



SPD Laboratory, Inc.
Hamamatsu, Japan

CORPORATE GUIDANCE

2027

Corporate Guidance

From Thin Films to True Power

For successful future R&D of state-of-the-art thin-film formation and next-generation solar cells



Thin-Film Deposition

Spray pyrolysis deposition (SPD) systems from desktop R&D units to 300 mm production machines, inkjet thin-film printers, coating services and materials.

Solar Cell Characterization

PV power analyzers with MPPT, IPCE systems, LED solar simulators, sample holders and capacitor / battery analyzers.

Next-Generation Solar Cell Fabrication

Automated instruments for every step of dye-sensitized and perovskite solar cell production.

SPD Laboratory, Inc.

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CORPORATE GUIDANCE 2027

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At a glance

2004

Founded as a venture enterprise
originating from Shizuoka
University

41

products and services in seven
product families

2015

First PV power analyzer with
MPPT for perovskite solar cell
research

7

Japanese patents, with new
MPPT-related applications filed
in 2025 – 2026

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New in this edition

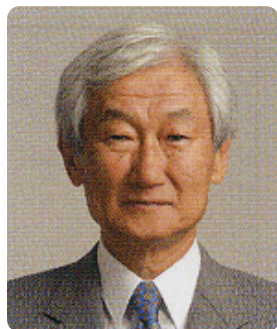
- ✓ VK-PA-2000 PV power analyzer for solar modules up to 220 V / 2.5 A, and the RC-3618 calibrated Si reference cell
- ✓ FTO glass and ITO glass substrates — four standard sizes, with measured sheet resistance and transmittance data
- ✓ VK-MPA-100 Multi-Channel PV Power Analyzer — October 2026 specifications and control software version 3, with double-diode curve fitting and periodic I-V scans during MPPT
- ✓ VK-PA-100 PV Power Analyzer — October 2026 specifications and the latest control software, with daily power-generation logging

MESSAGE FROM THE PRESIDENT

Bridging academia and industry since 2004

A research-driven venture enterprise originating from Shizuoka University, dedicated to thin-film technology for clean energy.

Our story



Shoji Kaneko, Ph.D.
President & CEO

In 1989, seeing great promise in terms of energy saving, resource saving and low cost, I began researching spray pyrolysis deposition (SPD). With simple equipment and easy operation, this method forms thin films in open air in a short time through thermal decomposition and chemical reaction of raw materials. Our first hand-made apparatus evolved within a few years into large, automated systems.

In 2004 I founded SPD Laboratory with the goal of spreading the practical applications of the SPD thin-film technology I had developed at Shizuoka University. Bridging the gap between academia and industry with creative, tailor-made products has been our target from the beginning. We produce SPD machines and build the latest dye-sensitized and perovskite solar cell systems using thin films prepared by SPD — aiming always to supply products of the highest quality at a good price.

Mission, philosophy and direction

Mission

As a venture enterprise originating from Shizuoka University, we aim to introduce next-generation technology to people all over the world and make their lives more comfortable by applying our accumulated intellectual property to clean energy supply and environmental preservation.

Philosophy

In the fields of energy and the environment, we take on the challenge of creating creative, high-value-added products that meet real needs — contributing to our customers and to society.

Customer-oriented & tailor-made

Every product is developed from a researcher's point of view, so we are confident in its precision and ease of use. Through an "open lab" approach and close collaboration with universities and institutes in Japan and abroad, we keep expanding our line-up to meet customer needs.

Company profile

Company name	SPD Laboratory, Inc.
Established	June 1, 2004
Representative	Shoji Kaneko, Ph.D., President & CEO
Address	2-35-1 Johoku, Chuo-ku, Hamamatsu, Shizuoka 432-8011, Japan
Phone / Fax	+81-53-474-7901 / +81-53-401-7080
Email	inq@spd-lab.com
Business	Manufacture and sale of SPD thin-film deposition systems, solar cell evaluation instruments, DSC/PSC fabrication equipment and TCO films; contract research on SPD technology and next-generation solar cells



COMPANY

Business status and outlook

In June 2019 we celebrated our 15th anniversary. Building on our experience with SPD technology and dye-sensitized solar cell manufacturing, we are committed to: (1) being unique and number one in processes, materials and instruments; (2) thoroughly pursuing “High Quality – Best Price”; and (3) supporting young researchers. True to our venture spirit — “rich in ideas; perseverance is power” — we will continue to be of service to you.

Our main products fall into four groups: thin-film deposition equipment, next-generation solar cell (DSC/PSC) fabrication processes, solar cell performance evaluation systems, and supercapacitor/battery evaluation systems. The spread of photovoltaics requires integration with power storage devices, and we are focusing our thin-film expertise on this area too.

Business policy

- ✓ Manufacture and sale of SPD thin-film deposition systems, DSC and PSC prototyping equipment, and FTO / ITO transparent conductive films
- ✓ Manufacture and sale of new solar cell performance evaluation systems
- ✓ Contract prototyping and research on next-generation thin-film solar cells
- ✓ Development of thin-film power storage devices
- ✓ Prototyping of thin-film devices and development of their evaluation equipment

RESEARCH & DEVELOPMENT

Promising future developments

Transparent conductive oxide (TCO) films

Using SPD we prepare fluorine-doped tin oxide (FTO) and tin-doped indium oxide (ITO) films on glass with high electrical conductivity and visible-light transmittance, for display panels, electromagnetic-shielding glass, solar cells and more.

R&D on DSC and PSC

A DSC consists of a photo-electrode coated with a porous wide-band-gap semiconductor and dye, and a counter electrode coated with a very thin platinum layer, with electrolyte in between. Requiring no vacuum system and no hazardous materials, DSCs are an attractive low-cost next-generation solar cell — switching can save more than 50 % of the cost.

Instrumentation for solar cells & power storage

We aim to combine DSC/PSC photovoltaics with battery/supercapacitor power storage. We have initiated PSC processing with piezoelectric inkjet printing and developed PV power analyzers with MPPT — contributing to next-generation solar cell research together with highly motivated scientists and engineers.

Recent activities

2026.10	VK-MPA-100 control software version 3 released
2026.09	Presentation at ISOS-17, Paris-Saclay, France
2025.10	Guest lecture: “Machine Learning: Practical Applications in Research”
2025.09	Poster at ISOS-16, Genk, Belgium
2024.11	Two posters at PVSEC-35, Numazu, Japan
2024.09	Presentation at ISOS-15, Berlin, Germany
2024.07	Exhibited at IPS-24, Hiroshima
2024.07	Second place poster award at ICCG 2024
2024.02	Talk and poster at AFMD-2024, Chennai, India

Major customers in Japan

AISIN

Toyota Motor Corporation

AGC (Asahi Glass)

Panasonic

TOTO

Sekisui Chemical

Canon

ROHM

AIST Research Center for Photovoltaics

NIMS

RIKEN

Kanagawa Institute of Industrial Science and Technology

Kyushu University

University of Tsukuba

Toyota Technological Institute

Kyoto University

The University of Tokyo

Nagoya University

University of Yamanashi

Tokyo Institute of Technology

Waseda University

Shizuoka University

Tokyo University of Science

Hokkaido University

Our instruments are also used by universities, research institutes and companies around the world.

