdTe layer, causing internal short circuiting or current leakage, fatally damaging the solar cell performance.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new method of manufacturing compound semiconductor solar cells comprising n-type and p-type compound semiconductors and electrode layers having improved performance, uniform characteristics, and low production cost, brought about by formation of the layers without pin-holes and with uniform thicknesses and smooth surfaces.

To obtain the above object, a method of manufacturing a solar cell according to the present invention comprises the steps of forming a layer of an n-type compound semiconductor, a layer of a p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor comprises preparing a paste by mixing a semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it, and firing said dried paste, and vibrating said substrate during or after the application of the paste.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sectional view of a Group II-VI compound semiconductor solar cell of n-CdS/p-CdTe type.

FIGS. 2(A)-2(B) are microphotographs of sections of sintered CdS layers on a glass substrate.

FIGS. 3A-3D are graphs of the open circuit voltages, short circuit currents, fill factors, and intrinsic photoelectric conversion efficiencies of solar cells fabricated according to the present invention, as well as by the conventional method.

DETAILED DESCRIPTION OF THE INVENTION

An example of the method of manufacturing a Group II-VI compound semiconductor solar cell according to the present invention is now explained by referring to FIG. 1.

A paste was prepared by mixing a fine powder of cadmium sulphide (CdS), cadmium chloride (CdCl.sub.2), and propylene glycol (PG), the CdCl.sub.2 being a flux, and the PG being a viscous agent.

The paste was applied to a substrate of barium borosilicate glass by screen printing to form a coating layer of 60 .mu.m thickness.

The glass substrate was subjected to vibration of 20 .mu.m amplitude and 28 kHz ultrasonic frequency by contacting the output end of a piezoelectric vibrator on the outer end of the substrate for 5 seconds, whereby the roughness of the deposited layer due to the screen net disappeared and the bubbles in the layer were removed. The substrate with the vibrated layer was then dried in the atmosphere at 120.degree. C. (PG was removed by vaporization), and sintered at 690.degree. C.

A comparison substrate coated with a CdS layer was fabricated by a similar method but without the application of vibration.

The light transmittance and sheet resistance of the two kinds of samples were then measured and microphotographs of sections thereof (.times.500) were taken. The results are shown in Table 1 and FIGS. 2(A)-2(B).

TABLE 1 - CdS layer formed according to the CdS layer formed present invention without vibration - Light transmittance (%) 63 60 (.lambda. = 0.7 um) Sheet resistance 28 33 (.OMEGA./cm.sup.2)

As is observed in FIG. 2(B), the CdS layer on the substrate prepared without vibration has projections and depressions on the surface, void spaces and/or pin-holes, and the thickness is not uniform. Moreover, it is not sufficiently adherent to the substrate. On the contrary, the CdS layer of the sample shown in FIG. 2(A) fabricated with vibration has few voids and/or pin-holes, uniform thickness, and a smooth surface, fully adherent to the substrate. Numerically, Table 1 indicates improvements of the light transmittance by 5% and reduction of the sheet resistance by 15%. Thus it is expected the CdS layer formed with the vibration would have superior characteristics as the window layer of a solar cell.

Next, Cd.Te paste was prepared by kneading well an equi-mol mixture of cadmium (Cd) and tellurium (Te) powders with addition of CdCl.sub.2 and PG, and the paste was applied in a 30 um thickness on the above CdS sintered layer by screen printing, dried in the atmosphere, and sintered at 620.degree. C., to form a CdTe layer.

Then, a carbon paste, prepared by kneading carbon powder and a viscous agent made of a solution of a resin in an organic solvent was applied on the CdTe layer, to form an electricity collecting electrode 4 on the n-CdS/p-CdTe heterojunction.

Further, the carbon electrode layer 4 and the CdS layer 2 were provided with a positive terminal 5 and a negative terminal 6 of Ag.In by depositing Ag.In paste by screen printing and drying and baking, the Ag.In paste being prepared by kneading of silver (Ag) and indium (In) powders with a viscous agent made of a solution of a resin in an organic solvent.

On the positive and negative electrodes 6 and 5 of Ag.In, copper paste was applied by screen printing, and dried and baked. Further, on the other parts of the cell a passivation layer was likewise applied by printing, and dried and baked, to complete the cell. The sinterings or bakings in the above processes were made in a nitrogen atmosphere.

The following describes the effect of vibration given to the glass substrate when, in the above described manufacturing process of a compound semiconductor solar cell, the pastes made of the mixtures of the respective powdered n-type and p-type compound semiconductor materials, flux agent, and viscous agent were applied to form the n-type and p-type layers and electrode layers on the substrate.

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A: A sample cell fabricated with the semiconductor and electrode layers dried and fired after the application of the paste on the substrate without vibration, i.e. according to the prior art.

B: A sample cell fabricated with vibration given to the substrate only after the application of CdS paste, i.e. no vibration during the other processes.

C: A sample cell fabricated with vibration given only after the application of CdTe, i.e. no vibration during the other processes.

D: A sample cell fabricated with vibration given only after the application of the carbon paste, i.e. no vibration during the other processes.

E: A sample cell prepared with vibration given to the substrate after application of the CdS paste, CdTe paste, and carbon paste, with further drying and firing.

The vibration was given at 20 .mu.m amplitude and 22 kHz frequency for 10 seconds by contacting the output end of the ultrasonic oscillator to the reverse side of the glass substrate; the reverse side being the surface on which the semiconductor layers were not applied. The other conditions were the same.

For the solar cells of these samples, the open circuit voltage (Voc), short circuit current (Isc), fill factor (FF), and intrinsic photo-electric conversion efficiency (EFF) were measured, with the results shown in FIGS. 3A-3D as values relative to the values for sample cell A taken as 1.00.

From the measurements of the sample cell B as shown in FIGS. 3A-3D, it is seen that the vibration after the CdS application has caused, by removing the paste bubbles, smoothing the film surface, and by improvement of the adhesion between the CdS layer and the substrate, resulting in an increase in light transmittance, and a reduction in surface resistance, an improvement of Isc, and, through the reduction of the number of pin-holes at the junction, improvements of Voc and FF.

From the data for the sample cell C, it is seen that the vibration after the Cd. Te paste application has led to the improvement of Voc, Isc, and FF as a result of CdTe grain size or orientation or other improvement in the film quality.

The measurements of the sample cell D show the contribution of the vibration after the carbon paste application to the improvement of Isc, FF, and EFF. It is thought that the contact resistance between the carbon electrode layer and the CdTe layer is reduced by the vibration.

Lastly, from the data of the sample cell E, it is clear that an about 10% increase of EFF compared to sample cell A has been obtained by the combined effect of the vibrations after each of the applications of CdS, Cd.Te, and carbon pastes.

Thus, it is understood that the characteristics of the solar cells are improved by the simple measure of vibrating the glass substrate after the applications of the pastes, without requiring any significant change of the process or manufacturing installation.

