

Energy Applications and Cleantech



Definitions of Cleantech

- **What is "cleantech"?**
- *The term "cleantech" refers to technologies that:*
 - - *Use energy, water and other raw materials more efficiently and productively,*
 - - *Deliver equal or superior performance,*
 - - *Improve customer profitability, through cost reduction and / or increased revenues, and*
 - - *Create less waste or toxicity*
- *... as compared to incumbent technologies*
- <http://cleantechvc.blogspot.com/>

Companies in Cleantech

- Energy
 - Solar, fuel cell, batteries
- Environmental Remediation
 - Air, water, soil
- Water purification
- Sensor technology

Clean and abundant ***energy***

Environmental ***remediation***

Water ***purification***

Sensors for ***environmental health***

Materials for ***energy conservation***

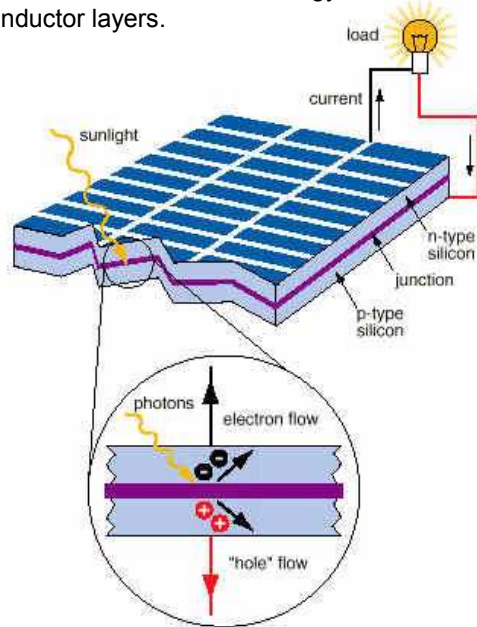
Materials for ***intelligent manufacturing***

Clean Energy

- Solar energy
- Fuel cells
- Batteries
- Motors
- Wind production
- Hydrogen production
- LED and CNT lighting

Solar cells

It is a photovoltaic cell that converts solar energy into electricity. A photovoltaic cell consists of semiconductor layers.



Semiconductor Solar Cells

Traditional solar cells are photovoltaic cells, which work by converting energy from photons of light into electricity (photo means light, and voltaic means electricity). The cells do this by utilizing the unique properties of semiconductors. Silicon is the most common material used.

The cells consist of two pieces of doped silicon, one N-type and one P-type. When the two pieces are put together, the negative free-carriers (electrons) in the N-type are attracted to the positive free-carriers (holes) in the P-type. Electron then move to fill the holes until equilibrium is reached. This only occurs where the two materials meet (called the NP junction).

Free carriers within the rest of the material (away from the junction) remain where they are. At the junction site, the movement of charges leaves both pieces of silicon with a slight electric charge. Since the N-type lost electrons, it now has a slight positive charge. Since the P-type gained electrons, it has a slight negative charge. These charges create an electric field between the two pieces of silicon. This field acts like a diode, forcing any free electrons to the N-type layer and any free holes to the P-type side.

Nanosolar

Popular Science innovation of the year 2007!

<http://www.popsci.com/popsci/flat/bown/2007/index.html>

The company produces its PowerSheet solar cells with printing-press-style machines that set down a layer of solar-absorbing nano-ink onto metal sheets as thin as aluminum foil, so the panels can be made for about a tenth of what current panels cost and at a rate of several hundred feet per minute.



Nanosolar



A thin-film solar cell consists most fundamentally of an absorber layer (the semiconductor) sandwiched in between a top and a bottom electrode layer.