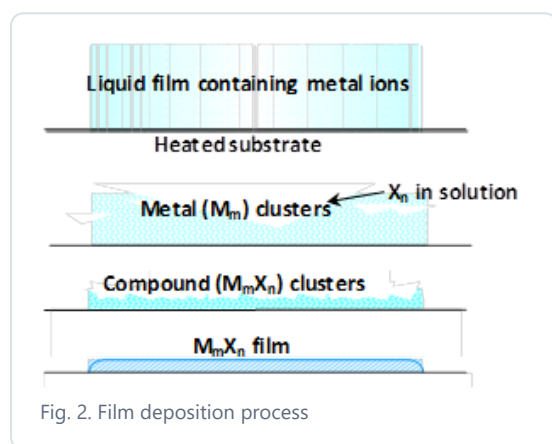
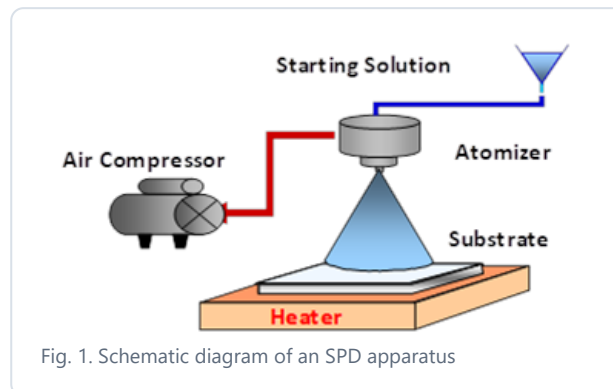
TECHNOLOGY

What is Spray Pyrolysis Deposition?

SPD is one of the chemical thin-film formation methods: a solid film is deposited from a liquid phase sprayed onto a heated substrate.

1. Principle

SPD is performed at atmospheric pressure using a simple apparatus consisting of an atomizer, air compressor, solution reservoir and heater (Fig. 1). The raw-material solution is atomized onto a heated substrate by a pneumatic system — intermittently rather than continuously, to keep the substrate temperature constant, since the mixture of solution and air cools the substrate. Inorganic and organic metal compounds are used as raw materials; the principal components and composition of the starting solution are retained in the deposited film (except for easily evaporated additives), so the method normally gives the prescribed film composition.



2. Deposition process

- 1 Countless mists from the atomizer wet the substrate and form a liquid film. According to Gibbs' phase rule, the solvent stays at its boiling temperature until fully evaporated, even though the substrate is much hotter.
- 2 The temperature of the remaining solute rises rapidly, yielding metal clusters through thermal decomposition and/or chemical reaction.
- 3 These metal clusters are instantly converted to compound clusters by reacting with negative ions in the solution.
- 4 Condensation and cohesion of the compound clusters on the substrate immediately yield a solid film.

3. Features

SPD produces dense, even films with thicknesses from 10 nm to 10 μm . Complex-compound and solid-solution films can also be obtained as non-equilibrium or metastable phases by controlling starting solutions and substrate temperatures. Particle shape and size, microstructure and texture are controllable through deposition conditions. Film thickness increases in proportion to solution concentration, spray rate, time and number of cycles, and depends on substrate temperature, solute vapor pressure and wetting ability. Pausing the atomization to avoid cooling the substrate is believed to promote atomic diffusion, crystallization of fine particles and densification — contributing to film quality.

Advantages of SPD

- ✓ Simple apparatus and easy operation
- ✓ Film formation possible in open air
- ✓ Wide choice of raw materials
- ✓ Easy adjustment of components and composition
- ✓ Low-temperature formation possible
- ✓ High deposition rate
- ✓ Easy scale-up to large areas and coating of complex shapes

SOLAR CELL CHARACTERIZATION

Pioneers of MPPT Solar Cell Characterization

SPD Laboratory was the first to introduce MPPT as a characterization technique for perovskite solar cells, beginning with the VK-PA-25. The first VK-PA-25 was delivered to the Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, in 2015.

Why MPPT?

Maximum power point tracking (MPPT) is the standard technique for getting the most power out of rooftop solar panels, but it was not commonly used to characterize individual cells in the laboratory. Perovskite solar cells (PSCs) changed that. Planar PSCs show a large hysteresis between forward and reverse I-V scans: because of their capacitive nature, charge accumulates and is released during a conventional scan, the output current is over- or underestimated, and the power conversion efficiency (PCE) calculated from the two scan directions differs significantly.

In 2015 SPD Laboratory introduced a PV power analyzer that, rather than only scanning the I-V curve, holds the cell at its maximum power point and plots maximum output power and conversion efficiency against time. Although first intended for PSCs, the technique has proved highly effective for all types of solar cells: an I-V curve gives only the instantaneous output, whereas MPPT shows the continuous power output of the cell over time.

From the VK-PA-25 to today

Our first-generation PV Power Analyzer, the VK-PA-25, with a built-in MPPT function, was delivered in 2015 to Prof. Segawa's group at the Research Center for Advanced Science and Technology (RCAST), The University of Tokyo. Using it, Prof. Satoshi Uchida advanced his research on PSC hysteresis and applied MPPT to evaluate PSC performance for the first time. It was especially significant to clarify that the hysteresis of a stacked PSC is caused by its internal capacitance component.

Capacitance analyzers, capacitor and battery analyzers, LED solar simulators and a six-channel MPPT analyzer have followed, and all of our PV power analyzers carry the same core idea.