The method of application of the various pastes is not confined to the screen printing as referred to in the above examples. Various other methods can be employed; nozzle printing of paste from a nozzle, including printing of a figure in a desired pattern on a glass substrate by adjusting the distance between the tip of the nozzle and the surface of the substrate to change the paint thickness; relief and intaglio printing; and spray printing of paste with a spray gun while shielding the non-printed areas by a mask.

Table 2 shows how the spread of unevenness of the surface (the difference between the maximum thickness and the minimum thickness) and the yields in production change depending upon whether or not the ultrasonic treatment is employed on every layer of the cells. As is observed, by the vibration after the paste application similar effects can be obtained as with the screen printing.

TABLE 2 - Without ultrasonic With ultrasonic treatment treatment Spread of Yield Spread of Yield Printing unevenness (um) (%) unevenness (um) (%) Screen 35 92 8 95 Nozzle 15 85 9 89 Relief 21 72 4 82 Intaglio 26 82 9 90 Spray 18 74 12 91 Instead of vibrating the outer circumference or the outer surface after the application of the pastes as explained above, vibration during printing of the paste may have the same effects.

For the application of such ultrasonic vibration, 5 to 10 seconds are sufficient, so that the application of paste with the vibration and further vibration thereafter of a short time less than 5 seconds is sufficient; therefore substantial elongation of manufacturing time does not occur.

