Research Equipment

- Atmosphere Control
- Thin Films & Coatings
- Solar Cells

# IRASOL

General Catalog

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# IRASOL AIR

# GLOVEBOX

Mini-computer-based glovebox with remote access

## OVERVIEW

GLX-280AS is a mini-computer controlled glovebox, allowing access and control of the system through the internet. The mini-computer controls the gas input/output and vacuum pump based on reading multiple sensors.
Five sensors are installed on the system: differential pressure sensor, absolute pressure sensor, oxygen sensor, humidity sensor and volatile organic compound (VOC) sensor.

One of the main features of the GLX-280AS
is the very low leakage rate. There are multiple pre-defined routines, including: Normal Operation, Sample Load, Sample Unload, Continuous Purge and Vacuum Purge, making the operation of the system very easy.

Besides, in the Manual Mode, one can manually control the valves for custom applications. The mini-computer saves the condition of the system at each second on memory, allowing to analyze the system for possible problems.

It is also possible to check the system through the internet.


## FEATURES

- Mini-computer based control system
- Remote control of the system through the internet
- Multiple pre-defined operation routines for easy use of system
- Very low leakage rate
- Multiple electrical and gas ports
- $O_2$, $H_2O$, VOC, P and DP sensors installed on system
- Easy system troubleshooting by company through the internet

## SPECIFICATIONS

| GLX-280AS Technical Specifications | |
|---|---|
| Model | GLX-280AS |
| Glovebox size (l x w x h) | 138 cm x 65 cm x 85 cm |
| Main chamber size (l x w x h) | 82 cm x 60 cm x 70 cm |
| Loading chamber size | l = 33 cm, D = 20 cm (Volume = 8 lit) |
| Main chamber walls | Stainless steel, t = 1.5 mm |
| Glovebox window | Tempered glass, t = 10 mm |
| Glove Port | Round Al port, for 8 inch gloves |
| Shelves | 2 shelves, 50 cm x 12 cm, mounted at different height |
| Gas Ports | KF-40 port (1x), 1/4 inch manual on/off valve (2x) |
| Gloves | l = 70 cm, D = 7 inch, t = 0.6 mm |
| Light | Warm white (1x), Cool white (1x) |
| Manual pressure gauge | 2 manual pressure gauge: vacuum gauge (-1 - 1 bar), Input gas pressure gauge (0 - 10 bar) |
| Loading chamber doors | Outside door: rotation sliding, screw lock ; Inside door: Jack-lift, screw lock |
| Sensors | Oxygen sensor: Electrochemical, 0-100% , Resolution 0.1% |
| | Temperature sensor: Resolution 0.1 °C |
| | Humidity sensor: 0-100%, Resolution 0.1% |
| | Differential pressure sensor: 0-4000 Pa, Resolution 1 Pa |
| | Absolute pressure sensor: -1000 mbar - 1000 mbar, Resolution 2 mbar |
| | VOC sensor: 0-100 ppm, Resolution 1 ppm |
| Mini-computer and electronics system | 7 inch touch LCD, Resolution 480x800 |
| | Ethernet port, USB port, Wifi, Bluetooth |
| | Automatic saving of sensors and valves data (one dataset per second) |
| Software features | Automatic control of pressure by tuning the rate of gas input and exhaust |
| | Pre-defined routine for sample loading and unloading |
| | pre-defined routine for continuous or vacuum purging |
| | Manual mode to turn on/off the valves |
| | Automatic control of vacuum pump |
| | Online display of the sensor values |
| | Internet access and control of the system |
| Electric ports | 4 banana plug connections |
| Pneumatic system | Electric valves, 1/4 inch and 1 inch. |
| | Pressure regulator 0-10 bar at the gas input line |
| | Stainless steel bellow for vacuum connections |
| | Exhaust foot pedal (to ease of working with gloves) |
| Vacuum pump | Power: 1/4 HP, Max flow: 50 L $min^{-1}$ |
| Power | Single phase, 220 VAC, 1000W |
| | 16A surface socket inside main chamber (2x) |
| | 6 A circuit breaker for electronic system |
| | 6 A circuit breaker for electric valves |
| | 16 A circuit breaker for the surface sockets |
| | Safety switch |
| Weight | 175 Kg |

# LITHIUM BATTERY GLOVEBOX

Glovebox with oxygen and moisture levels below 1ppm

## OVERVIEW

Lithium battery glovebox ASP series possess a high efficiency gas purification system to reduce the moisture and oxygen levels in the chamber down to 1ppm. The glovebox is ideal for lithium ion battery fabrication, as well as other applications where ppm level moisture and oxygen are needed. The closed cycle purification system removes oxygen and moisture, as well as organic vapors (VOCs) and dust particles. All the processes are controlled using a PLC and a dedicated software on a 10 inch HMI display. The system can be monitored and debugged over internet.

## FEATURES

- Oxygen and moisture removal to below 1 ppm
- PLC control system and a dedicated software
- Removal of organic vapors (VOC) and dust particles
- Regeneration of moisture and oxygen absorbers
- Applicable for positive and negative pressures

## SPECIFICATIONS

| GLX-600ASP Technical Specifications | | |
|---|---|---|
| Main Chamber | Glovebox size (l x w x h) | 200 cm x 75 cm x 195 cm |
| | Main chamber size (l x w x h) | 110 cm x 70 cm x 80 cm |
| | Main chamber walls | Stainless steel 304, t = 3 mm |
| | Glovebox window | Tempered glass, t = 10 mm |
| | Glove Port | Round Al port, for 8 inch gloves |
| | Shelves | 2 shelves, 60 cm x 20 cm, mounted at different height |
| | Gas Ports | KF-40 port (4x), 1/4 inch manual on/off valve (2x) |
| | Gloves | Butyl gloves, l = 32 inch, D = 8 inch, t = 0.4 mm |
| | Light | Warm white (1x), Cool white (1x) |
| | Electric ports | 4 banana plug connections<br>2 BNC Connections<br>1 Power outlet, 220 V, 16 A |
| Antechambers | Dimension | Large vacuum chamber: a cylinder with a length of 50 cm, diameter: 30 cm<br>Small vacuum chamber: a cylinder with a length of 30 cm, diameter: 13 cm |
| | Loading chamber doors | Outer and inner door of large vacuum chamber with lifting mechanism<br>Outer and inner door of small vacuum chamber with hinged mechanism |
| | Control system | The pressure inside each of the large and small vacuum chambers is indicated by a hand gauge and the pressure information is digitally transmitted to the PLC by a pressure transmitter and displayed on the HMI. The process of vacuuming and gassing the vacuum chambers is done automatically and according to the defined scenarios, and the corresponding process is displayed on the HMI. The user is able to view the pressure of the containers online. |
| Sensors | Temperature sensor | Resolution 0.1 °C |
| | Differential pressure senor | 0-4000 Pascal, precision: 1 Pascal |
| | Pressure sensors (2x) | -1000 mbar - +1000 mbar |
| | Pressure regulator at the inert gas input line | 0-18 bar |
| | VOC sensor | Solid state sensor, Indicator |
| Analyzers | Oxygen analyzer | Micro-fuel cell sensor |
| | Humidity analyzer | Capacitive sensor |
| Display | 10 Inch Capacitive Touch Screen HMI Panel | |
| Software | Adjusting the pressure of main chamber between 10- mbar and 10+ mbar<br>Automatic controlling the vacuum of chambers and adjusting the desired pressure<br>Independent program to enter parts and materials into the main chamber (Sample Load)<br>Independent program to remove parts and materials from inside the main compartment (Sample Unload)<br>Independent program to purge the main chamber (Continuous Purge)<br>Adjusting and changing all parameters of programs and scenarios (Setting)<br>Manual turning off and on all valves and also through touch monitor (Manual Operation)<br>Independent manual and automatic program for the regeneration of absorbents.<br>Turning the vacuum pump on and off intelligently through the software and switchboard<br>Possibility of switch on and off the purifier system and adjust the intensity of purifier system<br>Display of oxygen and humidity in ppm and percentage<br>Ability to issue commands and open and close programs using the pedal<br>Remote controlling and monitoring using LAN cable<br>Ability to define countless user codes, passwords and access levels | |

| GLX-600ASP Technical Specifications-Continued | | |
|---|---|---|
| Purifier Unit | Particle Filter | HEPA |
| | VOC absorber | Activated carbon |
| | O2 absorber | Cu-based |
| | Humidity absorber | Molecular sieve |
| | Blower | Variable up to 15 m3/h |
| | Connections | KF40 |
| | Final O2 concentration | < 1ppm |
| | Final humidity concentration | < 1ppm |
| power | Single phase, 220V, 16A | |
| Weight | 410 Kg | |

# IRASOL SURFACE

# UV-OZONE SURFACE TREATMENT SYSTEM

Rotating bed UV-Ozone with uniform and high intensity treatment

## OVERVIEW


UV-Ozone processing is an essential treatment in fabrication of devices such as LEDs and solar cells, as well as many other cleaning and functionalization applications. It works based on a synergic effect of UV irradiation (254 nm) and ozone (generated by 185 nm radiation), to provide a highly intense oxidizing condition. The intensity of UV and the concentration of ozone are, however, highly non-uniform across the substrate holder; more intense near the lamp sources. This results in irreproducible device performance. One of the unique features of UZ-1929R series is the rotating bed, which provides uniform exposure of samples to UV and ozone. Besides, these series are designed for high intensity UV-Ozone, leading to shorter process time.