What SPD Lab analyzers do

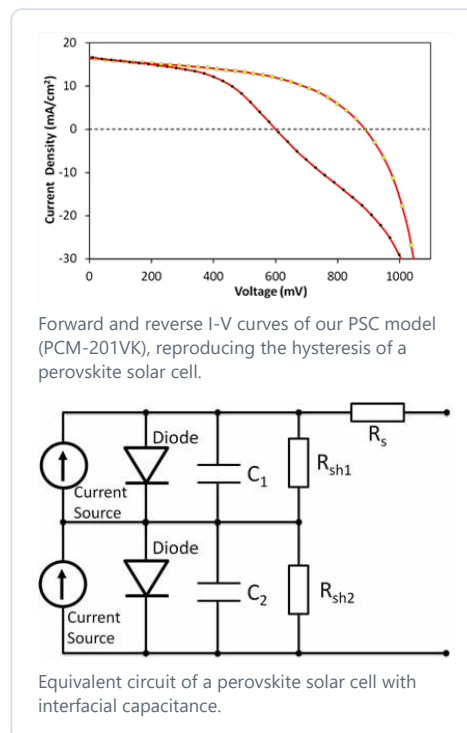
- 1 True MPPT in firmware.** An advanced MPPT algorithm in the instrument firmware keeps the cell continuously at its maximum-output condition. Plotting $P_{\max}$ from a series of I-V curves does not solve the problem, because every I-V curve gives two different $P_{\max}$ values for the forward and reverse scans.
- 2 Results against time.** Efficiency, $P_{\max}$, V_{mpp} , I_{mpp} and total energy are plotted against time on auto-scaling graphs.
- 3 I-V tracing that shows hysteresis.** Auto Reverse plots forward and reverse scans on the same graph; Advanced I-V adds start, middle and end-point holding times and I-t transient plots.
- 4 Wireless and easy to use.** Control software for Windows is supplied with every analyzer; data are saved as text, CSV or formatted Microsoft® Excel workbooks with graphs.

Key publications

- 1 L. Cojocaru, S. Uchida*, P. V. V. Jayaweera, S. Kaneko, J. Nakazaki, T. Kubo and H. Segawa, "Origin of the Hysteresis in I-V Curves for Planar Structure Perovskite Solar Cells Rationalized with a Surface Boundary Induced Capacitance Model," *Chemistry Letters*, 44(12), 1750–1752 (2015). DOI: 10.1246/cl.150933 — **Editor's Choice**
- 2 L. Cojocaru, S. Uchida, P. V. V. Jayaweera, S. Kaneko, J. Nakazaki, T. Kubo and H. Segawa, "Determination of unique power conversion efficiency of solar cell showing hysteresis in the I-V curve under various light intensities," *Scientific Reports*, 7, 11790 (2017). DOI: 10.1038/s41598-017-10953-3 — **Top 100 read article (#13 in Materials Science) in 2017**

Recent patent applications

- **JP Appl. 2026-095132** — Steady-state maximum power point evaluation apparatus for hysteresis-affected solar cells
- **JP Appl. 2026-014557** — Global maximum power point voltage estimation for photovoltaic arrays using a machine learning model
- **JP Appl. 2025-282338** — Environmental information-based MPPT control device for photovoltaic modules



CORPORATE GUIDANCE 2027

Product lineup

About forty products and services, developed from a researcher's point of view and made in Hamamatsu, Japan.
Page numbers refer to this booklet.

Coating Services FTO, ITO, TiO₂ and other oxide films coated on your substrates — plain or patterned, in the size, shape and pattern you need.



Coating Service

Custom Coated Substrates &
Patterned Thin Films

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Thin Film Deposition Spray pyrolysis deposition (SPD) systems and inkjet thin-film printers — from desktop R&D units to 300 mm production machines.



KV-25II

Desktop Spray Pyrolysis
Deposition System

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KV-100

Desktop Spray Pyrolysis
Deposition System

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KM-150

Medium-Size Spray Pyrolysis
Deposition System

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KM-300

Large-Size Spray Pyrolysis
Deposition System

p. 12



VK-TFP-120

Thin Film Printer

p. 13



KV-PPS-25

Patterned FTO Preparation
System

p. 15

Solar Cell Characterization PV power analyzers with MPPT, IPCE systems, LED solar simulators and capacitance analyzers for next-generation solar cells.



VK-MPA-100

Multi-Channel PV Power
Analyzer

p. 16



VK-PA-1000

PV Power Analyzer for
Module Testing

p. 22



VK-PA-2000

PV Power Analyzer for Solar
Modules up to 220 V / 2.5 A

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VK-PA-100

PV Power Analyzer

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VK-PA-300

PV Power Analyzer

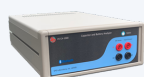
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VK-PA-Pico

Pico-Ampere PV Power
Analyzer

p. 25



VK-CA-1000

Solar Cell Capacitance
Analyzer

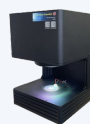
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VK-IPCE-10

IPCE & Spectral Response
Measurement System

p. 27



VK-SS-50

LED Solar Simulator

p. 29



PCM-201VK

Perovskite Solar Cell (PSC)
Model

p. 30



RC-3618

Calibrated Si Reference Cell

p. 30

Sample Holders & Probe Stations

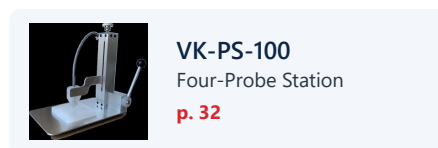
We custom-make any type of sample holder with spring-tension contact probes — including temperature-controlled holders and sealed holders for inert atmosphere (N_2 / He purging) — as well as four-probe stations.



VK-SH-50
Solar Cell Sample Holder
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VK-SH-150
Sample Holder with Contact Probes
p. 32



VK-PS-100
Four-Probe Station
p. 32

Energy Storage & Electronics

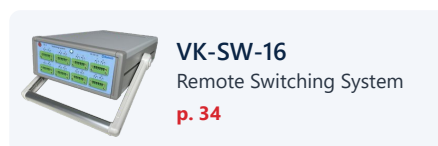
Capacitor & battery analyzers, wireless data loggers, remote switching systems and energy-harvesting power boards.



VK-CA-8000
Capacitor & Battery Analyzer
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VK-DL-1256
High-Resolution Wireless Data Logger
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VK-SW-16
Remote Switching System
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VK-PM-5V
Power Management Board (Type 1)
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VK-PM2-5V
Power Management Board (Type 2)
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DSC Fabrication Equipment

Automated instruments covering every step of dye-sensitized solar cell production — from electrode printing to electrolyte filling.



Large-Area DSC Process
Large-Area Dye-Sensitized Solar Cell Fabrication Process
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Small-Area DSC Process
Small-Area Dye-Sensitized Solar Cell Fabrication Process
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EasyFill
Automatic Electrolyte Filling Machine Series
p. 37



Multi-Cell Filler
Multi-Cell Electrolyte Filling Machine
p. 37



KVP-300
Automatic Electrode Pile-up Machine
p. 38



VK-PUM-1010×4
Automatic Electrode Pile-up & Heat Curing Machine
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VK-UV-1515
UV Irradiation Apparatus
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VK-DC-1010
Automatic Dye Coating Machine
p. 40



VK-Ag-3030
Silver Grid Formation Apparatus
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VK-SD-3030
Sealant Dispensing Apparatus
p. 41



VK-HD-3030
Hole Drilling Robot
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Materials

FTO glass and ITO glass substrates, FTO, ITO and TiO_2 spray solutions, masking and silver pastes, UV sealant, insulating polymer and fine chemicals.