Although ultrasonic vibration given to the glass substrate during or after the pastes of the n-type and p-type compound semiconductor layers and electrode layer were applied was effective, vibration given during or after application of the pastes for the formation of the terminal or passivation layer did not bring about remarkable effects on the cell characteristics.
It is added that the method of the present invention, thus far explained with reference to CdS/CdTe compound semiconductor solar cells, can be applied to the formation of other compound semiconductor layers of solar cells including Group I-III-VI.sub.2 compounds, for example CuInSe.sub.2, in the place of CdTe, provided the layer is formed by coating and firing. As explained above in detail, when a solar cell is fabricated by forming a laminate of n-type and p-type compound semiconductor layers and electrode layers on a glass substrate, the layers become free of bubbles, and the surfaces flat, if vibration is given to the glass substrate during or after the paste of the raw material and viscous agent for the layer are applied; and drying and firing thereafter provide dense layers of uniform thickness and in good contact with the next layer, and a solar cell with improved, uniform characteristics.

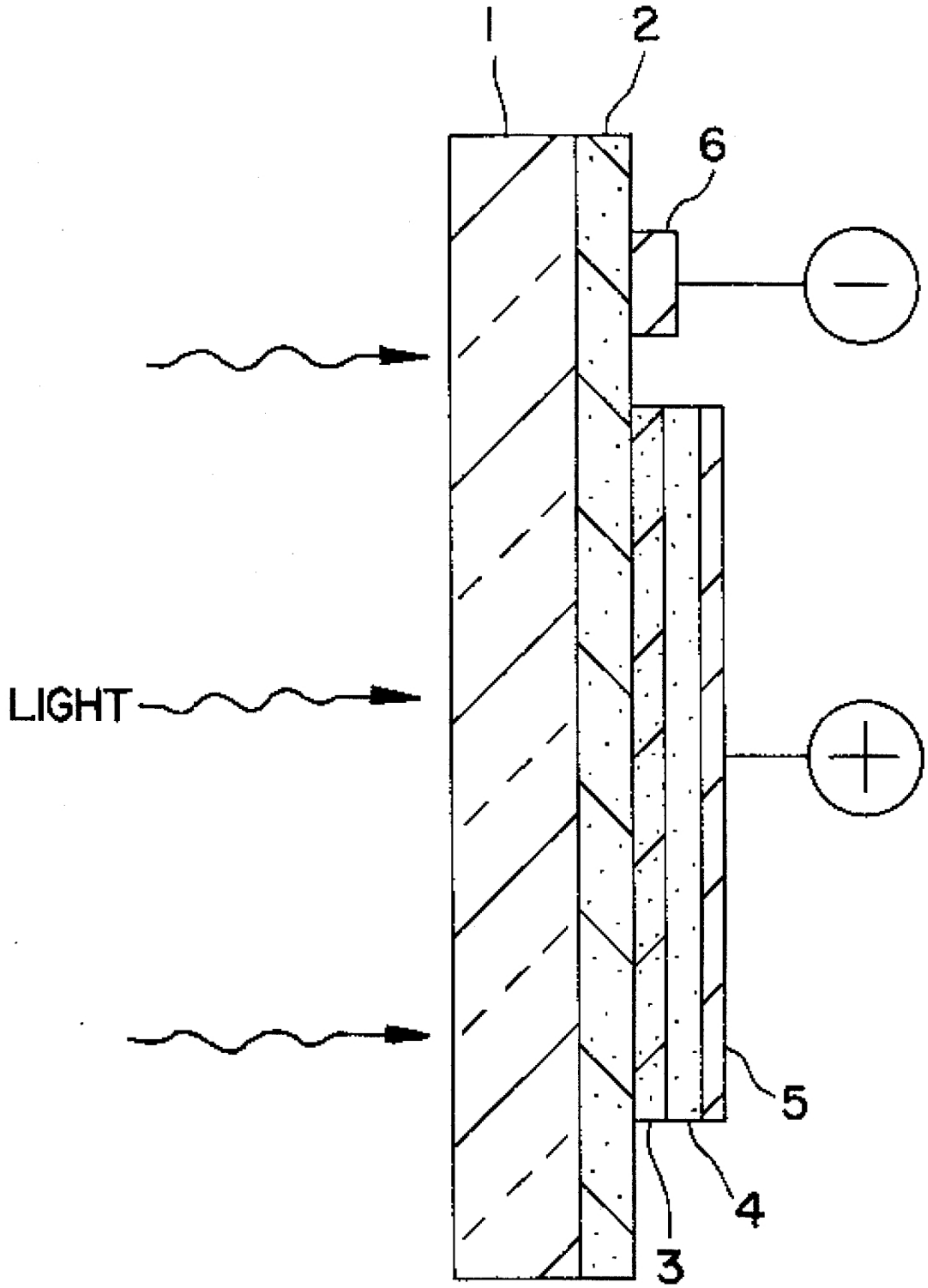
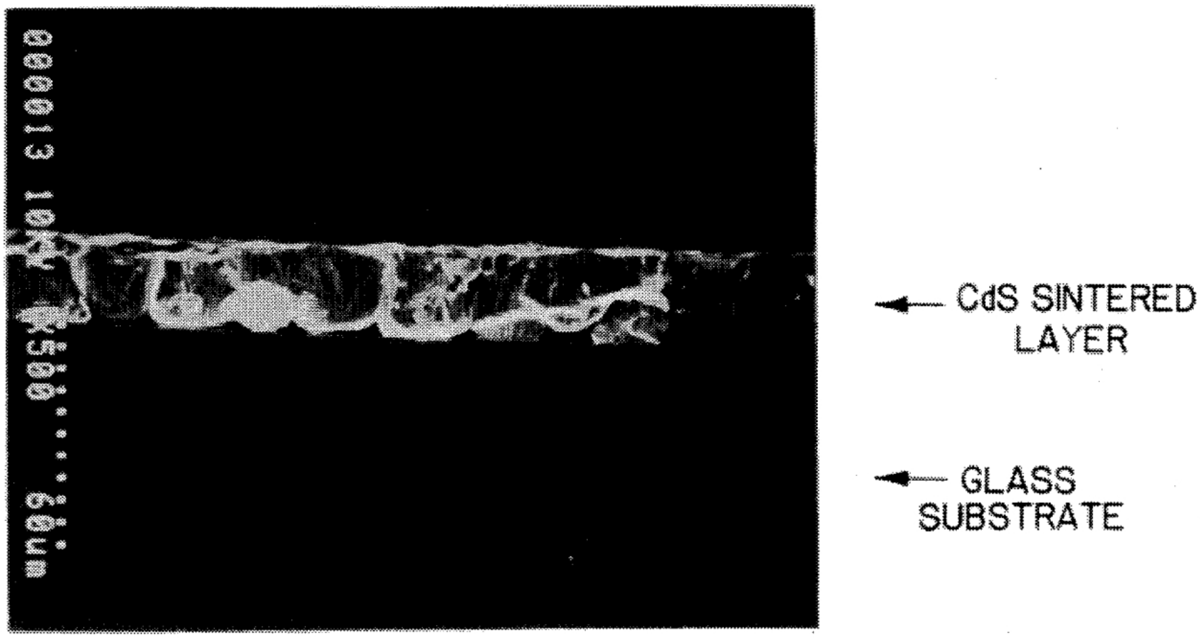
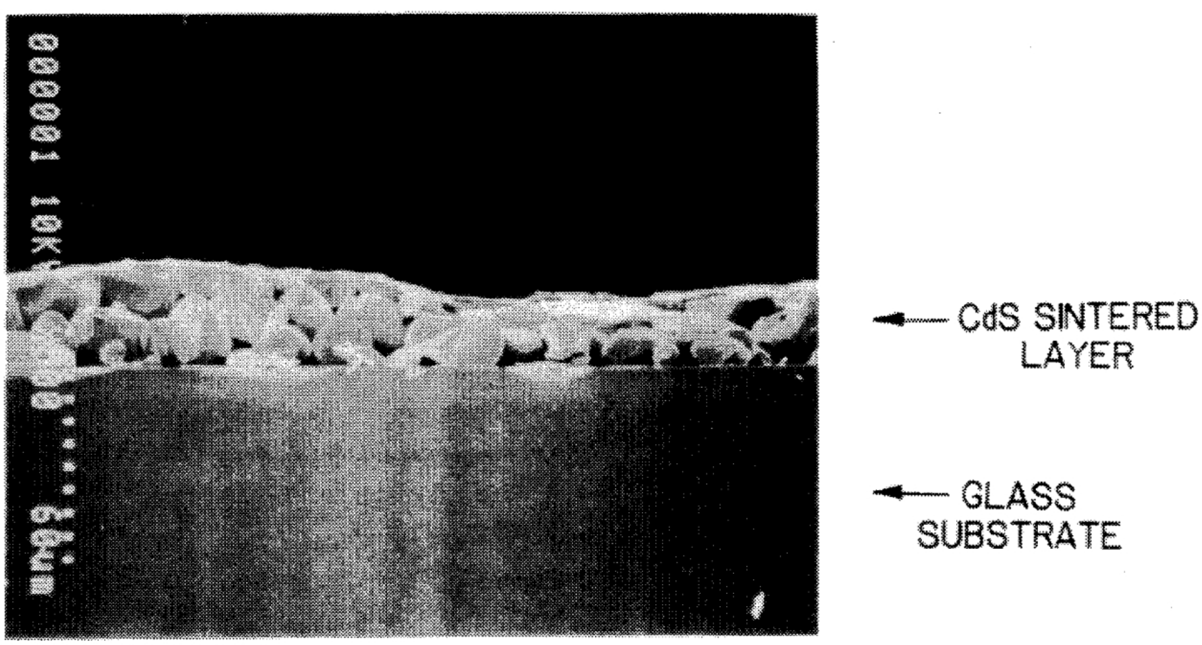