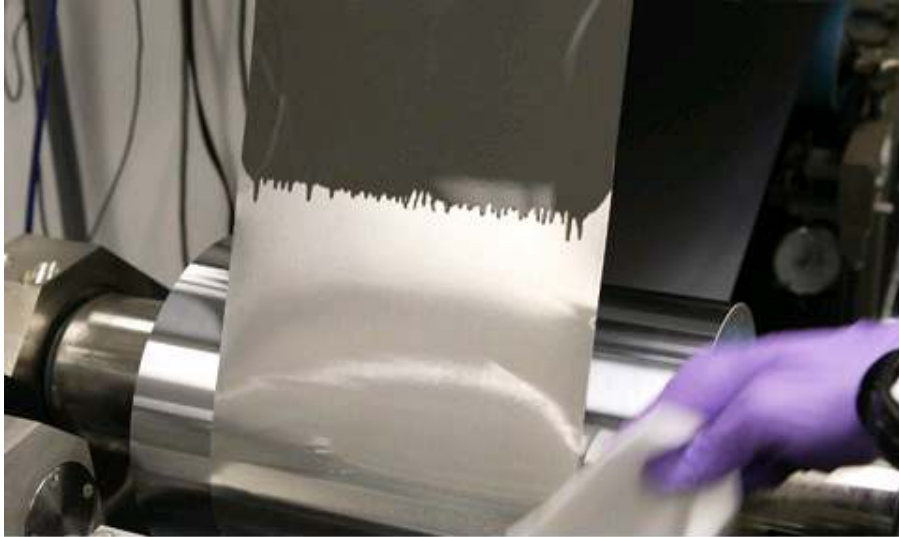
The thin films of a solar cell are deposited directly onto a highly conductive metal foil (as opposed to glass or stainless steel), then the bottom electrode gets much simpler because the substrate can do the job of carrying the current.

Conductive Substrate



HOW IT'S MADE As reams of aluminum foil . . .

Nanosolar



... the printer deposits a thin layer of semiconducting ink that absorbs the sun's photons.

Nanoparticle Ink



A homogeneous mix of nanoparticles in the ink in just the right overall amounts ensures that the atomic ratios of the four elements are correct wherever the ink is printed, even across large areas of deposition.

Nanosolar



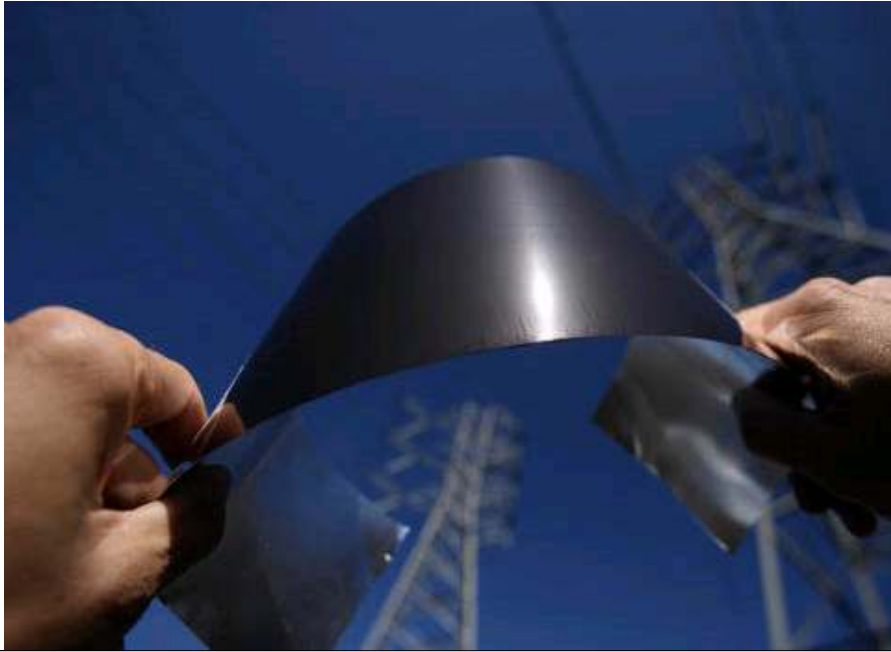
Next, the thin film goes through another press that coats it with a transparent conductive layer before it's cut into sheets of solar cells.