## FEATURES

- Uniform exposure to UV-Ozone using a rotating bed
- Rapid processing by high intensity UV and small lamp-sample spacing
- Easy sample loading by sliding tray mechanism
- No UV and ozone leakage through dedicated sealing
- Rapid drain of ozonated air upon sliding out the sample tray
- LED signs, indicating the failed UV lamps to be replaced
- Useful for samples sizes up to 6 mm thickness and 180 mm length
- Ideal for cleaning substrates, including glass, silicon and GaAs
- Useful for improving adhesion to plastics and creating thin oxide on silicon or other materials

## SPECIFICATIONS

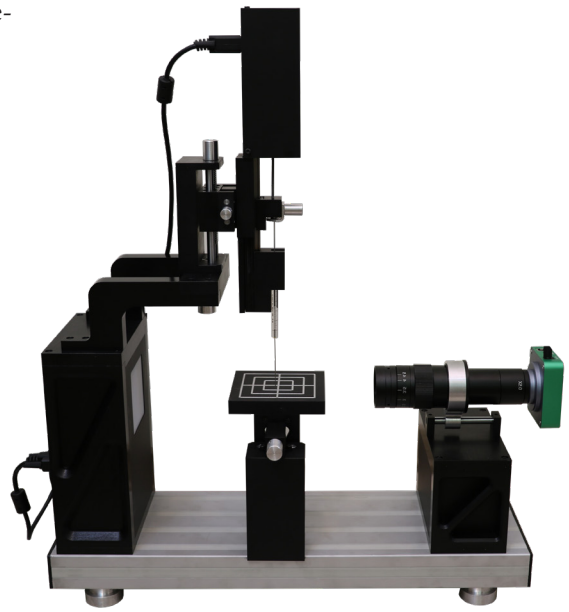
| UZ Technical Specifications | |
|---|---|
| Model | UZ-1929R |
| UV lamp type | Low pressure mercury quartz UV lamp |
| UV lamp dominant wavelengths | 185 nm, 254 nm |
| UV lamp dimensions | 10 cm × 19 cm |
| Ozone generating lamp | 220 V , 9 * 6 W Hg lamp |
| Power supply | 220 V , 50-60 Hz |
| Max run time | 99 hours |
| Safety features | Exhaust fan, electrical fuse |
| Sample holder | Sliding tray equipped with a rotating bed |
| Size of rotating bed | D = 180 mm |
| Max. recommended substrate size | 180 mm × 180 mm × 6 mm (the vertical space can be increased up to 10 mm, by request) |
| Dimensions (WxHxD) | 30 cm × 30 cm × 30 cm |
| Weight | 15 Kg |

# CONTACT ANGLE MEASUREMENT SYSTEM

Semi-automatic contact angle measurement

## OVERVIEW

CA-500A is an economic semi-automatic contact angle measurement system, based on a static Sessile drop method (upgradable to dynamic).



## FEATURES

- Static sessile drop contact angle measurement
- Software control of dispenser
- 32 Mega pixel camera
- Manual fitting and measurement of droplet contact angle
- Accurate and easy to use

## SPECIFICATIONS

| CA Technical Specifications | |
|---|---|
| Model | CA-500A |
| Measurement method | Static Sessile drop |
| Analysis method | Manual curve fit analysis |
| Measurement range | 0-180 degrees |
| Resolution | 0.01 degree |
| Accuracy | 0.1 degree |
| Camera | High performance CMOS Sensor,<br>32 Megapixel & 140x magnification, Video 30 frame per second |
| Lighting | LED Based diffused lighting mechanism;<br>Light intensity can be varied using software |
| Dispenser | Automated dispenser with precision of 0.5 microliter; a 50 microliter syringe is provided with the system, (Compatible with 20-100 microliter syringes) |
| Dispenser movement (z) | 5.6 cm |
| Sample stage movement (x, y, z) | 10 cm x 2.6 cm x 5.6 cm |
| Inlet Power | 100-240 VAC, 50-60 Hz |
| Dimensions (l x w x h) | 51 cm x 16 cm x 65 cm |
| Weight | 10 Kg |

# RAPID THERMAL PROCESSING (RTP)

Rapid visible/IR light heating for lab-scale samples

## OVERVIEW

RTP-1SX is a tube furnace with irradiation heating of samples and low heat capacity body, facilitating rapid heating and cooling of samples. The heating temperature and time can be set, and the atmosphere can be controlled, i.e. inert gas or vacuum. The irradiation is provided by maximum of 4 halogen lamps, each 1000 W. The trapped light inside the tube provides high energy concentration for rapid heating of samples.


## FEATURES

- Heating rate up to 900 °C/min
- Max temperature up to 700 °C
- Easy replace of heating elements
- Heating in controlled atmosphere
- Selection of heating power up to 4000 W

## SPECIFICATIONS

RTP Technical Specifications

| Model | | RTP1-SV | RTP1-SW |
|---|---|---|---|
| Furnace structure | Double layer Aluminum or Steel casing with air cooling keeps furnace surface temperature lower than °70C.<br>Without any extra insulating | √ | √ |
| | Aluminum casing with water and air cooling keeps furnace surface temperature lower than °70C.<br>Without any extra insulating | - | √ |
| Heating Elements | 1000 W halogen lamps (4x)<br>Dia. = 10 mm, L=190 mm, Heated Length =225mm<br>Standard working life: 2000 hrs<br>(halogen lamp is consumable) | √ | √ |
| Heating zone | 150 mm length with 100 mm constant temperature zone within ± °5 C uniformity | √ | √ |
| Working Temperature | for < 4 minute<br>(Note: For this temperature, you should be careful about your quartz tube quality that can be stable at this temperature near softening point of quartz glass - Available by 4 lamps and light graphite box) | 700 °C Max. | 850 °C Max. |
| | for < 8 minutes (Available by 4 lamps ) | 650 °C Max. | 800 °C Max. |
| | for < 20 minutes for < 60 minutes | 600 °C Max. | 750 °C Max. |
| | for < 60 minutes | 550 °C Max. | - |
| | for Continuous | 450 °C Max. | 700 °C Max. |
| Max. heating rate | 700 °C/min (Dependent on heat capacity and light absorption of the holder ,number of lamps that are on appropriate to electrical network capacity) | √ | √ |
| Max. Cooling rate | 150 °C/min (Dependent on heat capacity and light absorption of holder and gas inserted into the tube) | √ | √ |
| Temperature control | Proportional-Integral-Derivative (PID) controller | √ | √ |

| RTP Technical Specifications (Continued) | | | |
|---|---|---|---|
| Model | | RTP1-SV | RTP1-SW |
| Quartz Tube & Sample Holder | Quart Tube Size: 800 mm Length - O.D and I.D >><br>The graphite sample holder is removable from the flange for using the RTP furnace for other purposes. | 38 mm O.D<br>36 mm I.D | 60 mm O.D<br>55 mm I.D |
| Sample holder | Optional: Graphite sample holder for samples not larger than 1.4 cm in size. | √ | √ |
| Max sample size | (depending on thickness of sample holder) for direct use without sample holder | 19× 14 $mm^2$ | 55× 100 $mm^2$ |
| Power input | 220 AC, 50 Hz single phase or 3 phase (25 A)V | √ | √ |
| Water circulation system for body cooling | | - | √ |
| Flow-meter (Optional) | One flow meter is installed on the front panel for adjusting the gas flow from 1000-50 sccm | Optional | Optional |
| Atmosphere | | Air, Vacuum, Gas static, Gas flow | Air, Vacuum, Gas static, Gas flow |
| Accessories (Optional) | Vacuum pump, Vacuum Gage, special Graphite box,<br>Flow-meter, Programmable PID controller | √ | √ |
| Safety | Thermal Safety system for auto-deactivate setup when the temperature of setup body increase more than acceptable temperature<br>Residual Current Devices (RCD) | √ | √ |

# IRASOL PV

# SOLAR CELL EXTERNAL QUANTUM EFFICIENCY MEASUREMENT SYSTEM (IPCE)

Economical and Semi-automatic system

## OVERVIEW

IRASOL's IPCE-020 is an optimized LED-based system that is economic and compact, well suited for lab-scale solar cell characterization. In IPCE-020 innovative design, the quasi monochromatic light is provided using single wavelength LEDs that cover spectral range from 370 nm to 940 nm. This results in a compact and easy-to-use system. It is low-weight and requires no optical bench or optical alignment and setup.
The intensity of LED light is considerably important in solar cells in which the current collection efficiency depends on light intensity.
IPCE-020 is well-suited for new-generation solar cells including perovskite and dye solar cells, but it can be safely used for other types of solar cells.