FIG. 1



X500

FIG. 2A



X500

FIG. 2B

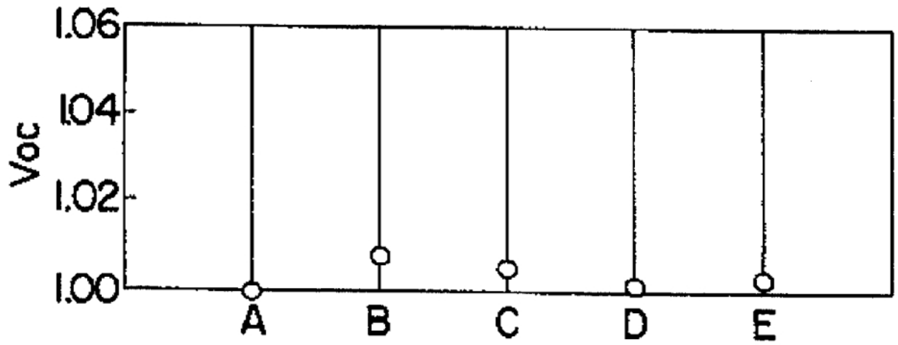


FIG. 3A

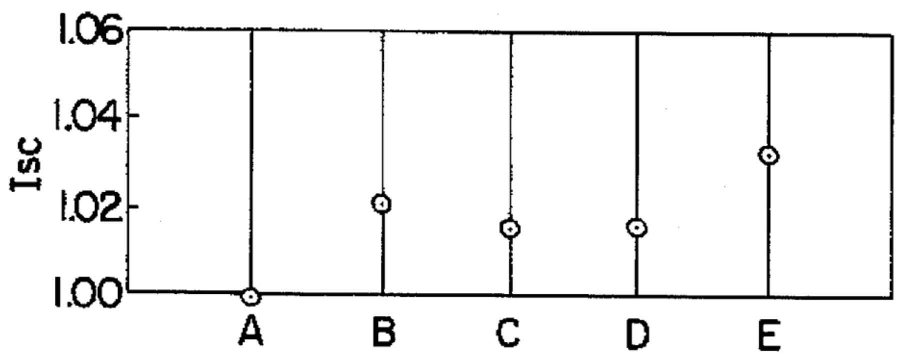


FIG. 3B

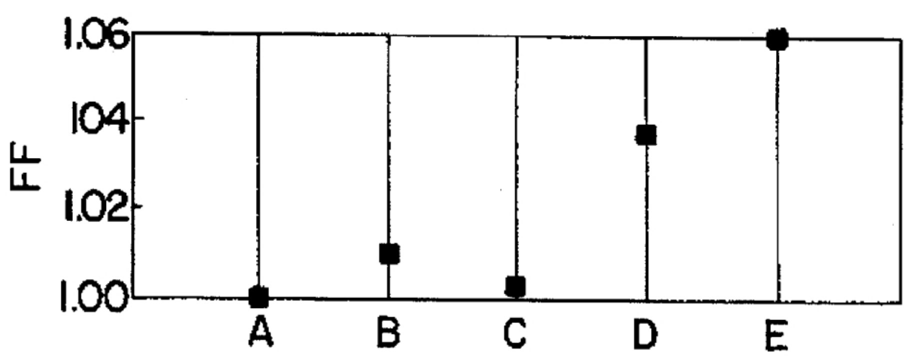
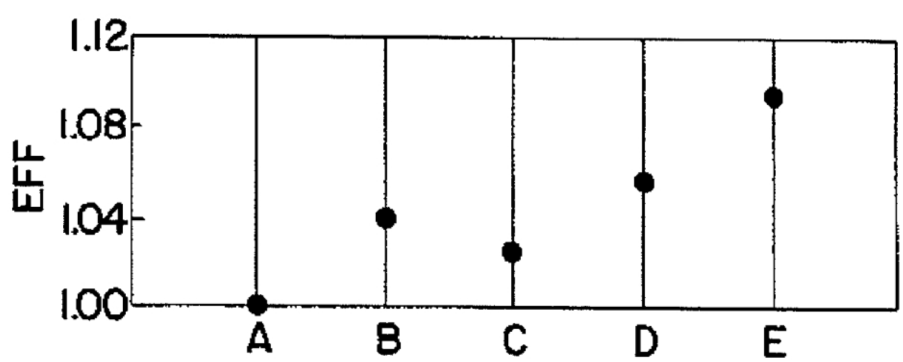
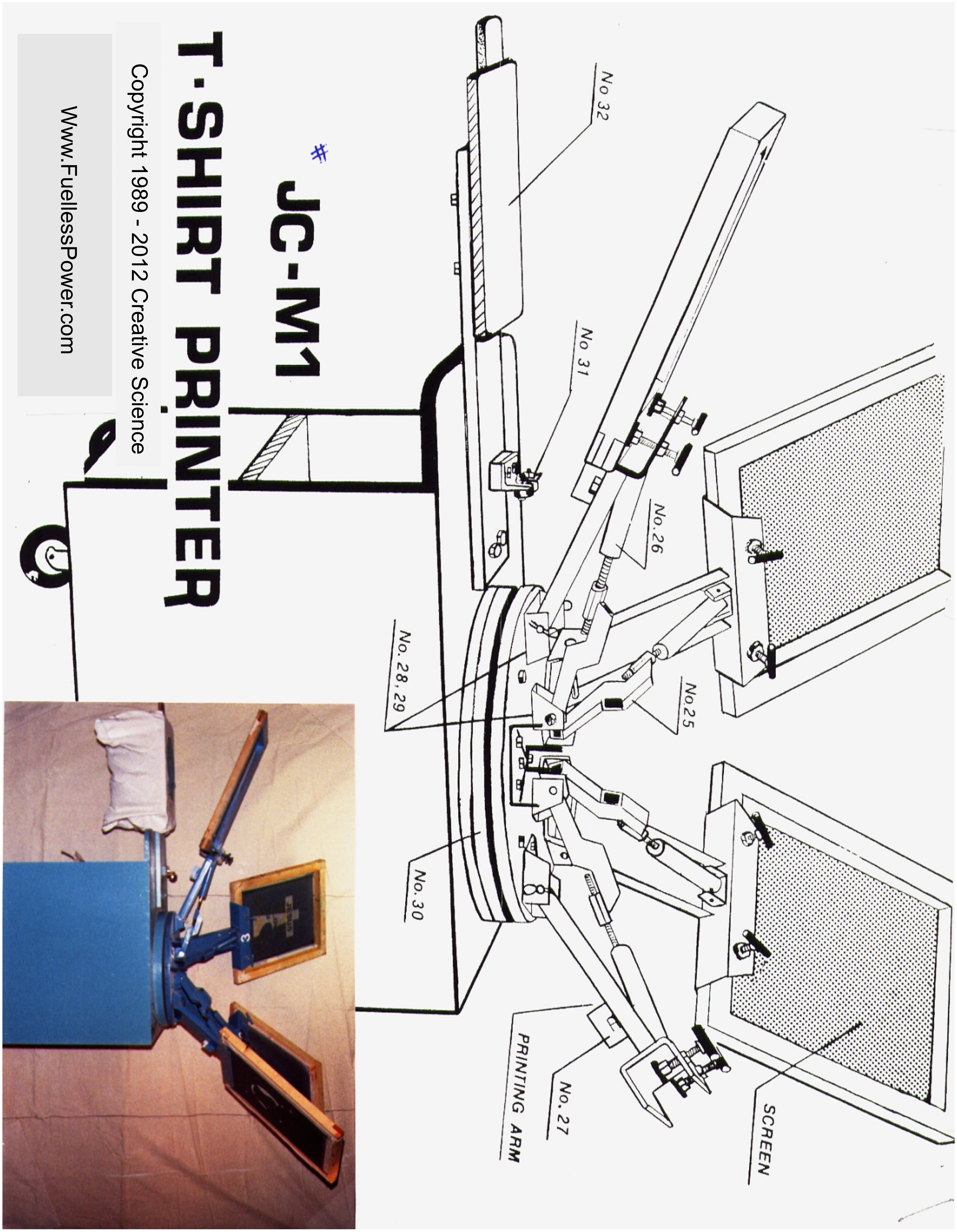


FIG. 3C



This is a screen printing machine that anyone can make. This printer can also be used to print solar cells. Plans are only $19.95 order # JC-M1

Phone: 1-812-945-5839



US005538903A

United States Patent [19]

Aramoto et al.