Transparent Conductive Glass
FTO Glass and ITO Glass Substrates
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SPD Spray Solutions
FTO, ITO & TiO_2 Precursor Solutions for Spray Pyrolysis
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SPD Pastes & Sealants
Masking Paste, Silver Paste, UV Sealant & Insulating Polymer
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SPD Fine Chemicals
Fine Chemicals
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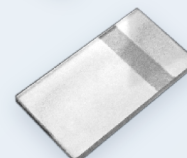
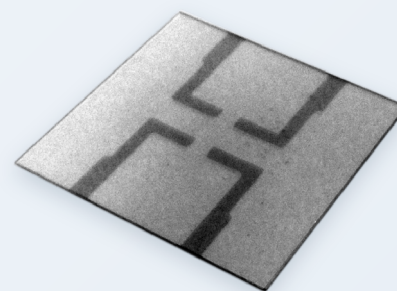
COATING SERVICES

Coating Service

Custom Coated Substrates & Patterned Thin Films

FTO, ITO, TiO_2 and other oxide films coated on your substrates by SPD — plain or patterned, up to 300 mm × 300 mm.

- ✓ FTO, ITO, ATO, TiO_2 , SnO_2 , ZnO and other oxide films
- ✓ Patterned films without etching — uncoated areas stay exceptionally clean
- ✓ Glass, silicon wafers, quartz and other substrates
- ✓ Substrates up to 300 mm × 300 mm
- ✓ Film properties, size, shape and pattern tailored to your requirements



Product page

Overview

SPD Laboratory supplies substrates coated with transparent conducting oxides (FTO, ITO, ATO) and other functional oxide films such as TiO_2 , SnO_2 and ZnO, made with our own spray pyrolysis deposition (SPD) systems. FTO and ITO films combine high electrical conductivity with high visible-light transmittance for solar cells, display panels, electromagnetic-shielding glass and other devices.

Patterned films are our speciality. Patterned FTO combines transparency, conductivity and stability with a pattern of your own design, making it an essential component for gas sensors, perovskite and dye-sensitized solar cells and other electronic and optoelectronic devices. We use a unique technique that coats the film only on the patterned areas — unlike etching methods, the uncoated substrate remains exceptionally clean.

Coatings can be made on glass, silicon wafers, quartz and other substrates up to 300 mm × 300 mm. Tell us your film, substrate, size and pattern — send us your drawing or requirements and we will prepare a quotation.

Available films

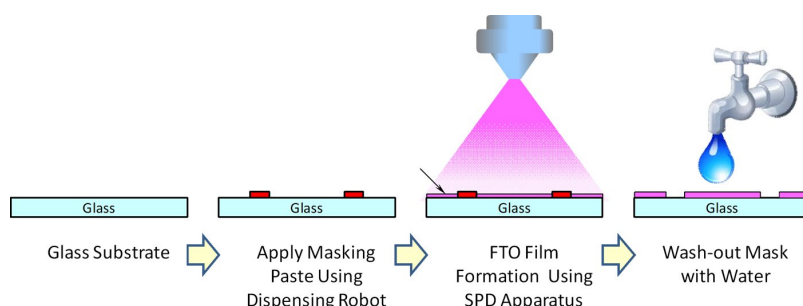
- Fluorine-doped tin oxide (FTO)
- Tin-doped indium oxide (ITO)
- Antimony-doped tin oxide (ATO)
- Titanium oxide (TiO_2) — dense or porous
- SnO_2 , ZnO and other oxide films on request

Typical applications

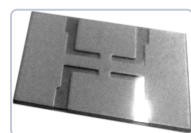
- Perovskite and dye-sensitized solar cells
- Gas sensors and patterned electrodes
- Transparent electrodes for electronic and optoelectronic devices
- Display panels and electromagnetic-shielding glass

How patterned films are made

- 1** Clean substrate (glass, Si wafer, quartz ...)
- 2** Water-washable, heat-resistant masking paste applied in your pattern by a dispensing robot
- 3** Film formation (FTO, ITO, TiO_2 ...) by spray pyrolysis deposition
- 4** Mask washed out with water — patterned film on a clean substrate



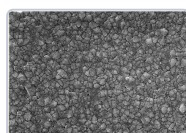
Patterned film process: masking paste → SPD film formation → wash-out with water



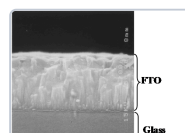
Glass with dispensed masking paste



Patterned FTO used for gas sensors



SEM image of an FTO surface



Cross section of FTO on glass

What to tell us for a quotation

- ✓ Film material and target properties (e.g. sheet resistance, thickness, transmittance)
- ✓ Substrate material, size and thickness
- ✓ Pattern drawing (PDF, DXF or a simple sketch) — or full-area coating
- ✓ Quantity and required delivery date

THIN FILM DEPOSITION

KV-25II

Desktop Spray Pyrolysis Deposition System

Desktop SPD apparatus for thin-film formation on substrates up to 25 mm × 25 mm.

- ✓ Moving spray nozzle for uniform coverage
- ✓ Built-in exhaust pump with dust filters
- ✓ Keypad/LCD or PC control via Bluetooth
- ✓ Stores up to 10 operation programs
- ✓ Real-time liquid flow monitoring



Product page

Specifications

Substrate size	Up to 25 mm × 25 mm
Substrate temperature	Max. 550 °C
Spray distance	150 mm to 300 mm (continuous)
Reaction chamber	W320 × D360 × H360 mm, Teflon coated for corrosion resistance
Capacity of solution bottle	250 ml
Power supply	100 VAC single phase, 50/60 Hz, 1.5 kW (240 VAC on request)
Air source pressure	Over 0.6 MPa (oil-free air only, inlet: ø6 mm)
Exhaust system	Built-in exhaust pump with powder filters, outlet: 45 mm
External dimensions	W650 × D400 × H730 mm
Weight	50 kg

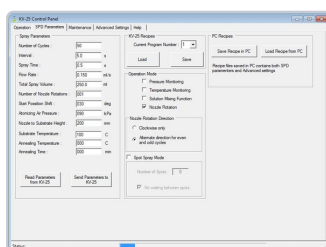
Applications

- Porous and dense thin-film formation
- Transparent conducting oxide films (ITO, FTO, AZO, etc.)
- Other functional films (TiO₂, ZnO, SnO₂, Cu₂O, SnS, etc.)