## FEATURES

- Automated IPCE measurement for lab-scale solar cells
- LED-based light source with 19 individual wavelengths
- Covering spectral range from 370 nm to 940 nm
- Containing a calibrated reference cell installed on the system
- Small, low cost and robust system
- Long-life LED light source (compared to conventional Xe lamps)
- No need for optical bench and optical alignment
- Ideal for perovskite and dye solar cells, as well as other types of solar cell

## SPECIFICATIONS

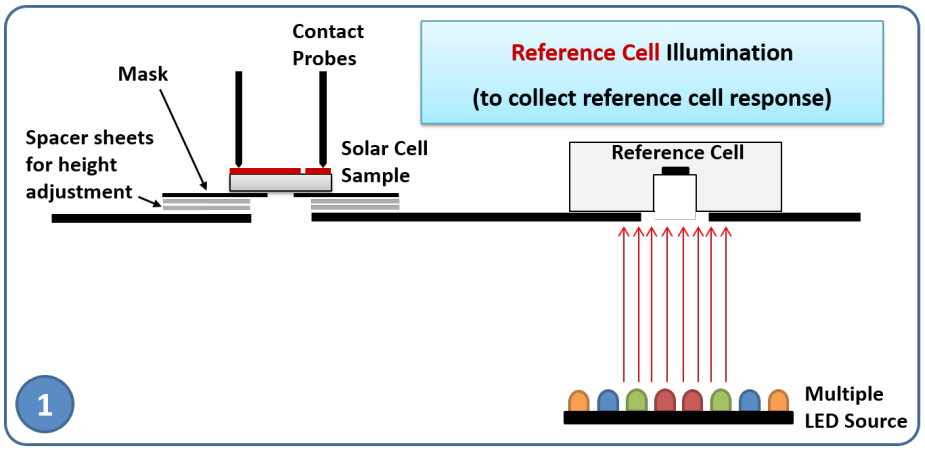
| IPCE-020 Technical Specifications | |
|---|---|
| Wavelength Points (nm) | 370, 400, 420, 450, 465, 505, 530, 570, 595, 610, 625, 660, 700, 730, 765, 800, 845, 895, 940 |
| Reference Cell | Silicon PN photodiode (area: 0.073 $cm^2$) |
| Power Supply | 12 VDC, 2A (Input: 100-240 VAC) |
| Computer Interface | USB 2.0 |
| Solar Cell Active Area | 0.01 to 0.5 $cm^2$ (0.05 to 0.3 $cm^2$ is preferred) |
| Minimum Requirement for Solar Cell Sample | $J_{sc}$ (@AM1.5) > 1 $mA/cm^2$ (depends on cell area and wavelength) |
| Dimension (LxWxH) | 61 cm × 30 cm × 19 cm |
| Weight | 9.4 Kg |

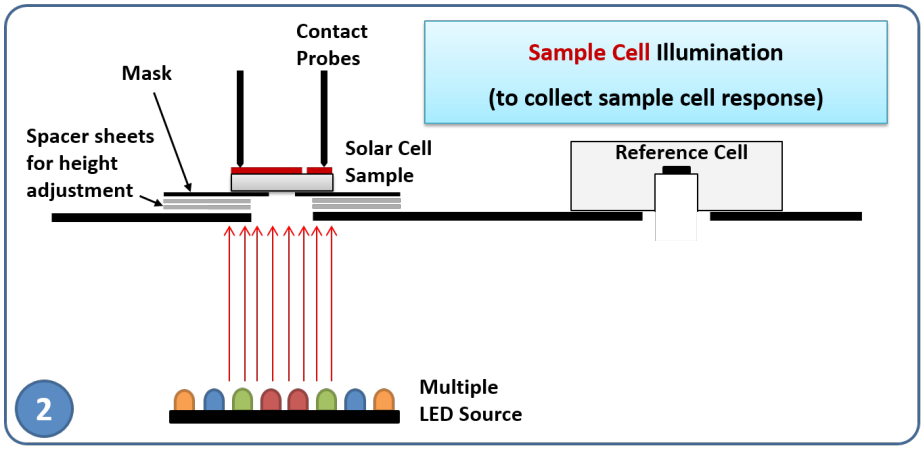
## HOW IT WORKS

In IPCE-020 a full LED light source is utilized. Each category of LEDs produces quasi-monochromatic light which is used for the measurement.

There are 19 types of LEDs with the same number of wavelengths covering 370-940 nm range.

Measurement method for the IPCE-020 system is schematically shown in the following scheme. For each run of measurement, the short circuit current of the reference cell is measured first to determine the light intensity for each wavelength. After this stage, the sample is pushed above the LED lamp and short circuit current measurement is made for the sample.



# UNIVERSAL SOLAR CELL TESTER

A comprehensive package of characterizations for lab-scale solar cells

## OVERVIEW

The universal solar cell tester consists of a solar simulator and I-V measurement module, that allows various measurements at different temperatures and light intensities under controlled atmosphere conditions. The solar simulator includes an all-LED source with AM1.5 spectrum, according to IEC60904-9.
Although perovskite solar cells have a record efficiency of more than 25%, there are still problems of thermal stability, light stability, hysteresis, ion migration, and so on. By performing a wide range of measurements that are usually taken in laboratories with various equipment and methods, this system provides quick feedback for the evaluation and optimization of perovskite solar cells on a laboratory scale.

## FEATURES

- Including solar simulator, I-V measurement module, temperature and atmosphere control module and comprehensive measurement software
- Measurement of solar cell characteristics in the temperature range of 5 °C-75 °C
- Measurement under different light intensities 0.1 – 1 Sun
- The possibility of evaluating the thermal and optical stability of peovskite cells
- Comprehensive software, with automatic calculation of relevant quantities in each measurement
- Possibility of measurement under controlled atmosphere

| Univeral Solar Cell Tester Specifications | |
|---|---|
| Model | UPT-100 |
| Light source | Multiple LED source |
| Wavelength range | 400-1000 nm |
| Non-uniformity of irradiance | < 2% (Class A) |
| Spectral match | < 5% (Class A+) |
| Temporal instability | < 0.5% (Class A) |
| Direction of illumination | Source down, sample top |
| Sample size | Max 28 mm |
| Lamp intensity adjustment | 0.1 Sun- 1.0 Sun |
| Sample temperature sensing | Hot-plate sensor, IR pyrometer sensor |
| Thermal Protection | Heat sink temperature |
| I-V tracer voltage range | ± 5 V |
| Voltage set resolution | 1 mV |
| Maximum current | 1 A |
| Current range | 50 mA, 5 mA, 0.5 mA |
| Current resolution | %0.001 of current range (22-16 bit ADC) |
| Input voltage | 220 VAC (60-50 Hz) |
| Computer interface | USB |
| Control software | UPTS-100.0.0 |
| Measurement methods | Current-voltage/light<br>Current-voltage/dark<br>Variable light intensity<br>MPP tracking<br>Voc decay<br>Stability test<br>Thermal response |
| Software requirement | OS: Windows 10 |

## FTO, ITO & COATED ELECTRODES

IRASOL supplies different options of conductive glass (glass/ITO) at different sizes. It also provides different coated electrodes on glass/ITO substrates.