Semiconductor Printing

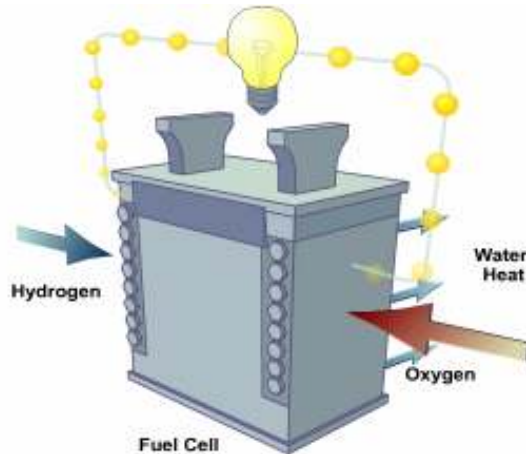


Printing is much simpler and more robust than vacuum deposition techniques such as sputtering or evaporation which have conventionally been used to fabricate thin-film solar cells.

Nanosolar



Fuel Cell Technology



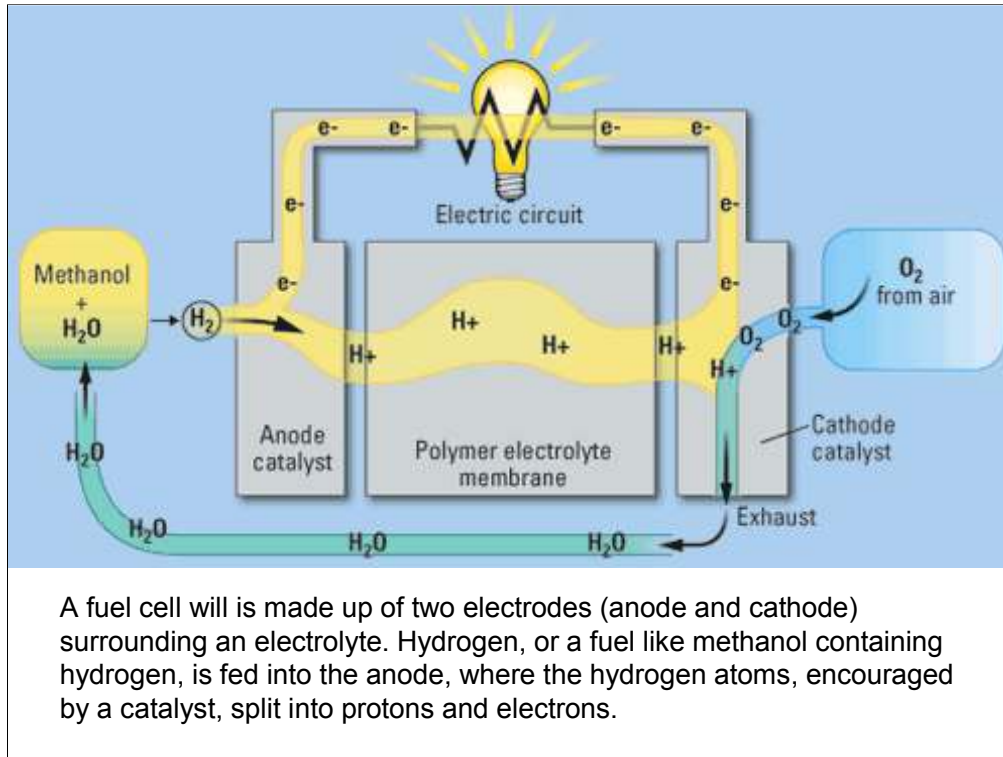
A hydrogen fuel cell would bring in hydrogen and oxygen, create electricity to power your vehicle, home, etc, and release water and heat.

Hydrogen fuel cells use hydrogen and oxygen gas to create electrical energy.

They differ in their internal chemistries but the reaction is always basically the same: **hydrogen+oxygen=water**, the basic reason for their eco-friendly reputation.