[11] **Patent Number: 5,538,903**

[45] **Date of Patent: Jul. 23, 1996**

[54] **METHOD OF MANUFACTURING SOLAR CELL**

[75] Inventors: **Tetsuya Aramoto**, Osaka; **Nobuo Nakayama**, Hirakata; **Kuniyoshi Omura**, Higashiosaka; **Mikio Murozono**, Hirakata, all of Japan

[73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka, Japan

[21] Appl. No.: **342,445**

[22] Filed: **Nov. 18, 1994**

[30] **Foreign Application Priority Data**

Nov. 18, 1993 [JP] Japan 5-314478

[51] **Int. Cl.**^{6} **H01L 31/18**

[52] **U.S. Cl.** 437/5; 136/260; 136/264; 136/265; 427/74; 427/76; 427/346; 437/9; 437/234

[58] **Field of Search** 437/5, 9, 234; 427/74–76, 346; 136/260, 264, 265

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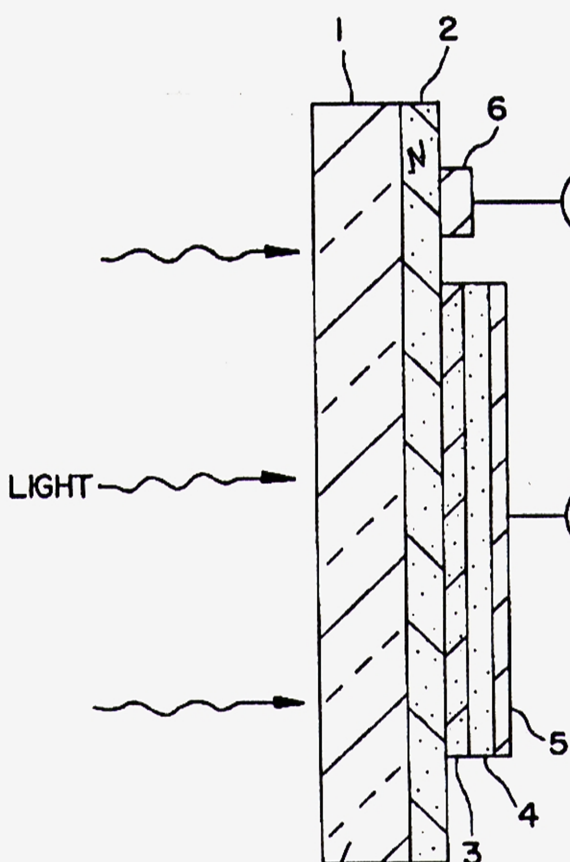
Primary Examiner—Aaron Weisstuch
Attorney, Agent, or Firm—Ratner & Prestia

[57] **ABSTRACT**

A method of manufacturing a solar cell, comprising the steps of forming a layer of n-type compound semiconductor, a layer of p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor layer comprises preparing a paste by mixing a semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it, and firing the dried paste, and vibrating said substrate during or after the application of the paste, to remove the bubbles in the paste, resulting in a semiconductor layer which is smooth, dense, and having good adhesion, thus realizing a solar cell with improved and uniform characteristics.

24 Claims, 3 Drawing Sheets



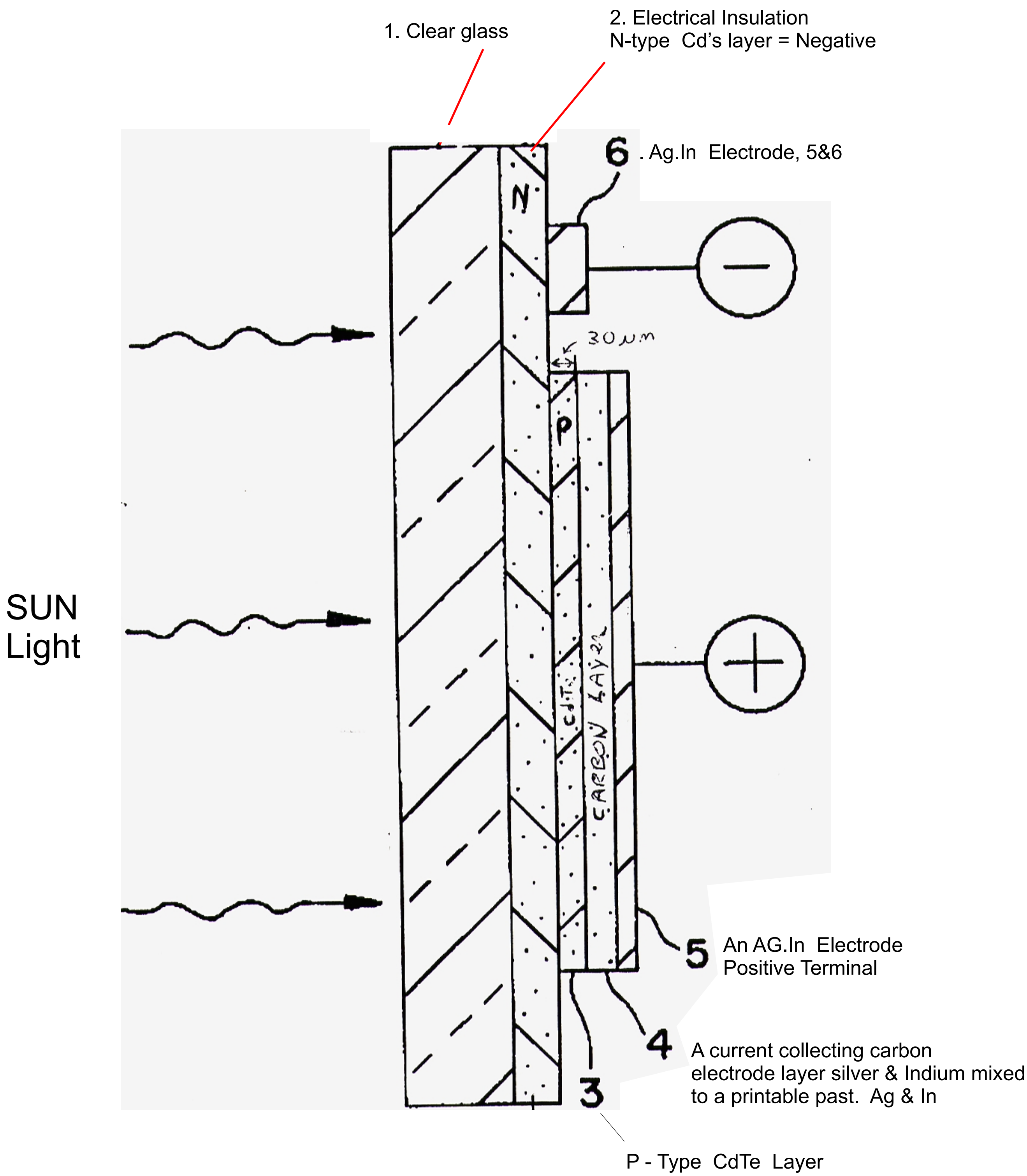
GlASS

mixed
*2 N-TYPE cAdmium Sulphid
cAdmium chlori
& Propylene Glyc

*? why couldn't you simply screen print a silver mesh screen 1st onto glass then Apply Negative Layer By screen printing over - silver. ?

(do what Patent says first!)

#3 P-TYPE



Try to double or triple print #2, to do this you print the first layer, let dry and then print the 2nd layer = 60 um thickness. #3 layer print only one layer using the same screen printing screen.

METHOD OF MANUFACTURING SOLAR CELL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of manufacturing a solar cell of compound semiconductors by way of coating | and firing.