Conductive glass: Glass/ITO
Electrodes: $TiO_2$ blocking layer electrode| ZnO blocking layer electrode | Transparent meso-$TiO_2$ electrode | Transparent/Reflector $TiO_2$ electrode | Pt electrode

### Glass/ITO

]Indium tin oxide (ITO) conductive glass

ITO (indium tin oxide) coated glass is the most common transparent conductive film in various devices. It is also used in solar cells, for instance, in p-i-n perovskite solar cells. It should be noted that the sheet resistance of ITO may change upon heat treatment.

| ITO Technical Specifications | | |
|---|---|---|
| Glass thickness: 1.1 mm | Packaging and Order Number | |
| Sheet Resistance: 8-10 Ω/□ | TCO-ITO-14MM-20 | 14×14 $cm^2$ |
| | TCO-ITO-20MM-20 | 20×20 $mm^2$ |
| | TCO-ITO-E-14MM-20 | 14×14 $cm^2$ -Etched |
| | TCO-ITO-E-20MM-20 | 20×20 $mm^2$ -Etched |

### $TiO_2$ Blocking Layer Electrode

Clear $TiO_2$/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. A thin layer of $TiO_2$ is the most commonly used blocking layer and the films are best deposited by spray pyrolysis. $TiO_2$ blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of $TiO_2$.

| ELD-TBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: $TiO_2$ thin film | ELD-TBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: 50-70 nm | | |
| Color: Transparent | | |

## ZnO Blocking Layer Electrode

Clear ZnO/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. ZnO blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of ZnO using spray pyrolysis.

| ELD-ZBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: ZnO thin film | ELD-ZBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: <100 nm | | |
| Color: Transparent | | |

## Transparent meso-$TiO_2$ Electrode

A transparent meso-$TiO_2$ layer on FTO for DSSC fabrication

Transparent meso-$TiO_2$ electrode contains Glass/FTO which is coated with several micrometer transparent layer of meso-$TiO_2$. It is used to fabricate the photo-anode of dye sensitized solar cells. Before using the electrode it is recommended to heat the electrode at around 500 °C for a few minutes in a furnace.

| ELD-20T Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: meso-$TiO_2$ | ELD-20T-20 | 20 |
| Deposition method: Screen print | | |
| Thickness: ~ 6-7 µm | | |
| Color: Transparent | | |

## Transparent / Reflector $TiO_2$ Electrode

A transparent / Reflector $TiO_2$ double layer on FTO for DSSC fabrication

Transparent /reflector $TiO_2$ film contains ~5 µm of reflector $TiO_2$ particles and ~7 µm layer of $TiO_2$ nanoparticles with average size of 20 nm, deposited on FTO glass. The scattering layer increases light harvesting efficiency. This electrode can be used as a standard photo-anode to evaluate dye molecules, quantum dots, electrolyte and different cathodes for dye sensitized solar cells. Annealing at 500 °C is recommended prior to use.

| ELD-TR Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: meso-$TiO_2$ / Reflector Anatase $TiO_2$ | ELD-TR-20 | 20 |
| Deposition method: Screen print | | |
| Thickness: ~ 10-12 µm | | |
| Color: White | | |

## Pt Electrode

Pt nanoparticle layer on FTO as counter electrode of DSSCs

Platinum electrode containing Pt nanoparticles on FTO glass is applied as cathode for dye-sensitized solar cells. Note that annealing at 460 °C for 15 min is required prior to use.

| ELD-PT Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: Pt nanoparticles | ELD-PT-20 | 20 |
| Deposition method: Screen print | | |
| Thickness: < 10 nm | | |
| Color: Light gray | | |

## Inks and Pastes

IRASOL, in collaboration with partner labs, has developed various inks and pastes, mainly used and optimized for solar cells fabrication. Inks can be applied on the surface using spin coating, spray and other printing techniques. Pastes can be applied mainly by blade coating or screen printing.

METAL INKS AND PASTES:

Gold ink | Tetrachloroauric acid | Silver ink | Silver nanowire ink | Pt paste

CARBON INKS AND PASTES:

Graphene oxide ink | Carbon paste

METAL OXIDE PASTES:

$TiO_2$ Paste- Transparent | $TiO_2$ Paste- Reflector Anatase | $TiO_2$ Paste- Reflector Rutile | $TiO_2$ Paste- Reflector Rutile@$SiO_2$

METAL OXIDE INKS:

Crystalline aqueous $TiO_2$ sol | Amorphous aqueous $TiO_2$ sol | Acidic aqueous $TiO_2$ sol | Crystalline $TiO_2$ sol in ethanol

NON-OXIDE INKS AND PASTES:

$CuInS_2$ ink , $CuInGaS_2$ ink

## Gold Ink

Au stable ink to deposit Au films

Gold ink is an stable dispersion of gold nanoparticles dispersed in toluene. This ink can be used for deposition of Au electrodes for perovskite solar cells or other devices.

| INK-50AU Technical Specifications | | |
|---|---|---|
| Nanoparticles: Au | Packaging and Order Number | |
| Particle Size: Avg. 5-6 nm | INK-50AU-1ML | 1 mL |
| Concentration: 15% | | |
| Physical Form: Liquid dispersion | | |
| Color: Dark red-brown | | |
| Solvent: Toluene | | |
| Storage: 2-8 °C | | |

## Tetrachloroauoric Acid ($HAuCl_4$)

Au precursor solution

$HAuCl_4$ is the conventional source of Au, for the synthesis of Au nanoparticles or thermal deposition of Au film.

| PRE-HAUCL Technical Specifications | | |
|---|---|---|
| Material: $HAuCl_4$ | Packaging and Order Number | |
| Assay: >99.5% | PRE-HAUCL-10ML | 10 mL |
| Concentration: 100 mg/ml | | |
| Physical Form: Liquid solution | | |
| Color: Yellow | | |
| Solvent: $H_2O$ | | |

## Silver Ink

Silver conductive ink for wiring and metal contact

Silver ink consists of a concentrated Ag nanowire dispersion in $H_2O$, suitable for printing conductive wires and films.

| AG INK Technical Specifications | | |
|---|---|---|
| Particles: Ag Nanowires | Packaging and Order Number | |
| Particle Size: D ~ 100 nm, L < 10 µm | INK-100AG-1G | 1 g |
| Concentration: 25-30 wt% | INK-100AG-5G | 5 g |
| Physical Form: Liquid dispersion | INK-100AG-10G | 10 g |
| Color: Gray | | |
| Solvent: H2O | | |
| Shelf Life: 2 month | | |
| Curing Temperature/ Time: 100 °C /20 min | | |
| Resistivity (mΩ/sq/40µm): ≤ 85 at 25°C, ≤ 65 at 100°C, ≤ 40 at 250°C | | |
| Storage: < 5 °C | | |

## Silver Nanowire Ink

Silver nanowire ink to deposit transparent conductive electrodes

Silver nanowire ink consists of a dilute Ag nanowire dispersion in ethanol, designed for deposition of transparent conductive films. It can be sprayed or spin coated on a substrate.

| AGW INK Technical Specifications | | |
|---|---|---|
| Particles: Ag nanowires | Packaging and Order Number | |
| Particle Size: D ~ 100 nm, L > 10 µm | INK-100AGW-10ML | 10 mL |
| Concentration: 0.1 wt% | INK-100AGW-20ML | 20 mL |
| Physical Form: Liquid dispersion | | |
| Color: Gray | | |
| Solvent: Ethanol | | |

## Pt Paste

Pt containing paste to deposit Pt nanoparticle electrodes

Pt paste contains $H_2PtCl_6$ as Pt source in a paste containing solvent and binder. The paste can be easily applied by blade coating or screen printing. After thermal treatment a uniform thin layer of Pt nanoparticles is formed on the surface. Conventionally, Pt paste is applied on glass/FTO substrate acting as counter electrode of dye sensitized solar cells with high electrocatalytic activity.

| PST-PT Technical Specifications | | |
|---|---|---|
| Pt source: $H_2PtCl_6$ | Packaging and Order Number | |
| Concentration: 0.3% | PST-PT-1G | 1 g |
| Physical Form: Paste | PST-PT-5G | 5 g |
| Color: light Yellow | PST-PT-10G | 10 g |
| Storage: Dark 2-8 °C | PST-PT-20G | 20 g |

## Carbon Paste

Terpineopl based carbon paste as a conductive electrode

The carbon paste contains graphite and carbon black as carbon source, terpineol solvent and other additives and binders. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated and at below 400 °C the binder is removed.