Using pure hydrogen gas for fuel directly allows the simplest and most efficient fuel cell, but transporting and storing the hydrogen can be troublesome. Alternatively, the fuel cell can include a reformer to extract the hydrogen from most any hydrocarbon fuel, though that typically means a bulky system with high heat and considerable plumbing. Or a liquid fuel like methanol can be fed directly into the cell, where it produces hydrogen by chemical reaction, typically with water, requiring the addition of a circulation system for managing the flow of liquids.

http://www.smalltimes.com/display_article/312009/109/ARTCL/none/none/1/Nano-enables-practical,-portable-fuel-cells/



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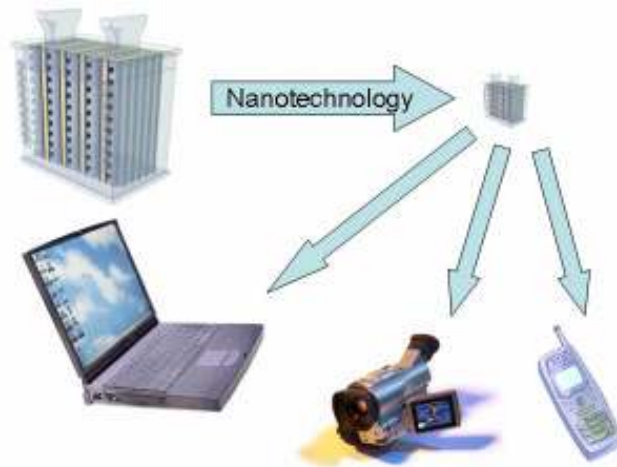
They differ in their internal chemistries but the reaction is always basically the same: **hydrogen+oxygen=water**, the basic reason for their eco-friendly reputation.

Flow plates are used to bring hydrogen gas to one side of the fuel cell while oxygen is brought to the other. A catalyst (usually platinum) breaks the hydrogen gas into positive ions (protons) and electrons. The central membrane, the proton exchange membrane, allows only positive charges to pass through. The positive ions pass through the central membrane while the electrons are stuck and flow away through conductors that provide the electrical current that provides the useful power.

Once the positive ions and electrons reach the other side of the fuel cell, where the oxygen is, another catalyst (usually platinum) combines the positive ions, electrons and oxygen yielding water and releasing heat.

As long as hydrogen and oxygen continue to be pumped to the fuel cell, the fuel cell can provide electrical energy. Unfortunately, the amount of energy produced by one fuel cell is very small. To make fuel cells more powerful several fuel cells are connected to provide higher voltage and more current. Nanotechnology is helping fuel cells by making them more efficient.

Nano Fuel Cells



Nanotechnology will help make fuel cells smaller and more efficient so that they can eventually be used to power everyday portable devices.

Nanotechnology also offers improvements in the proton-exchange membrane.

In addition, nanotechnology helps to improve the performance of the proton exchange membrane. Currently, the leading membrane for fuel cells is Nafion. Nafion is similar to Teflon, but inside Teflon's chemical resistant polymer matrix sulfonic acid groups were added. Sulfonic acid groups have strong ionic properties, therefore by adding these particles to the matrix, the cationic conductivity of the material increased. The true benefit to all of this is a material perfect for fuel cell application. Nafion does not conduct electricity, but conducts positive charges while having a high operating temperature and strong resistance to chemical corrosion.[21]

This is where most of the current research in nanotechnology is working, examining different nanoparticles to suspend in different polymer matrixes to yield the highest possible proton conductivity while also providing other essential properties including no electronic conductivity, gas permeability, stability, good mechanical strength, resistance to dehydration at high temperature, chemical stability towards oxidation, reduction and hydrolysis, and low cost. [22]

The use of metal phosphate nanoparticles at the boundary between the electrode and the polymer membrane of the fuel cell has also proven to increase the proton conductivity of the fuel cell.[23] For example, researchers recently demonstrated an increase proton conductivity at high temperatures when inorganic lamellae nanoparticles are inserted between the Nafion film and the electrode.