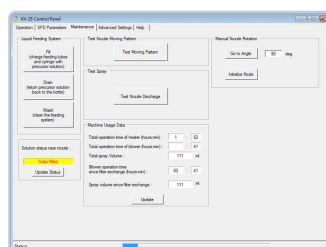
Control software



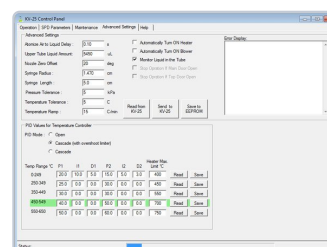
"Operation" tab: basic operation parameters and control buttons



"SPD Parameter" tab: set all spray parameters, save and load recipes



"Maintenance" tab: machine maintenance functions



"Advanced Settings" tab: machine-specific advanced parameters

Features

- **Moving spray nozzle:** the nozzle is mounted on a motorized stage and moves on a circular path to increase the uniform coverage area — important for porous metal-oxide films such as TiO₂.
- Built-in exhaust pump with input and output dust filters. (Exhaust air may contain chemical vapor and should be routed through a laboratory fume hood.)
- Easy setting of operation parameters through the keypad and LCD, or remote control from PC software via Bluetooth.
- Stores up to 10 sets of operation parameters (programs).
- Real-time liquid flow monitoring displays the volume of each spray and the total volume sprayed.
- Automatically fills tubes (removes air) when a new chemical bottle is connected; clears tubes by returning liquid with a single key.
- Substrate and heater temperatures, atomizing and liquid air pressures are displayed digitally and continuously monitored, with warnings if they deviate from preset ranges.
- Heater controlled by a cascade PID controller with two temperature sensors; five PID sets can be stored for different temperature regions.

THIN FILM DEPOSITION

KV-100

Desktop Spray Pyrolysis Deposition System

Desktop SPD apparatus for thin-film formation on substrates up to 100 mm × 100 mm.

- ✓ Motorized X-Y spray nozzle with special line pattern
- ✓ Syringe-pump spray-rate control
- ✓ Remote operation from PC via USB
- ✓ Stores up to 9 recipes on the machine
- ✓ Automatic priming, draining and cleaning



Product page

Specifications

Substrate size	Up to 100 mm × 100 mm
Substrate temperature	Max. 550 °C
Spray distance	150 mm to 250 mm (motorized)
Reaction chamber	W320 × D360 × H360 mm, Teflon coated for corrosion resistance
Capacity of solution bottle	250 ml
Power supply	100 VAC single phase, 50/60 Hz, 1.5 kW
Air source pressure	Over 0.6 MPa (oil-free air only, inlet: ø6 mm)
Exhaust system	Built-in exhaust pump with powder filters, outlet: 50 mm
External dimensions	W650 × D400 × H850 mm
Weight	80 kg

Applications

- Porous and dense thin-film formation
- Transparent conducting oxide films (ITO, FTO, AZO, ATO, etc.)
- Other functional films (TiO₂, ZnO, SnO₂, Cu₂O, SnS, etc.)

Special Features

- **Moving spray nozzle:** mounted on a motorized X-Y stage using a special spray-line pattern to produce uniform films.
- **Spray rate control:** the liquid-feeding system uses an automated syringe pump, so the exact spray rate and total liquid volume can be set as initial parameters.
- **Remote operation:** connect to a PC via USB and control all functions remotely; an unlimited number of recipes can be saved on the computer.
- Built-in exhaust pump with input and output dust filters. (Exhaust air may contain chemical vapor — an external scrubber must be used.)
- Easy parameter setting from the front-panel keypad and LCD; up to 9 film-making recipes stored in memory.
- Spray rate, volume of each spray and total volume are shown on the LCD.
- Automatic initializing and ending functions remove air from the tubes at the start and drain chemicals at the end; an automatic cleaning function assists maintenance.
- Substrate and heater temperatures and atomizing air pressure are shown on a separate LCD and continuously monitored with warnings.
- Cascade PID heater control with two temperature sensors; five PID sets can be stored for different temperature regions.

THIN FILM DEPOSITION

KM-150

Medium-Size Spray Pyrolysis Deposition System

Medium-size SPD apparatus for substrates up to 150 mm × 150 mm with three atomizing systems.



Product page



- ✓ Substrates up to 150 mm × 150 mm
- ✓ Substrate temperature up to 700 °C
- ✓ Three independent atomizing systems
- ✓ Touch-screen control with 10 stored nozzle patterns

This spray pyrolysis deposition (SPD) system is designed for short-time, low-cost thin-film formation. A Teflon-coated reaction chamber prevents corrosion. With three solution-atomizing systems, three kinds of layers can be made from different solutions. The built-in touch-screen control panel lets users program and store 10 nozzle-moving patterns and quickly select the preferred one.

Max. substrate size	150 mm × 150 mm
Max. substrate temperature	700 °C
Power source	AC 100 V, 1.5 kVA
Air pressure source	More than 0.6 MPa
Machine size	1315 (W) × 940 (L) × 1900 (H) mm
Machine weight	630 kg
Exhaust	Duct diameter 65 mm, more than 3 m ³ /min (adjustable)

Examples of Prepared Films

- Transparent conducting oxides (ITO, FTO, AZO, etc.)
- Other functional films (TiO₂, Cu₂O, SnS, CuInS₂, etc.)

THIN FILM DEPOSITION

KM-300

Large-Size Spray Pyrolysis Deposition System

Large SPD apparatus for substrates up to 300 mm × 300 mm using three scanning spray nozzles.



Product page



- ✓ Substrates up to 300 mm × 300 mm
- ✓ Three spray nozzles with special scanning pattern
- ✓ Servo-driven X-Y stage, 400 × 400 mm coating area
- ✓ Built-in cyclone powder collection

The KM-300 SPD apparatus is designed for substrates up to 300 mm × 300 mm. It uses three spray nozzles with a special scanning pattern to reduce the overall coating time and produce highly uniform films.

Dimensions	2,000 (W) × 1,200 (D) × 1,900 (H) mm
Painting color	JPCA: A25-90A
Input power source	3-phase 200 VAC, 50/60 Hz, 125 A
Air	150 NL/min, 0.5 MPa, intake: Φ8
Fresh-air intake system	With filter, variable air-intake quantity
Reaction chamber	Heat-resistant hard coating (1000 °C), smooth surface; detachable and washable; explosion-pressure diffusion aperture; easy maintenance
Exhaust system	Powder collection equipment (cyclone separator, installed inside the apparatus) and heat-resistant exhaust blower
Heater elevating stage	Manual operation, spray distance 350 mm ± 50 mm
Spray nozzles	3 × Fuso Seiki STS6R-1.0 with micro adjustment; mounting distance min. 75 mm, max. 150 mm, pitch 25 mm
X-Y drive stroke / speed	X, Y: 525 mm / max. 150 mm/s (servo motor)
Movable coating area	400 mm × 400 mm max.