| PST-100C Technical Specifications | | |
|---|---|---|
| Carbon source: Graphite, Carbon black | Packaging and Order Number | |
| Concentration of carbon: 20% | PST-100C-1G | 1 g |
| Physical Form: Paste | PST-100C-5G | 5 g |
| Color: black | PST-100C-10G | 10 g |
| Storage: 2-8 °C | PST-100C-20G | 20 g |

## Carbon Paste

Toluene-based carbon paste suitable for perovskite solar cells

PST-101C is a conductive caron paste based on toluene solvent. It is ideal for perovskite solar cells and in applications were polar solvents should be avoided. One of the advantages of this carbon paste is that it forms a relatively flexible structure and can be used in flexible devices. The paste can be applied by methods such as blade coating. A post treatment at temperatures higher than 100 C will cure the paste.

| PST-101C Technical Specifications | | |
|---|---|---|
| Compoition: Graphite, Binder, Additive in Toluene | Packaging and Order Number | |
| Concentration of carbon: 20% | PST-101C-1G | 1 g |
| Physical Form: Paste | PST-101C-5G | 5 g |
| Color: black | PST-101C-10G | 10 g |
| Storage: 2-8 °C | PST-101C-20G | 20 g |

## Nanocrystal $TiO_2$ Paste - Transparent

Ideal paste for meso-$TiO_2$ deposition

$TiO_2$ nanocrystal paste contains nanocrystals with narrow range of size distribution which form a very uniform and transparent film of mesoporous $TiO_2$. The paste can be applied as thick film by blade coating or screen printing for dye sensitized solar cells. For perovskite solar cells, the paste is first diluted and deposited as a thin film using spin coating. Thermal post-treatment is required after deposition. For thick films, a short ethanol vapor treatment helps level off the wet film. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-20T Technical Specifications | | |
|---|---|---|
| Nanoparticles: TiO2 - Anatase | Packaging and Order Number | |
| Particle Size: Around 20 nm | PST-20T-1G | 1 g |
| Concentration: 18% | PST-20T-5G | 5 g |
| Physical Form: Paste | PST-20T-10G | 10 g |
| Color: Cream | PST-20T-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Anatase

A paste of anatase $TiO_2$ particles for reflection layer of DSSCs

This type of $TiO_2$ paste contains relatively large anatase $TiO_2$ particles, formed as a paste using a solvent and binder. The size of particles is larger than 100 nm and produce high light reflection, which is required for a reflector layer in dye sensitized solar cells. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-300A Technical Specifications | | |
|---|---|---|
| Nanoparticles: TiO2 - Anatase | Packaging and Order Number | |
| Particle Size: >100 nm | PST-300A-1G | 1 g |
| Concentration: 28 wt% | PST-300A-5G | 5 g |
| Physical Form: Paste | PST-300A-10G | 10 g |
| Color: White | PST-300A-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Rutile

A paste of rutile $TiO_2$ particles for reflection layer of DSSCs

This type of $TiO_2$ paste contains relatively large rutile $TiO_2$ particles, formed as a paste using a solvent and binder. The particle size distribution is broad, with typical size of about 300 nm. Rutile $TiO_2$ has higher refractive index compared to anatase $TiO_2$, hence showing higher reflection of light. However, in dye sensitized solar cells the smaller bandgap of rutile may reduce the performance of device. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C particles are sintered.

| PST-300R Technical Specifications | | |
|---|---|---|
| Particles: $TiO_2$ - Rutile | Packaging and Order Number | |
| Particle Size: Around 300 nm | PST-300R-1G | 1 g |
| Concentration: 28 wt% | PST-300R-5G | 5 g |
| Physical Form: Paste | PST-300R-10G | 10 g |
| Color: White | PST-300R-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Rutile@$SiO_2$

A paste of rutile $SiO_2$ coated $TiO_2$ particles for reflection layer of DSSCs

This $TiO_2$ paste is essentially similar to rutile $TiO_2$ paste, however, the rutile particles are coated using a thin layer of $SiO_2$, in order to inhibit the electrical conductivity. In dye sensitized solar cells, a rutile@$SiO_2$ reflector layer only shows optical effect, and due to being an insulator, plays no electrical role in the solar cell device. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-400RS Technical Specifications | | |
|---|---|---|
| Particles: $TiO_2$–Rutile coated with $SiO_2$ | Packaging and Order Number | |
| Particle Size: 250-500 nm, $SiO_2$ shell: ~70 nm | PST-400RS-1G | 1 g |
| Concentration: 28 wt% | PST-400RS-5G | 5 g |
| Physical Form: Paste | PST-400RS-10G | 10 g |
| Color: White | PST-400RS-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Rutile@$SiO_2$

Paste of rutile $SiO_2$ coated $TiO_2$ particles for reflection layer of DSSCs

This $TiO_2$ paste is essentially similar to rutile $TiO_2$ paste, however, the rutile particles are coated using a thin layer of $SiO_2$, in order to inhibit the electrical conductivity. In dye sensitized solar cells, a rutile@$SiO_2$ reflector layer only shows optical effect, and due to being an insulator, plays no electrical role in the solar cell device. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-400RS Technical Specifications | | |
|---|---|---|
| Particles: $TiO_2$–Rutile coated with $SiO_2$ | Packaging and Order Number | |
| Particle Size: 250-500 nm, $SiO_2$ shell: ~70 nm | PST-400RS-1G | 1 g |
| Concentration: 28 wt% | PST-400RS-5G | 5 g |
| Physical Form: Paste | PST-400RS-10G | 10 g |
| Color: White | PST-400RS-20G | 20 g |
| Storage: 2-8 °C | | |

## Standard Iodine-based Electrolyte

DSSC electrolyte in acetonitrile

Standard electrolyte contains $I^-/I_3^-$ redox in acetonitrile solvent. With this electrolyte high current can be obtained with dye sensitized solar cell devices. However, acetonitrile is a low boiling point solvent and suitable sealing of cell is required.

| ELT-ACN-I Technical Specifications | | |
|---|---|---|
| Redox couple: $I^-/I_3^-$ | Packaging and Order Number | |
| Solvent: Acetonitrile | ELT-ACN-I-1ML | 1 mL |
| Additives: 8% | ELT-ACN-I-5ML | 5 mL |
| Physical Form: liquid | ELT-ACN-I-10ML | 10 mL |

## Crystalline Aqueous $TiO_2$ Sol

Nanocrystal $TiO_2$ stable neutral aqueous sol with no dispersing agent

Crystalline aqueous $TiO_2$ sol is a dispersion of $TiO_2$ nanoparticles in $H_2O$ with neutral pH. The sol is electrostatically stable, without any carbon-containing dispersing agents. It forms uniform and adhering films due to the highly sol-gel active surface of nanoparticles.

| SOL-30TC Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$ – anatase | Packaging and Order Number | |
| Particle shape: spindle shape | SOL-30TC-10ML | 10 mL |
| Particle Size: Around 30 nm (DLS) | SOL-30TC-50ML | 5 x 10 mL |
| Concentration: 1 wt% | | |
| Physical Form: Liquid dispersion | | |
| Color: yellow | | |
| Solvent: $H_2O$ | | |
| pH: neutral | | |
| Ion conductivity: ~ 200 mS/cm | | |
| Dispersing agent: No | | |

## Amorphous Aqueous $TiO_2$ Sol

Amorphous $TiO_2$ stable neutral aqueous sol with no dispersing agent

Amorphous aqueous $TiO_2$ sol is a dispersion of very small $TiO_2$ nanoparticles in $H_2O$ with neutral pH. The sol is electrostatically stable, without any carbon containing dispersing agents. It forms uniform and adhering films due to the highly sol-gel active surface of nanoparticles.

| SOL-10TA Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$ - amorphous | Packaging and Order Number | |
| Particle Size: <10 nm | SOL-10TA-10ML | 10 mL |
| Concentration: 1 wt% | SOL-10TA-50ML | 5 x 10 mL |
| Physical Form: Liquid dispersion | | |
| Color: Slightly Yellow | | |
| Solvent: $H_2O$ | | |
| pH: neutral | | |
| Ion conductivity: ~ 200 mS/cm | | |
| Dispersing agent: No | | |

## Acidic aqueous $TiO_2$ Sol

Acidic dispersion of small $TiO_2$ nanoparticles

Acidic aqueous $TiO_2$ sol is a dispersion of small amorphous $TiO_2$ nanoparticles in $H_2O$ with low pH. It can be used to form thin films of $TiO_2$.

| SOL-10TAC Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$- amorphous | Packaging and Order Number | |
| Particle Size: <10 nm (DLS) | SOL-10TAC-10ML | 10 mL |
| Concentration: 1 wt% | SOL-10TAC-50ML | 5 x 10 mL |
| Physical Form: Liquid dispersion | | |
| Color: transparent | | |
| Solvent: H2O | | |
| pH: < 2 | | |