2. Description of the Prior Art

In recent years, expectations for solar cells as a clean energy source have been raised, in view of the global warming, acid rain. ozone layer destruction, and other such environmental destruction. For the wide usage of solar cells to occur, improvement of the photo-electric conversion efficiency and reduction of the cost are most important, that purpose, solar cells made of compound semiconductors of Group III-V materials such as GaAs, InP. Group II-VI materials such as CdS/Cu_2S, CdS/CdTe, and Group I-III-VIa materials such as $CuInS_2$. $CuInSe_2$, as well as crystalline and amorphous silicon solar cells, have been investigated in many countries of the world. Among these, solar cells made of compound semiconductor helerojunctions of n-CdS/p-CdTe have been produced commercially, with relatively low material cost, conversion efficiency as high as 10%, less deterioration over long time peniods, and a relatively simple manufacturing process suitable for mass protuction consisting of printing, drying, firing (sintering or baking), resulting in a high density arrangment on a glass plate and realization of high voltage without outer wire connectionon, as well as large area cells.'

A typical solar cell of Group II-VI semiconductor, of which a sectional view is shown in FIG. 1, comprises a glass substrate 1 of high light transmittancc and electrical insulation provided on one surface thereof with an n-type CdS layer 2, a p-typc CdTe layer 3, a current collecting carbon electrode layer 4. an Ag.In electrode which is the positive terminal 5, and an Ag.In electrode which is the negative terminal 6 formed by laminating with printing and baking of each layer. Usually, although not shown in the figure, the thus prepared solar cell element is provided, on both the Ag-In electrodes, with a copper paste layer deposited, dried, and baked for easy soldering of lead wires. The cell is then covered all over with a passivation layer of a thermosetting resin such as epoxy and baked.

Light, including that of the sun, falls on the surface of the glass substrate 1 opposite to the surface having the above solar cell element layers, to generate electrical power by photo-electric conversion.

As the substrate, a heat-resistant barium borosilicate glass is employed which has a very low alkali metal content and a high softening point.

In the manufacturing of the compound semiconductor solar cell by the coating and firing method, it is important that each of the n-type compound semiconductor layer p-type compound semiconductor layer, and electrode layer have uniform thickness, a smooth surface. and no pin holes! Especially if the n-type CdS semiconductor layer formed directly on the substrate is uniform, smooth and non-porus, the adherence of the Ito the substrate is improved, resulting in an increase of the light transmittance. decrease of the sheet resistance, and, further, an increase of the photo-current and improvement of the characteristics of. the cell.

Conventionally, to obtain such a layer, a paste made of the powdered compound semiconducterr or elements "therefor, an eletroconducting agent, and a viscouse agnent mixed |together was kept under reduced pressure to remove bubbles therein and after the deposition, the substrate was held horizontally at about 50°C., which was lower than the drying temperature of the viscous agent, to reduce the viscosity of the ~ viscous agent and uniformly precipitate the raw material powders in order to obtain a high density layer. However, if the bubbles were removed from the paste before coating, it sometimes happened in the coating process by screen printing that bubbles were introduced from the surrounding 'atmosphere, resulting in uneven deposition-or pin-holes. Also, with the heat treatment only after coating, the raw material powders did not always uniformly precipitate- and the bubbles were not sufficiently removed, resulting in the layer not being fat, or of uniform thickness. The pin-holes left after coating and firing of the layers caused an Increase of the sheet resistance. Especially, if pin-holes were formed in the p-type CdTe layer, the carbon particles of the carbon electrode layer formed thereon penetrated into the pin-holes up to the CdS layer under the CdTe layer, causing internal short circuiting or current leakage, fatally damaging the solar cell performance.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new method of manufacturing compound semiconductor solar cells comprising ntlypc and p-type compound semiconductors and electrode layers having improved performance, uniform characteristics, and low production cost. brought about by formation of the layers without pin-holes and with uniform thicknesses and smooth surfaces.

To obtain the above object, a method of manufacturing a solar cell according to the present invention comprises th- steps of forming a layer of an n-type compound semiconductor, a layer of a p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor comprises preparing a paste by mixing a semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it and firing said dried paste, and vibrating said substrate during or after the application of the paste.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sectional view of a Group II-VI compound semiconductor solar cell of n-CdS/p-CdTe type.

FIGS. 2(A)-2(B) are microphotographs of sections of sintered CdS layers on a glass substrate.

FIGS. 3A-3D are graphs of the open circuit voltages. short circuit currents, fill factors, and intrinsic photoelectric conversion efficiencies of solar cells fabricated according to the present invention, as well as by the conventional method.

DETAILED DESCRIPTION OF THE INVENTION

An example of the method of manufacturing a Group II-VI compound semiconductor solar cell according to the present invention is now explained by referring to FIG. 1. A paste was prepared by mixing a fine powder of cadmium sulphide (CdS), cadmium chloride ($CdCl_2$). and pro. pylene glycol (PG). the $CdCl_2$ being a flux. and the PG being a viscous agent.

The paste was applied to a substrate of barium borosilicate glass by screen printing to form a coating layer of 60 μm thickness.

The glass substrate was subjected to vibration of 20 μm amplitude and 28 kHz ultrasonic frequency by contacting the output end of a piezoelectric vibrator on the outer end of the substrate for 5 seconds, whereby the roughness of the deposited layer due to the screen net disappeared and the bubbles in the layer were removed. The substrate with the vibrated layer was then dried in the atmosphere at 120° C. (PG was removed by vaporization), and sintered at 690° C.

A comparison substrate coated with a CdS layer was fabricated by a similar method but without the application of vibration.

The light transmittance and sheet resistance of the two kinds of samples were then measured and microphotographs of sections thereof (×500) were taken. The results are shown in Table 1 and FIGS. 2(A)–2(B).

TABLE 1

	CdS layer formed according to the present invention	CdS layer formed without vibration
Light transmittance (%) (λ = 0.7 μm)	63 %	60 %
Sheet resistance (Ω/cm^2)	28	33

As is observed in FIG. 2(B), the CdS layer on the substrate prepared without vibration has projections and depressions on the surface, void spaces and/or pin-holes, and the thickness is not uniform. Moreover, it is not sufficiently adherent to the substrate. On the contrary, the CdS layer of the sample shown in FIG. 2(A) fabricated with vibration has few voids and/or pin-holes, uniform thickness, and a smooth surface, fully adherent to the substrate. Numerically, Table 1 indicates improvements of the light transmittance by 5% and reduction of the sheet resistance by 15%. Thus it is expected the CdS layer formed with the vibration would have superior characteristics as the window layer of a solar cell.

Next, Cd.Te paste was prepared by kneading well an equi-mol mixture of cadmium (Cd) and tellurium (Te) powders with addition of $CdCl_2$ and PG, and the paste was applied in a 30 μm thickness on the above CdS sintered layer by screen printing, dried in the atmosphere, and sintered at 620° C., to form a CdTe layer.

Then, a carbon paste, prepared by kneading carbon powder and a viscous agent made of a solution of a resin in an organic solvent was applied on the CdTe layer, to form an electricity collecting electrode 4 on the n-CdS/p-CdTe heterojunction.