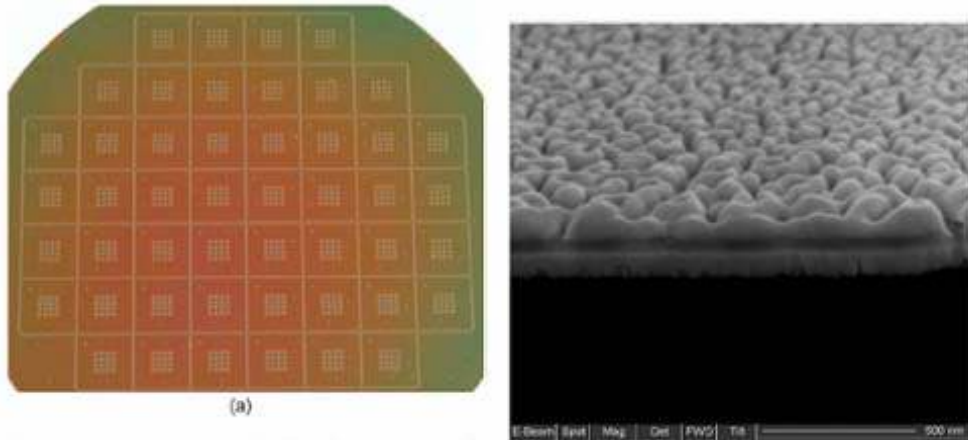
Nano Fuel Cells

Some of the initial commercial portable fuel cells improve conventional methanol polymer electrolyte membrane (PEM) fuel-cell technology with nanostructured catalytic layers and MEMS-based micro reformers.



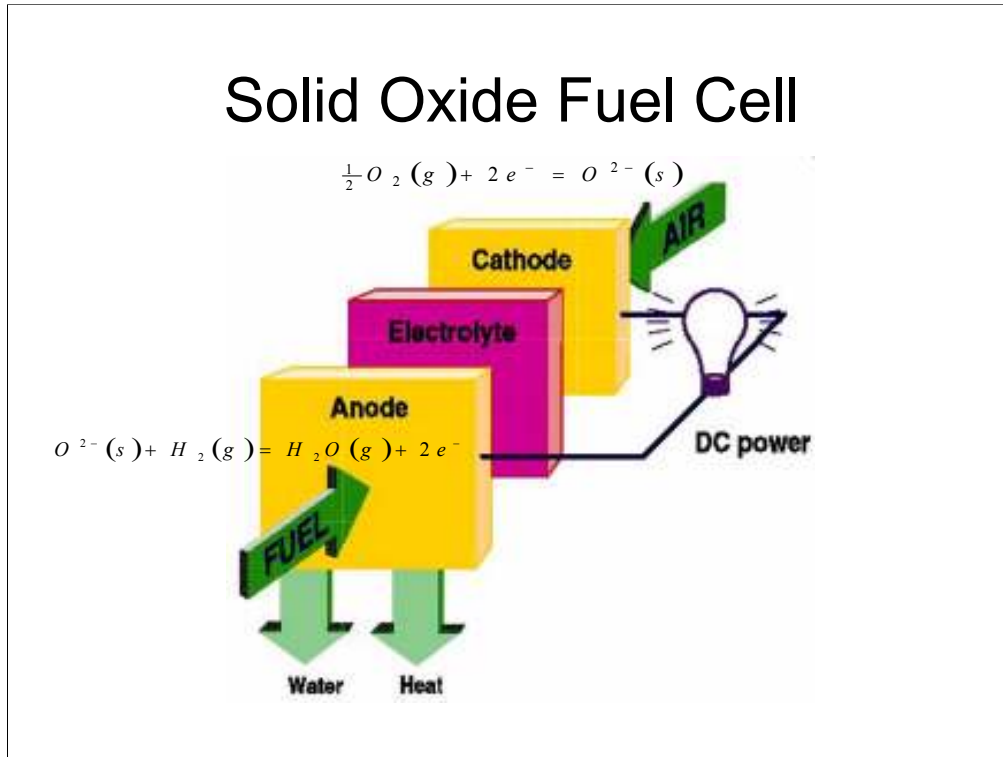
http://www.smalltimes.com/display_article/312009/109/ARTCL/none/none/1/Nano-enables-practical,-portable-fuel-cells/

Thin Film SOFC



Ultra-thin solid oxide fuel cell (SOFC) structures containing electrolyte membranes 50-150nm thick were fabricated with the help of sputtering, lithography, and etching. They were made of 50nm YSZ electrolyte and 80nm porous Pt as cathode and anode. The peak power densities were 200 and 400 mW/cm² at 350°C and 400°C, respectively.