## Crystalline $TiO_2$ Sol in Ethanol

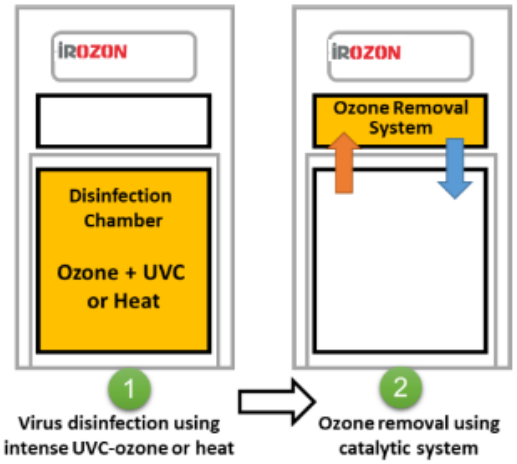
Ethanol dispersion of highly crystalline $TiO_2$ nanoparticles

Crystalline $TiO_2$ sol in ethanol is a dispersion of $TiO_2$ nanoparticles in ethanol. Nanoparticles are relatively mono-dispersed, with high crystallinity. It can be used to form thin films of highly crystalline $TiO_2$ nanoparticles.

| SOL-20TET Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$- Anatase | Packaging and Order Number | |
| Particle Size: Around 20 nm | SOL-20TET-10ML | 10 mL |
| Concentration: 0.1 wt% | SOL-20TET-50ML | 5 x10 mL |
| Physical Form: Liquid dispersion | | |
| Color: White | | |
| Solvent: Ethanol | | |

# DRY DISINFECTION SYSTEM

In addition to UVC-ozone process, the system supports thermal disinfection process. It raises the temperature to 60 -55 °C for 45-10 min.
For many of virus and bacteria species this thermal dose is sufficient to kill them. In the meantime, forced air guarantees uniform temperature distribution in the chamber.




| UDS Technical Specifications | |
|---|---|
| Model | UDS-400 |
| UV-Ozone source | Low pressure mercury lamp, 18 W ×2 |
| disinfection Mechanism | 3UVC photonic disinfection, Ozone-UVC synergic oxidative disinfection, thermal disinfection (55 – 60 °C heat process) |
| Ozone Removal System | $MnO_2$-based ozone decomposition catalyst |
| Catalyst replacement | Not required. In case catalyst is deactivated, it is regenerated by pushing the Catalyst Regeneration button |
| Ozone Sensing | 0.001 – 1000 ppm. Ozone sensor- low concentration, Ozone sensor- high con centration (Semiconductor based sensor), Plus optical ozone sensing |
| UV Sensing | UV sensor module, selective for UVC |
| Temperature/ Humidity Sensing | T: 0-60 °C, RH: 0-100%, temperature humidity sensor chip |
| Electronics | Microcontroller based. Automatic fault detection |
| Displayed Quantities | Ozone dose, UVC dose, Temperature, Humidity, Ozone high/safe alerts, Error alerts, System Status LEDs |
| UVS-Ozone Process Timing | 2 min, 5 min, 15 min |
| Thermal Processing Timing | 10 min, 25 min, 45 min |
| Typical Ozone Removal Time | 2.5 min |
| Chamber Walls | Al UVC reflective sheets |
| Dimensions (w × d × h) | 50 cm × 40 cm × 75 cm |
| Weight | 30 Kg |

## $CuInS_2$ Ink

Stable dispersion to deposit high performance HTM layers

$CuInS_2$ nanoparticles dispersed in chloroform can be applied with high uniformity using spin coating. It is a p-type semiconductor and has been successfully used as an inorganic hole transporting material (HTM) of perovskite solar cells.

| INK-20CIS Technical Specifications | | |
|---|---|---|
| Nanoparticles: $CuInS_2$ | Packaging and Order Number | |
| Particle Size: ~18 nm (DLS Analysis) | INK-20CIS-10ML | 10 mL |
| Concentration: 30 mg $mL^{-1}$ | | |
| Physical Form: Liquid dispersion | | |
| Color: Black | | |
| Solvent: Chloroform | | |

## $CuInGaS_2$ Ink

Stable dispersion to deposit an efficient absorbing layer of CIGS solar cells

$CuInGaS_2$ nanoparticles dispersed in chloroform can be applied with high uniformity using spin coating. It is a p-type semiconductor and has been successfully used as an absorbing layer of CIGS solar cells and inorganic hole transporting material (HTM) of perovskite solar cells.

| INK-25CIGS Technical Specifications | | |
|---|---|---|
| Nanoparticles: $CuInGaS_2$ | Packaging and Order Number | |
| Particle Size: 20-30 nm (DLS Analysis) | INK-25CIGS-10ML | 10 mL |
| Concentration: 25 mg $mL^{-1}$ | | |
| Physical Form: Liquid dispersion | | |
| Color: Black | | |
| Solvent: Chloroform | | |

## Materials for Dye Sensitized Solar Cells

IRASOL and its partner labs have long experience with high-efficiency dye sensitized solar cells (DSSC) and have developed various materials and electrodes suited for research in the field of DSSC.

$TiO_2$: $TiO_2$ Paste- Transparent | $TiO_2$ Paste- Reflector Anatase | $TiO_2$ Paste- Reflector Rutile | $TiO_2$ Paste- Reflector Rutile@$SiO_2$

ELECTROLYTE: Standard iodine-based | High performance iodine-based | Low volatility iodine-based

ELECTRODES: $TiO_2$ blocking layer electrode| ZnO blocking layer electrode | Transparent meso-$TiO_2$ electrode | Transparent/Reflector $TiO_2$ electrode | Pt electrode

OTHER PASTES: Pt paste | Carbon paste

## Nanocrystal $TiO_2$ Paste - Transparent

Ideal paste for meso-$TiO_2$ deposition

$TiO_2$ nanocrystal paste contains nanocrystals with narrow range of size which form a very uniform and transparent film of mesoporous $TiO_2$. The paste can be applied as thick film by blade coating or screen printing for dye sensitized solar cells.
For perovskite solar cells, the paste is first diluted and deposited as a thin film using spin coating. Thermal post-treatment is required after deposition. For thick films, a short ethanol vapor treatment helps level off the wet film. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-20T Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$ - Anatase | Packaging and Order Number | |
| Particle Size: Around 20 nm | PST-20T-1G | 1 g |
| Concentration: 18% | PST-20T-5G | 5 g |
| Physical Form: Paste | PST-20T-10G | 10 g |
| Color: Cream | PST-20T-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Anatase

Paste of anatase $TiO_2$ particles for reflection layer of DSSCs

This type of $TiO_2$ paste contains relatively large anatase $TiO_2$ particles, formed as a paste using a solvent and binder. The size of particles is larger than 100 nm and produce high light reflection, which is required for a reflector layer in dye sensitized solar cells. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-300A Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$ - Anatase | Packaging and Order Number | |
| Particle Size: >100 nm | PST-300A-1G | 1 g |
| Concentration: 28 wt% | PST-300A-5G | 5 g |
| Physical Form: Paste | PST-300A-10G | 10 g |
| Color: White | PST-300A-20G | 20 g |
| Storage: 2-8 °C | | |

## $TiO_2$ Paste – Reflector Rutile

Paste of rutile $TiO_2$ particles for reflection layer of DSSCs

This type of $TiO_2$ paste contains relatively large rutile $TiO_2$ particles, formed as a paste using a solvent and binder. The particles size distribution is broad, with typical size of about 300 nm. Rutile $TiO_2$ has higher refractive index compared to anatase $TiO_2$, hence showing higher reflection of light. However, in dye sensitize solar cells the smaller bandgap of rutile may reduce the performance of device. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C particles are sintered.

| PST-300R Technical Specifications | | |
|---|---|---|
| Particles: $TiO_2$ - Rutile | Packaging and Order Number | |
| Particle Size: Around 300 nm | PST-300R-1G | 1 g |
| Concentration: 28 wt% | PST-300R-5G | 5 g |
| Physical Form: Paste | PST-300R-10G | 10 g |
| Color: White | PST-300R-20G | 20 g |
| Storage: 2-8 °C | | |

## High Performance Iodine-based Electrolyte

DSSC electrolyte in acetonitrile/valeronitrile

High Performance electrolyte contains $I^-/I^-_3$ redox in acetonitrile/valeronitrile mixed solvent. Adding valeronitrile reduces the volatility of the electrolyte and improves the stability of cells.