THIN FILM DEPOSITION

VK-TFP-120

Thin Film Printer

Inkjet printing and paste dispensing of functional thin films in an inert-gas chamber — ideal for perovskite solar cells without a glovebox.

- ✓ Ideal for perovskite solar cell preparation without a glovebox
- ✓ Four piezoelectric inkjet print heads
- ✓ Two paste-dispensing units (carbon, silver paste, encapsulating resin)
- ✓ Fully automatic chemical feeding, purging, draining and cleaning
- ✓ Compatible with a wide range of solvents
- ✓ Entire process under an inert-gas environment

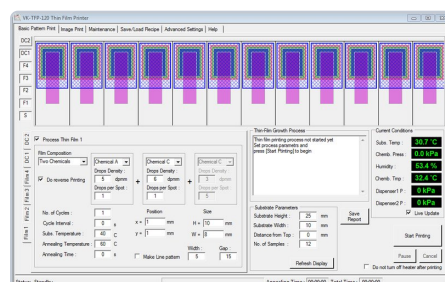


Product page

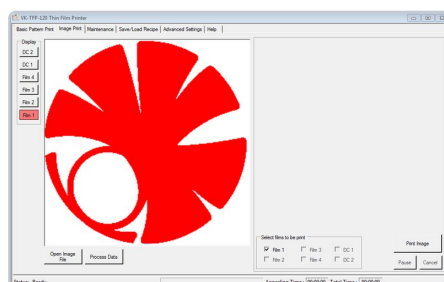
Specifications

Number of printing heads	4
Type of print head	Piezoelectric, 128 nozzles, 80 pl/droplet, 16.5 mm print width
Maximum printable area	120 mm × 120 mm
Substrate temperature	RT – 155 °C
Printing environment	Complete process in a nitrogen-purged airtight chamber
Machine control	PC software via USB
Raw materials	Up to 4 chemical solutions for inkjet printing; up to 2 pastes for dispense coating
Raw material inserting method	Filled into 60 ml syringes
Dimensions	L600 × W600 × H760 mm
Weight	50 kg

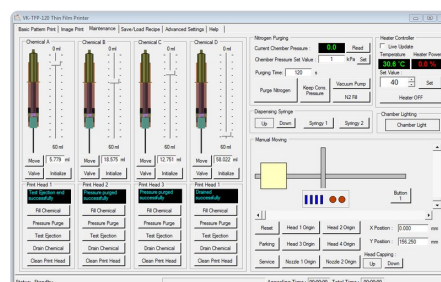
Control software



"Basic Pattern Print" tab of the thin-film printing software



"Image Print" tab



"Maintenance" tab

Special Features

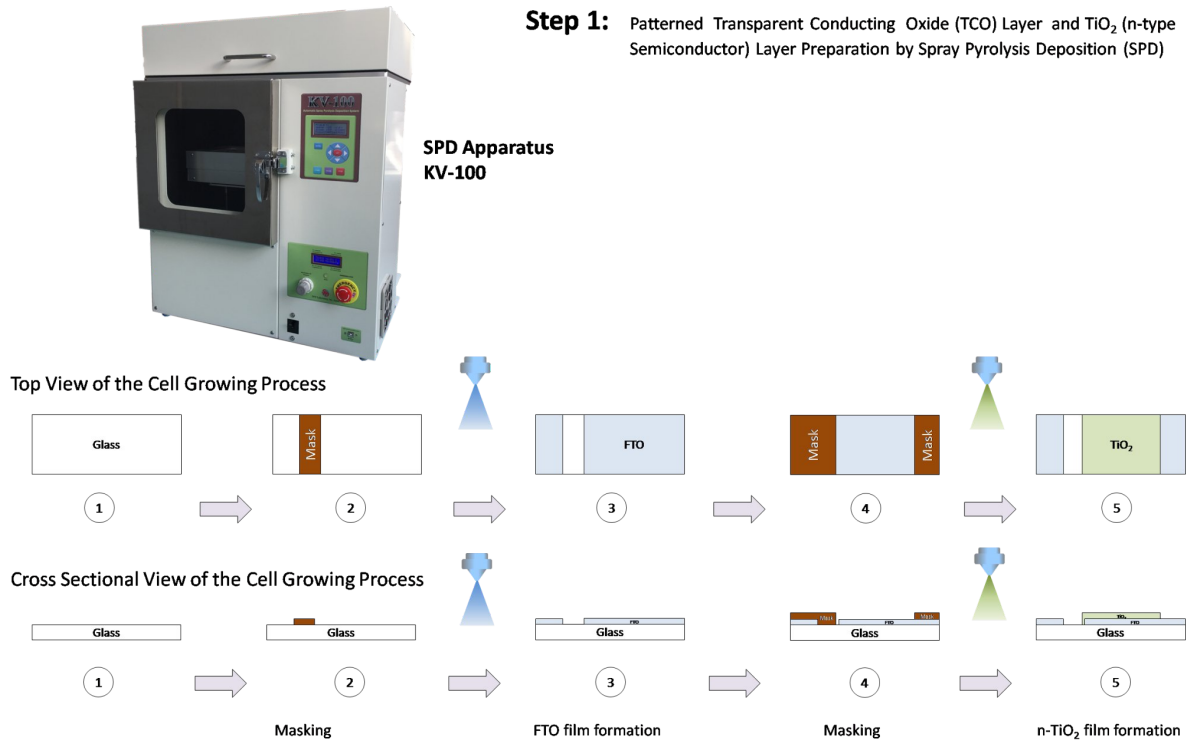
- **Single or combined chemical films:** up to four different chemical solutions can be used to form single-chemical or combined-chemical thin films by inkjet printing (e.g. $\text{CH}_3\text{NH}_3\text{I}$ + PbCl_2 , Spiro-OMeTAD).
- **Paste dispensing:** up to two different thick coatings can be dispensed with a single nozzle (Φ 0.2 – 1 mm), e.g. conducting carbon paste or encapsulating resin.
- **Automatic loading/purging:** raw chemical solutions are pumped to the print heads and air is removed from the system automatically.
- **Automatic draining:** pumps raw chemicals safely back to the storage syringes.
- **Automatic cleaning:** cleans print heads and all tubing using a given chemical solution.