Further, the carbon electrode layer 4 and the CdS layer 2 were provided with a positive terminal 5 and a negative terminal 6 of Ag.In by depositing Ag.In paste by screen printing and drying and baking, the Ag.In paste being prepared by kneading of silver (Ag) and indium (In) powders with a viscous agent made of a solution of a resin in an organic solvent. Karosin

On the positive and negative electrodes 6 and 5 of Ag.In, copper paste was applied by screen printing, and dried and baked. Further, on the other parts of the cell a passivation layer was likewise applied by printing, and dried and baked, to complete the cell. The sinterings or bakings in the above processes were made in a nitrogen atmosphere.

The following describes the effect of vibration given to the glass substrate when, in the above described manufacturing process of a compound semiconductor solar cell, the pastes made of the mixtures of the respective powdered n-type and p-type compound semiconductor materials, flux agent, and viscous agent were applied to form the n-type and p-type layers and electrode layers on the substrate.

A: A sample cell fabricated with the semiconductor and electrode layers dried and fired after the application of the paste on the substrate without vibration, i.e. according to the prior art.

B: A sample cell fabricated with vibration given to the substrate only after the application of CdS paste, i.e. no vibration during the other processes.

C: A sample cell fabricated with vibration given only after the application of CdTe, i.e. no vibration during the other processes.

D: A sample cell fabricated with vibration given only after the application of the carbon paste, i.e. no vibration during the other processes.

E: A sample cell prepared with vibration given to the substrate after application of the CdS paste, CdTe paste, and carbon paste, with further drying and firing.

The vibration was given at 20 μm amplitude and 22 kHz frequency for 10 seconds by contacting the output end of the ultrasonic oscillator to the reverse side of the glass substrate; the reverse side being the surface on which the semiconductor layers were not applied. The other conditions were the same.

For the solar cells of these samples, the open circuit voltage (Voc), short circuit current (Isc), fill factor (FF), and intrinsic photo-electric conversion efficiency (EFF) were measured, with the results shown in FIGS. 3A–3D as values relative to the values for sample cell A taken as 1.00.

From the measurements of the sample cell B as shown in FIGS. 3A–3D, it is seen that the vibration after the CdS application has caused, by removing the paste bubbles, smoothing the film surface, and by improvement of the adhesion between the CdS layer and the substrate, resulting in an increase in light transmittance, and a reduction in surface resistance, an improvement of Isc, and, through the reduction of the number of pin-holes at the junction, improvements of Voc and FF.

From the data for the sample cell C, it is seen that the vibration after the Cd. Te paste application has led to the improvement of Voc, Isc, and FF as a result of CdTe grain size or orientation or other improvement in the film quality.

The measurements of the sample cell D show the contribution of the vibration after the carbon paste application to the improvement of Isc, FF, and EFF. It is thought that the contact resistance between the carbon electrode layer and the CdTe layer is reduced by the vibration.

Lastly, from the data of the sample cell E, it is clear that an about 10% increase of EFF compared to sample cell A has been obtained by the combined effect of the vibrations after each of the applications of CdS, Cd.Te, and carbon pastes.

Thus, it is understood that the characteristics of the solar cells are improved by the simple measure of vibrating the glass substrate after the applications of the pastes, without requiring any significant change of the process or manufacturing installation.

The method of application of the various pastes is not confined to the screen printing as referred to in the above examples. Various other methods can be employed; nozzle printing of paste from a nozzle, including printing of a figure in a desired pattern on a glass substrate by adjusting the distance between the tip of the nozzle and the surface of the substrate to change the paint thickness; relief and intaglio printing; and spray printing of paste with a spray gun while shielding the non-printed areas by a mask.

Table 2 shows how the spread of unevenness of the surface (the difference between the maximum thickness and the minimum thickness) and the yields in production change depending upon whether or not the ultrasonic treatment is employed on every layer of the cells. As is observed, by the vibration after the paste application similar effects can be obtained as with the screen printing.

TABLE 2

Printing	Without ultrasonic treatment		With ultrasonic treatment	
	Spread of unevenness (μm)	Yield (%)	Spread of unevenness (μm)	Yield (%)
Screen	35	92	8	95
Nozzle	15	85	9	89
Relief	21	72	4	82
Intaglio	26	82	9	90
Spray	18	74	12	91

Instead of vibrating the outer circumference or the outer surface after the application of the pastes as explained above, vibration during printing of the paste may have the same effects.

For the application of such ultrasonic vibration, 5 to 10 seconds are sufficient, so that the application of paste with the vibration and further vibration thereafter of a short time less than 5 seconds is sufficient; therefore substantial elongation of manufacturing time does not occur.

Although ultrasonic vibration given to the glass substrate during or after the pastes of the n-type and p-type compound semiconductor layers and electrode layer were applied was effective, vibration given during or after application of the pastes for the formation of the terminal or passivation layer did not bring about remarkable effects on the cell characteristics.

It is added that the method of the present invention, thus far explained with reference to CdS/CdTe compound semiconductor solar cells, can be applied to the formation of other compound semiconductor layers of solar cells including Group I-III-VI_2 compounds, for example $CuInSe_2$, in the place of CdTe, provided the layer is formed by coating and firing.

As explained above in detail, when a solar cell is fabricated by forming a laminate of n-type and p-type compound semiconductor layers and electrode layers on a glass substrate, the layers become free of bubbles, and the surfaces flat, if vibration is given to the glass substrate during or after the paste of the raw material and viscous agent for the layer are applied; and drying and firing thereafter provide dense layers of uniform thickness and in good contact with the next layer, and a solar cell with improved, uniform characteristics.

What is claimed:

1. A method of manufacturing a solar cell, comprising the steps of forming a layer of n-type compound semiconductor, a layer of p-type compound semiconductor, and an electrode layer on a glass substrate, wherein at least one of said steps of forming a layer of compound semiconductor comprises:

preparing a paste by mixing a powdered semiconductor raw material and a viscous agent, applying said paste to said substrate, drying said paste to harden it, and firing said paste, and vibrating said substrate during or after the application of the paste.

2. A method of manufacturing a solar cell according to claim 1, wherein said vibration is of an ultrasonic pulse form.

3. A method of manufacturing a solar cell according to claim 2, wherein the application of the paste is performed by a method selected from the group consisting of screen printing, nozzle printing, relief printing, intaglio printing, and spray printing.

4. A method of manufacturing a solar cell according to claim 3, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

5. A method of manufacturing a solar cell according to claim 4, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

6. A method of manufacturing a solar cell according to claim 3, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and $CuInSe_2$.

7. A method of manufacturing a solar cell according to claim 6, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

8. A method of manufacturing a solar cell according to claim 3, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

9. A method of manufacturing a solar cell according to claim 2; wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

10. A method of manufacturing a solar cell according to claim 9, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

11. A method of manufacturing a solar cell according to claim 2, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and $CuInSe_2$.