| ELT-AV-I Technical Specifications | | |
|---|---|---|
| Redox couple: $I^-/I_3^-$ | Packaging and Order Number | |
| Solvent: Acetonitrile/valeronitrile | ELT-AV-I-1ML | 1 mL |
| Additives: ~ 10% | ELT-AV-I-5ML | 5 mL |
| Physical Form: Liquid | ELT-AV-I-10ML | 10 mL |

## Low Volatility Iodine-based Electrolyte

DSSC electrolyte in 3-methoxypropionitrile

This electrolyte contains $I^-/I_3^-$ redox in 3-methoxypropionitrile solvent. This is a low volatility electrolyte and provides solar cells with high stability.

| ELT-MPN Technical Specifications | | |
|---|---|---|
| Redox couple: $I^-/I^-_3$ | Packaging and Order Number | |
| Solvent: 3-methoxypropionitrile | ELT-MPN-I-1ML | 1 mL |
| Additives: 27% | ELT-MPN-I-5ML | 5 mL |
| Physical Form: Liquid | ELT-MPN-I-10ML | 10 mL |

## $TiO_2$ Blocking Layer Electrode

Clear $TiO_2$/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. A thin layer of $TiO_2$ is the most commonly used blocking layer and the films are best deposited by spray pyrolysis. $TiO_2$ blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of $TiO_2$.

| ELD-TBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: $TiO_2$ thin film | ELD-TBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: 50-70 nm | | |
| Color: Transparent | | |

## ZnO Blocking Layer Electrode

Clear ZnO/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. ZnO blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of ZnO using spray pyrolysis.

| ELD-ZBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: ZnO thin film | ELD-ZBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: <100 nm | | |
| Color: Transparent | | |

## Transparent meso-$TiO_2$ Electrode

A transparent meso-$TiO_2$ layer on FTO for DSSC fabrication

Transparent meso-$TiO_2$ electrode contains Glass/FTO which is coated with several micrometer transparent layer of meso-$TiO_2$. It is used to fabricate the photo-anode of dye sensitized solar cells. Before using the electrode it is recommended to heat the electrode at around 500 °C for a few minutes in a furnace.

| ELD-20T Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: meso-$TiO_2$ | ELD-20T-1 | 1 |
| Deposition method: Screen print | ELD-20T-5 | 5 |
| Thickness: ~ 6-7 µm | ELD-20T-10 | 10 |
| Color: Transparent | ELD-20T-20 | 20 |

## Transparent / Reflector $TiO_2$ Electrode

A transparent / Reflector $TiO_2$ double layer on FTO for DSSC fabrication

Transparent /reflector $TiO_2$ film contains ~5 µm of reflector $TiO_2$ particles and ~7 µm layer of $TiO_2$ nanoparticles with average size of 20 nm, deposited on FTO glass. The scattering layer increases light harvesting efficiency. This electrode can be used as a standard photo-anode to evaluate dye molecules, quantum dots, electrolyte and different cathodes for dye sensitized solar cells. Annealing at 500 °C is recommended prior to use.

| ELD-TR Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: meso-$TiO_2$ / Reflector Anatase $TiO_2$ | ELD-TR-1 | 1 |
| Deposition method: Screen print | ELD-TR-5 | 5 |
| Thickness: ~ 10-12 µm | ELD-TR-10 | 10 |
| Color: White | ELD-TR-20 | 20 |

## Pt Electrode

Pt nanoparticle layer on FTO as counter electrode of DSSCs

Platinum electrode containing Pt nanoparticles on FTO glass is applied as cathode for dye-sensitized solar cells. Note that annealing at 460 °C for 15 min is required prior to use.

| ELD-PT Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: Pt nanoparticles | ELD-PT-1 | 1 |
| Deposition method: Screen print | | |
| Thickness: < 10 nm | | |
| Color: Light gray | | |

## Pt Paste

Pt containing paste to deposit Pt nanoparticle electrodes

Pt paste contains $H_2PtCl_6$ as Pt source in a paste containing solvent and binder. The paste can be easily applied by blade coating or screen printing. After thermal treatment a uniform thin layer of Pt nanoparticles is formed on the surface. Conventionally, Pt paste is applied on glass/FTO substrate acting as counter electrode of dye sensitized solar cells with high electrocatalytic activity.

| PST-PT Technical Specifications | | |
|---|---|---|
| Pt source: $H_2PtCl_6$ | Packaging and Order Number | |
| Concentration: 0.3% | PST-PT-1G | 1 g |
| Physical Form: Paste | PST-PT-5G | 5 g |
| Color: light Yellow | PST-PT-10G | 10 g |
| Storage: Dark 2-8 °C | PST-PT-20G | 20 g |

## Carbon Paste

Terpineopl based carbon paste as a conductive electrode

The carbon paste contains graphite and carbon black as carbon source, terpineol solvent and other additives and binders. The paste can be applied by blade coating or screen printing. By thermal treatment, at around 100 °C the solvent is evaporated and at below 400 °C the binder is removed.

| PST-100C Technical Specifications | | |
|---|---|---|
| Carbon source: Graphite, Carbon black | Packaging and Order Number | |
| Concentration of carbon: 20% | PST-100C-1G | 1 g |
| Physical Form: Paste | PST-100C-5G | 5 g |
| Color: black | PST-100C-10G | 10 g |
| Storage: 2-8 °C | PST-100C-20G | 20 g |

## Materials for Perovskite Solar Cells

IRASOL produces various precursors, inks and pastes which are used in the fabrication of perovskite solar cells (PSCs). The materials are developed by PSC experts and carefully produced and tested for use in PSCs.

PRECURSORS: $PbI_2$ | $PbBr_2$ | $PbCl_2$ | MAI | MABr | MACl | FAI

$TiO_2$: $TiO_2$ Paste- Transparent

HTM: $CuInS_2$ | $CuInGaS_2$

ELECTRODES: $TiO_2$ blocking layer electrode| ZnO blocking layer electrode/ Carbon paste

### $PbI_2$ | Lead Iodide

Perovskite ink precursor

Lead iodide is a critical starting material in perovskite solar cells. The synthesis process is designed for high purity $PbI_2$ suited for high-efficiency solar cells. $PbI_2$ is soluble in solvents such as DMF and gamma-butyrolactone and can be applied on the surface using spin coating.

| PER-PBI2 Technical Specifications | | |
|---|---|---|
| CAS Number: 10101-63-0 | Packaging and Order Number | |
| Physical Form: Powder | PER-PBI2-5G | 5 g |
| Color: Yellow | PER-PBI2-10G | 10 g |
| Molecular weight: 461.01 g/mol | PER-PBI2-20G | 20 g |
| Density: 6.16 g/cm$^3$ | | |

### $PbBr_2$ | Lead Bromide

Perovskite ink precursor

Lead bromide is used in the perovskite formulations containing Br as anion. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-PBBR2 Technical Specifications | | |
|---|---|---|
| CAS Number: 10031-22-8 | Packaging and Order Number | |
| Physical Form: Powder | PER-PBBR2-5G | 5 g |
| Color: White | PER-PBBR2-10G | 10 g |
| Molecular weight: 367.01 g/mol | PER-PBBR2-20G | 20 g |
| Density: 6.66 g/cm$^3$ | | |

## $PbCl_2$ | Lead Chloride

Perovskite ink precursor

$PbCl_2$ is used to add Cl into the perovskite film. Cl is known to improve the crystallinity and diffusion length of perovskite films. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-PBCL2 Technical Specifications | | |
|---|---|---|
| CAS Number: 7758-95-4 | Packaging and Order Number | |
| Physical Form: Powder | PER-PBCL2-5G | 5 g |
| Color: White | PER-PBCL2-10G | 10 g |
| Molecular weight: 278.1 g/mol | PER-PBCL2-20G | 20 g |
| Density: 5.85 g/cm$^3$ | | |

## MAI | Methylammonium Iodide

Perovskite ink precursor

Methylammonium iodide is one is the main ingredients of conventional $CH_3NH_3PbI_3$ perovskites. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-MAI Technical Specifications | | |
|---|---|---|
| CAS Number: 14965-49-2 | Packaging and Order Number | |
| Physical Form: Powder | PER-MAI-5G | 5 g |
| Color: White | PER-MAI-10G | 10 g |
| Molecular weight: 158.97 g/mol | PER-MAI-20G | 20 g |