Solid Oxide Fuel Cell



The SOFC consists of a cathode, electrolyte and an anode. Oxygen air is led into the cathode where the oxygen is reduced. The fuel (H_2 or CH_4) is fed through the anode.

Because of the difference in oxygen activity between the cathode and anode, oxygen ions will diffuse through the electrolyte towards the anode.

The oxygen ions free two electrons at the anode. The free electrons are then sent back to the cathode through the outer circuit creating a current. The electrons then travel to the cathode, where they reduce oxygen from air, thus continuing the electricity-generating cycle.

Cells are combined in series to get a higher voltage or in parallel to get a higher current.

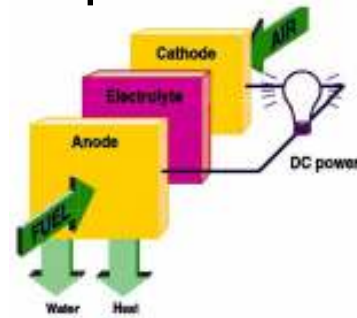
The ultimate goal is to increase the oxygen ion conductivity through the electrolyte ion the fuel cell.

Electrolyte Material Properties

The role of the electrolyte in a SOFC is two fold:

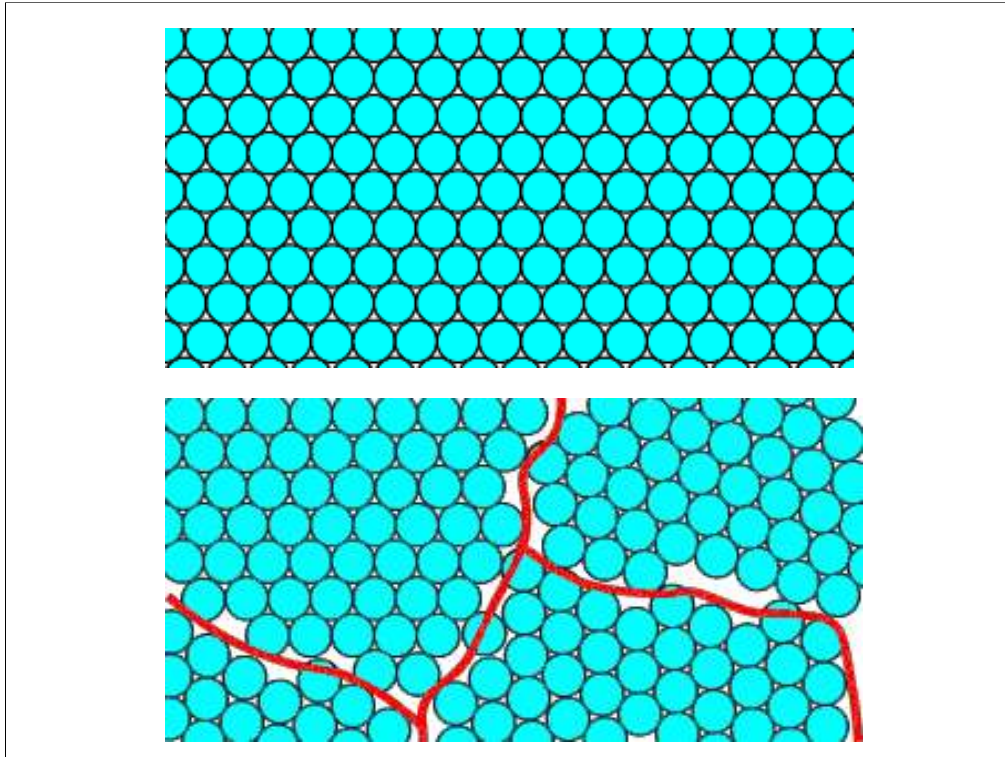
It must form a barrier to prevent fuel and oxidant gases mixing.