FABRICATION PROCESS

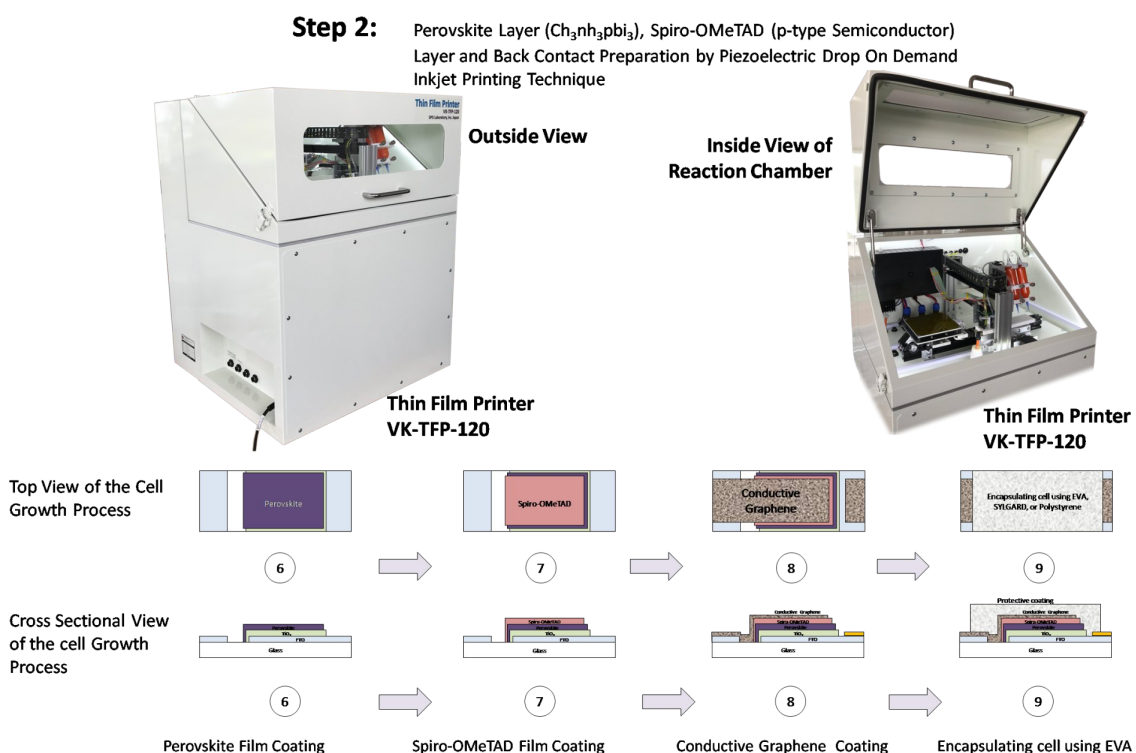
Perovskite solar cell preparation process

A two-step process proposed by SPD Laboratory: the transparent conducting oxide and compact TiO_2 layers are formed by spray pyrolysis deposition, and the perovskite, hole-transport and back-contact layers are printed in the VK-TFP-120 thin film printer.

Step 1 — Patterned TCO (FTO) layer and n-type TiO_2 layer by spray pyrolysis deposition (KV-100)



Step 2 — Perovskite layer, Spiro-OMeTAD layer and back contact by piezoelectric drop-on-demand inkjet printing (VK-TFP-120)

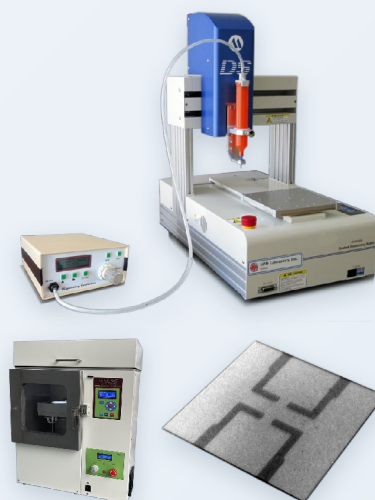


THIN FILM DEPOSITION

KV-PPS-25**Patterned FTO Preparation System**

Dispensing robot plus desktop SPD system for making patterned FTO in your own laboratory — no photolithography or etching.

- ✓ Patterned FTO without photolithography or etching
- ✓ Programmable dispensing robot for any mask pattern
- ✓ KV-25 desktop SPD system for film formation
- ✓ Mask removed simply with water



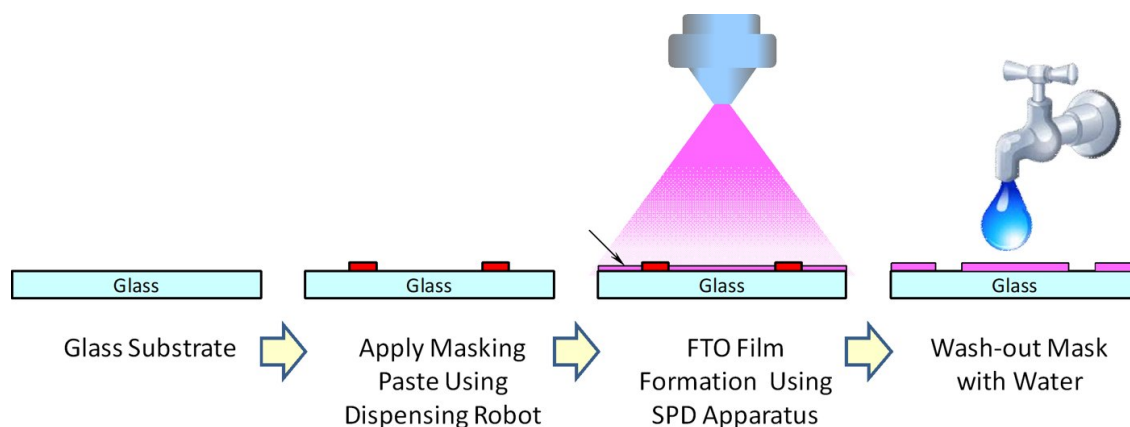
Product page

Overview

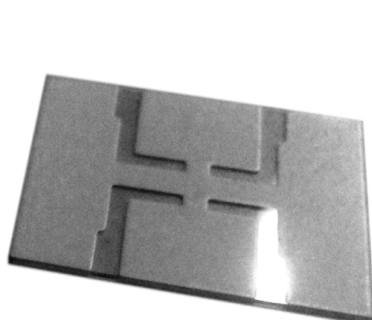
The system makes patterned FTO on a glass substrate by the following procedure: a water-washable, high-temperature-resistant masking paste is applied in the desired pattern by a dispensing robot, FTO is then formed on the masked substrate by spray pyrolysis deposition, and the patterned FTO is finally obtained by washing the paste off the substrate with water.