## MABr | Methylammonium Bromide

Perovskite ink precursor

Methylammonium bromide is used in perovskite formulations where adding MA as cation and Br as anion are required. In particular, it is one of the main starting materials in conventional three cation perovskites. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-MABR Technical Specifications | | |
|---|---|---|
| CAS Number: 6876-37-5 | Packaging and Order Number | |
| Physical Form: Powder | PER-MABR-5G | 5 g |
| Color: White | PER-MABR-10G | 10 g |
| Molecular weight: 111.97 g/mol | PER-MABR-20G | 20 g |

## MACl | Methylammonium Chloride

Perovskite ink precursor

Methyl ammonium chloride is mainly used to add Cl in the perovskite formulation. Cl is known to improve perovskite crystallinity and diffusion length. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-MACL Technical Specifications | | |
|---|---|---|
| CAS Number: 593-51-1 | Packaging and Order Number | |
| Physical Form: Powder | PER-MACL-5G | 5 g |
| Color: Colorless Crystals | PER-MACL-10G | 10 g |
| Molecular weight: 67.52 g/mol | PER-MACL-20G | 20 g |

## FAI | Formamidinium Iodide

Perovskite ink precursor

Formamidinium iodide is used in perovskite formulations containing FA as cation. FA and MA are the main organic cations in perovskites, while FA-based perovskites are generally more stable and produce better solar cell efficiencies. Our synthesis process is designed for high purity material suited for high-efficiency solar cells.

| PER-FAI Technical Specifications | | |
|---|---|---|
| CAS Number: 879643-71-7 | Packaging and Order Number | |
| Physical Form: Powder | PER-FAI-5G | 5 g |
| Color: White | PER-FAI-10G | 10 g |
| Molecular weight: 171.97 g/mol | PER-FAI-20G | 20 g |

## Nanocrystal $TiO_2$ Paste - Transparent

Ideal paste for meso-$TiO_2$ deposition

$TiO_2$ nanocrystal paste contains nanocrystals with narrow range of size which form a very uniform and transparent film of mesoporous $TiO_2$. The paste can be applied as thick film by blade coating or screen printing for dye sensitized solar cells.
For perovskite solar cells, the paste is first diluted and deposited as a thin film using spin coating. Thermal post-treatment is required after deposition. For thick films, a short ethanol vapor treatment helps level off the wet film. By thermal treatment, at around 100 °C the solvent is evaporated, at below 400 °C the binder is removed and at >500 °C nanocrystals are sintered into a sufficiently good conductivity film.

| PST-20T Technical Specifications | | |
|---|---|---|
| Nanoparticles: $TiO_2$ - Anatase | Packaging and Order Number | |
| Particle Size: Around 20 nm | PST-20T-1G | 1 g |
| Concentration: 18% | PST-20T-5G | 5 g |
| Physical Form: Paste | PST-20T-10G | 10 g |
| Color: Cream | PST-20T-20G | 20 g |
| Storage: 2-8 °C | | |

## $CuInS_2$ Ink

Stable dispersion to deposit high performance HTM layers

$CuInS_2$ nanoparticles dispersed in chloroform can be applied with high uniformity using spin coating. It is a p-type semiconductor and has been successfully used as an inorganic hoe transporting material (HTM) of perovskite solar cells.

| INK-20CIS Technical Specifications | | |
|---|---|---|
| Nanoparticles: $CuInS_2$ | Packaging and Order Number | |
| Particle Size: ~18 nm (DLS Analysis) | INK-20CIS-10ML | 10 mL |
| Concentration: 30 mg $mL^{-1}$ | | |
| Physical Form: Liquid dispersion | | |
| Color: Black | | |
| Solvent: Chloroform | | |

## $CuInGaS_2$ Ink

Stable dispersion to deposit high performance HTM layers

$CuInGaS_2$ nanoparticles dispersed in chloroform can be applied with high uniformity using spin coating. It is a p-type semiconductor and has been successfully used as an absorbing layer of CIGS solar cells and inorganic hole transporting material (HTM) of perovskite solar cells.

| INK-25CIGS Technical Specifications | | |
|---|---|---|
| Nanoparticles: $CuInGaS_2$ | Packaging and Order Number | |
| Particle Size: 20-30 nm (DLS Analysis) | INK-25CIGS-10ML | 10 mL |
| Concentration: 25 mg $mL^{-1}$ | | |
| Physical Form: Liquid dispersion | | |
| Color: Black | | |
| Solvent: Chloroform | | |

## $TiO_2$ Blocking Layer Electrode

Clear $TiO_2$/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. A thin layer of $TiO_2$ is the most commonly used blocking layer and the films are best deposited by spray pyrolysis. $TiO_2$ blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of $TiO_2$.

| ELD-TBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: $TiO_2$ thin film | ELD-TBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: 50-70 nm | | |
| Color: Transparent | | |

## ZnO Blocking Layer Electrode

Clear ZnO/FTO layers as starting electrodes of for dye and perovskite solar cells

In many types of solar cells, the first layer is a blocking layer which thoroughly covers the FTO substrate. ZnO blocking layer electrode is a Glass/FTO substrate deposited by a thin layer of ZnO using spray pyrolysis.

| ELD-ZBL Technical Specifications | | |
|---|---|---|
| Substrate: Glass/FTO | Packaging and Order Number | |
| Coating: ZnO thin film | ELD-ZBL-20 | 20 |
| Deposition method: Spray pyrolysis | | |
| Thickness: <100 nm | | |
| Color: Transparent | | |

## Carbon Paste

Toluene-based carbon paste suitable for perovskite solar cells

PST-101C is a conductive caron paste based on toluene solvent. It is ideal for perovskite solar cells and in applications were polar solvents should be avoided. One of the advantages of this carbon paste is that it forms a relatively flexible structure and can be used in flexible devices. The paste can be applied by methods such as blade coating. A post treatment at temperatures higher than 100 C will cure the paste.

| PST-101C Technical Specifications | | |
|---|---|---|
| Compoition: Graphite, Binder, Additive in Toluene | Packaging and Order Number | |
| Concentration of carbon: 20% | PST-101C-1G | 1 g |
| Physical Form: Paste | PST-101C-5G | 5 g |
| Color: black | PST-101C-10G | 10 g |
| Storage: 2-8 °C | PST-101C-20G | 20 g |

# IROZON
# DRY DISINFECTION SYSTEMS

# DRY DISINFECTION SYSTEM

Virus disinfection of surfaces by intense Ozone + UVC or thermal process

## OVERVIEW

UDS-400 is a dry disinfection system based on intense UVC and ozone exposure, with additional feature of heating. Disinfection protocols are carried out by the automated system via ozone and temperature sensors readings. A catalytic ozone removal system decomposes the remaining ozone after the disinfection process.

## FEATURES

- Virus disinfection by intense UVC-ozone, or heat
- Decomposition of remaining ozone after the process
- Regeneration of ozone decomposition catalyst after deactivation
- Automated system control based on ozone and temperature sensors
- 50L double-wall process box with internal UVC reflectors
- Self-diagnostic system, indicating possible faults


## APPLICATIONS

- Disinfection of medical parts and instruments
- Disinfection of paper, cash, money and plastic-ware
- Disinfection of glass, spoon, dishes, etc. in restaurants and hotels
- Disinfection of electronic utilities such as mobile and laptop
- Disinfection of home utilities, shoes, clothes and purchased items

## HOW IT WORKS

UDS-400 is a system to disinfect the surface of objects using UVC-ozone or thermal process. It is aimed at dry disinfecting of objects. The UVC lamps produce simultaneous ozone and UVC dosing. The synergic effect of UVC and ozone provides a highly oxidative atmosphere that kills both viruses and bacteria on the surface.
Besides, UVC reflective walls trap the UVC photons inside the chamber and provide a relatively uniform and high -intensity UVC irradiation. UVC is known to disinfect by photonic absorption in the virus or bacteria. While UVC is only effective for the outer surface of objects exposed to UVC light, ozone can penetrate into the dark regions of the object and make a complete disinfection. Fan circulation inside the chamber results in effective ozone transport. This is why, UVC+ozone is a more reliable disinfection process compared to UVC-only systems.
After UVC-ozone disinfection process, an ozone removal process automatically starts. It circulates the air through an ozone decomposition catalyst. With this process, the ozone concentration is rapidly reduced and reaches to a safe level before the user can open the door and take the object. The catalyst will be aged after some time and its activity is reduced. A regeneration process is provided inside the system that can be activated in order to regenerate the catalyst to its high activity state.

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