12. A method of manufacturing a solar cell according to claim 11, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

13. A method of manufacturing a solar cell according to claim 2, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

14. A method of manufacturing a solar cell according to claim 1, wherein the application of the paste is performed by a method selected from the group consisting of screen printing, nozzle printing, relief printing, intaglio printing, and spray printing.

15. A method of manufacturing a solar cell according to claim 14, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

16. A method of manufacturing a solar cell according to claim 15, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

17. A method of manufacturing a solar cell according to claim 14, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and $CuInSe_2$.

18. A method of manufacturing a solar cell according to claim 17, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

19. A method of manufacturing a solar cell according to claim 14, further comprising a step of forming a passivation

layer of resin over said cell except for the positive and negative output terminals thereof.

20. A method of manufacturing a solar cell according to claim **1**, wherein the powdered raw materials for the layers of n-type and p-type semiconductors comprise elements of groups II and VI or a compound thereof.

21. A method of manufacturing a solar cell according to claim **20**, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

22. A method a manufacturing a solar cell according to claim **1**, wherein said n-type compound semiconductor layer comprises CdS, and said p-type compound semiconductor layer comprises one of CdTe and $CuInSe_2$.

23. A method of manufacturing a solar cell according to claim **22**, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

24. A method of manufacturing a solar cell according to claim **1**, further comprising a step of forming a passivation layer of resin over said cell except for the positive and negative output terminals thereof.

* * * * *

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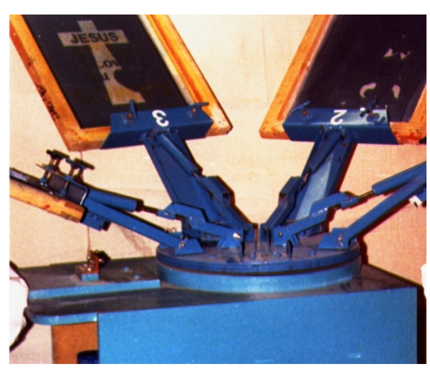

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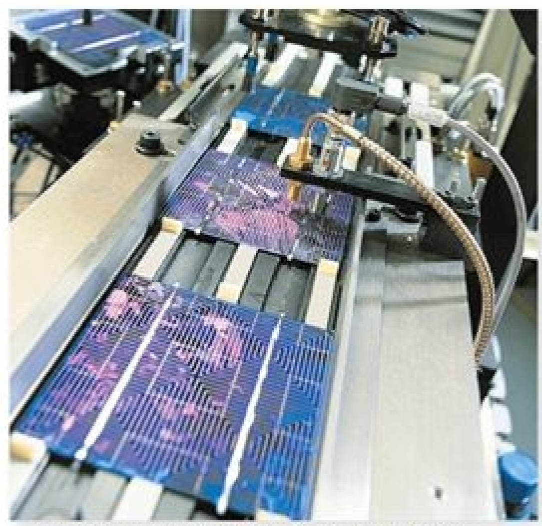
Photowatt chooses Dupont's Solamet™ materials for its PV solar cells

For many years, Photowatt has been a European leader in the manufacture of photovoltaic (PV) solar cells. Since 1997, the company, based at Bourgoin-Jallieu, near Lyon, France, has been a part of ATS (Automation Tooling Systems), a large multinational concern with its headquarters in Toronto, Canada. ATS specializes in the fabrication of automated production lines for the automotive and electronics industries.

In 2001, the PV market grew by 39 per cent, based on power in megawatts (MWp), and Photowatt is well positioned to take advantage of this buoyant market. Like most large PV manufacturers, the company has increased capacity every year to cope with demand and, between 1995 and 2002, its production capacity has increased 10-fold, from 2 to 20 MW.

Photowatt has an advantage in the industry by being a vertically-integrated PV cell manufacturer with the capability to produce solar panels from silicon feedstock. It can therefore control all of the intermediate processing and manufacturing steps, including ingot casting, silicon wire sawing, solar cell metallisation, lamination and assembly.


Printing of Photowatt's front-side PV cells.

ATS's fully-automated solar cell lines

The company's parent, ATS, has a strong background in the automation of manufacturing processes. This has enabled Photowatt to install two new fully-automated high volume PV cell and module manufacturing lines which are shown in the photo on the right. These lines started operating in 2000 and can undertake the screen printing of the rear and front metallisation pastes, drying and firing of the pastes, deposition of the anti-reflective coating (ARC), sorting, ribbon soldering, lamination of the protective insulation layer and module assembly.

Today, the standard size of a multi-crystalline Si cell is 125 x 125 mm (5 inches square) with a thickness of 300 Mm. Using a titanium dioxide anti-reflective coating, Photowatt's solar cell efficiency was about 13 per cent. More recently, using new silicon nitride anti-reflective coating technology, this efficiency has been improved to over 15 per cent on the company's own multi-crystalline silicon. DuPont MicroIrcuit Materials has been

The Research group mentioned earlier, Jabbour's group, print very flat, thin cells, onto glass in a similar way. First they coat the glass with a transparent electrically conducting material (metal ink) that acts as one of the solar cell's electrodes. On top of this, they lay down a thin film of a polymer, which helps to gather current from the photovoltaic material.

Finally they deposit a blend of two organic compounds that convert light into electricity. One is a carbon-based molecule called a fullerene, it produces charged particles that carry an electrical current when light shines onto the molecules. The other is a polymer, it ferries the current to the electrodes on the top and the bottom of the solar cell.

Under blue light, these screen-printed solar cells have an efficiency of 4.3 per cent. And the Japanese cells are much greater than that! Many of the flexible solar cell panels that you see today are screen printed.

Now lets take a look at what The Dupont Company is doing with there solar cells. Dupont is involved in the development of solar cell metallisation since the 1970's. Although all PV cell manufacturers use different processes to make there solar cells, the metallisation of the rear and front sides is in many cases **DONE BY SCREEN PRINTING!** Which has shown itself to be one of the most economic way to produce solar cells.

Recently, Dupont achieved a real breakthrough in the formulation of front-side contacts for silicon solar cells that has resulted in customers, such as photowatt, to realize the screen printing efficiency by changing their anti-reflection technology from **titanium dioxide to silicon nitride.** This came at just the right time for the Photowatt solar cell company, Because they have been using there own past material for the front side metallisation since it first started manufacturing solar cells. The development of the metallisation from Dupont for the back side, (p-side). These pasty inks are either silver pastes containing Al, or pure Al pastes to secure a good ohmic contact with the p-side of the solar cell. We have told you all this to help you better understand and leam the screen printing solar cell process and what others are doing.

An example of a complete Free Energy System, Using Solar cells in series and parallel to charge 12 volt deep cycle batteries, which in turn runs our 5,000 watt inverter to run your home on 120 vac x 60 Hz. We recommend replacing the solar panels with our Fuel less Engine connected to a 12 volt car alternator to keep up batteries. The lawn mower motor we use as a back up.