Transport oxygen ions across the membrane from the cathode to the anode (with minimal electronic conductivity).



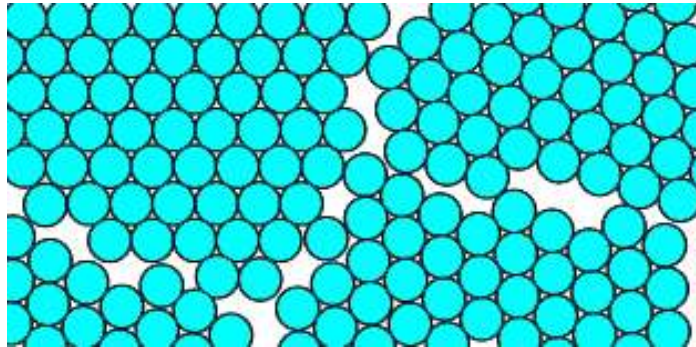
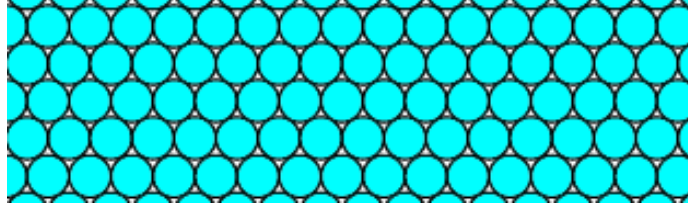
In a working fuel cell the electrolyte must therefore possess various properties:

- Stability in both reducing and oxidizing environments.
- Sufficiently high ionic conductivity at the cell operating temperature
- Good thermal stability.
- In addition, the material must be able to be formed into a thin, dense film gas tight to hydrogen.



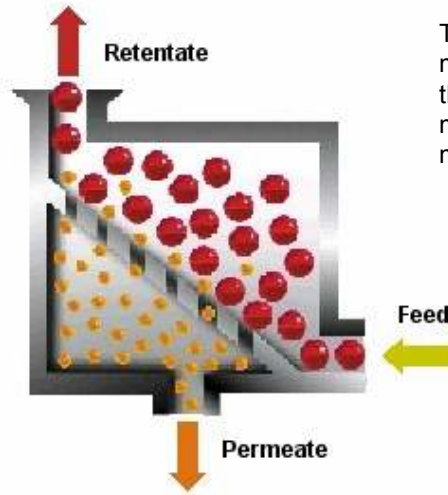


Grain boundaries act as high diffusivity pathways, allowing more oxygen ions to move through the electrolyte, therefore increasing the overall efficiency of the cell.



Nanofiltration/Water Purification

Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm. Nanofiltration is mainly used for the removal of ions or the separation of different fluids



The liquid to be filtered passes over the membrane at high velocity. Depending on the membrane pore size, different sizes of molecules are able to pass through the membrane.

The water treatment plant at Méry-sur-Oise provides the Parisian suburbs (4 million inhabitants) with high quality water thanks to a membrane process developed by researchers at Veolia Water.



This process, first used in the medical world, has been adapted by researchers at Veolia Water to allow for its use with large volumes of water and for the large scale production of drinking water at prices suited to market demand. Nanofiltration has been used since 2002 in Coliban, Australia, to treat up to 126 million liters of water a day

Photocatalytic Air Purifier

8200V electronic filter absorbs the miniature dust and decomposed particles.

Producing a high ion density, therefore provides you the most healthy air.

Nanophotocatalytic filter disinfection, enabling better performance in removing germs and eliminating stinking air.

UV lamp effectively destroys the DNA and RNA of all sort of germs. It also activates the photocatalytic device.

The TiO₂ filter conducts the first disinfection process and slows down the air flow for better particle absorption

Pre-filter provides the first cleaning process to remove larger particles, dust mites, hairs or fibers.