Process

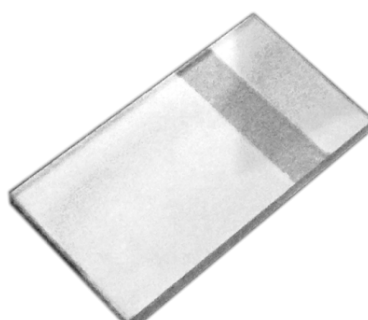
- 1** Glass substrate
- 2** Apply masking paste with the dispensing robot
- 3** FTO film formation with the SPD apparatus
KV-25II → p. 10
- 4** Wash out the mask with water



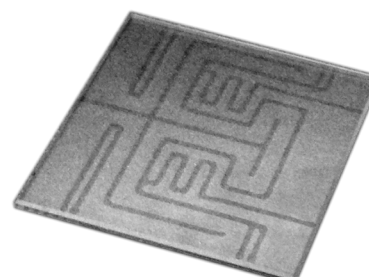
Patterned FTO preparation procedure

Examples

Masked glass



Patterned FTO used for perovskite solar cells



Patterned FTO used for gas sensors

SOLAR CELL CHARACTERIZATION **NEW**

VK-MPA-100

Multi-Channel PV Power Analyzer

Simultaneous I-V tracing and maximum power point tracking (MPPT) for up to six solar cells, with continuous light-intensity and temperature logging.

- ✓ I-V tracing and MPPT of up to 6 solar cells at once — six independent electronic loads
- ✓ Light intensity and temperature plotted with $P_{\max}$
- ✓ Each sample up to 10 V and 1 A — 6 voltage ranges and 16 current ranges
- ✓ Resolution down to 3 pA and 16 nV (24-bit ADCs, max. $6\frac{1}{2}$ digits)
- ✓ Double-diode I-V curve fitting and periodic full I-V scans during MPPT
- ✓ Dedicated, user-friendly control software in English or Japanese
- ✓ Bluetooth wireless link to the PC (USB also possible)



Product page

6
independent PV channels

10 V / 1 A
maximum per channel

24-bit
simultaneous V and I ADCs

3 pA / 16 nV
maximum resolution

Overview

The VK-MPA-100 is a six-channel PV power analyzer built around six independent programmable electronic loads. It traces the I-V curves of up to six solar cells simultaneously and holds each cell at its own maximum power point for continuous tracking, while incident light intensity and temperature are recorded throughout. Every function is operated from the dedicated Windows control software over Bluetooth or USB.

Typical applications

- ✓ Multi-cell I-V characterization
- ✓ Continuous MPP tracking for stability evaluation
- ✓ Output monitoring under changing light intensity
- ✓ Light / dark cycle testing with Cycle MPPT

Front and rear panels



Front panel

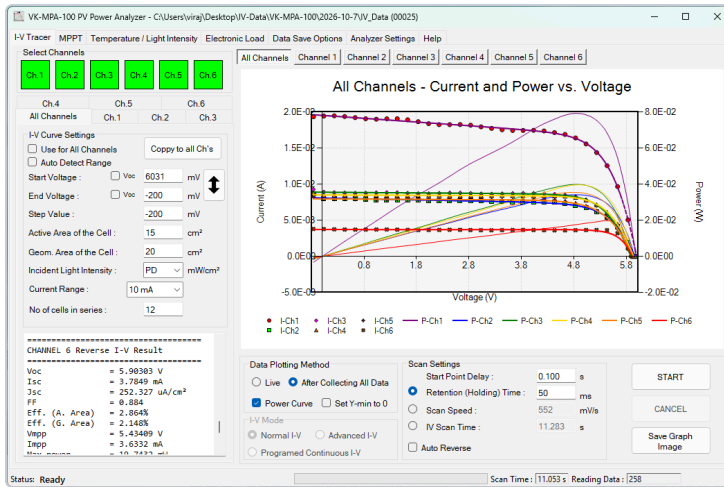


Rear panel

- Front: PV channels 1 – 6 (4-wire, 10 V / 1 A max. each), Si photodiode input, pyranometer inputs (3 channels, 0 – 2.5 V), K-type thermocouple input, auxiliary outputs (relay × 1, open-drain × 2) and status indicator
- Rear: power switch and socket, USB port, Bluetooth antenna and cooling fans

SOLAR CELL CHARACTERIZATION

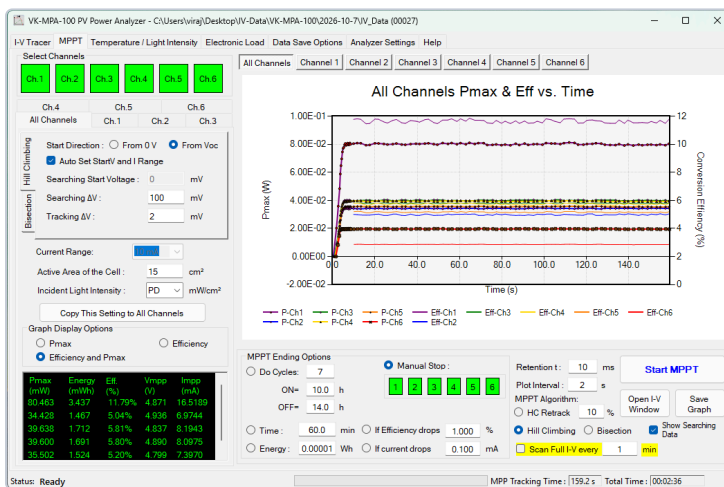
VK-MPA-100 — Control software



"I-V Tracer" tab — measured data are plotted as points and the fitted curves as lines

2 Double-Diode Curve Fitting

- Every forward and reverse scan of each channel is fitted with a double-diode model; measured data are plotted as points and the fitted curves as lines.
- R_s and R_{sh} are taken from the fitted curve.
- The fitted curve and all fit parameters are saved with the I-V data.
- I-V scans taken during MPPT are fitted in the same way.



"MPPT" tab — Pmax and conversion efficiency vs. time for all channels

5 Periodic Full I-V Scan during MPPT

- At a set interval each tracking channel is scanned ($V_{mpp} \rightarrow V_{oc} \rightarrow 0 V \rightarrow V_{mpp}$), then tracking continues from the same point.
- The I-V curves are plotted and V_{oc} , I_{sc} , FF, efficiency, V_{mpp} , I_{mpp} and maximum power of each channel are displayed.
- The data of every scan are saved for each channel.
- Requires analyzer firmware 20.26.10.06 or newer.

6 Cycle MPPT (light / dark cycle testing)

- Repeats tracking (ON) and rest (OFF) periods for a set number of cycles.
- The auxiliary outputs can switch the solar simulator power, trigger and shutter with individual delay timings.

1 Solar Cell I-V Tracing ("I-V Tracer" tab)

Current and power vs. voltage curves for up to six cells in a single run, with curve fitting.

- Up to 6 solar cells can be connected and traced simultaneously; all channels are plotted together and each channel also has its own graph.
- User-selectable START, END and STEP voltages, or automatic detection of the voltage and current ranges.
- Scan defined by the desired scan speed, scan time or holding time, with a start-point delay and an Auto Reverse option.
- Curves are plotted live during the scan or after all data have been collected.
- Calculated results: V_{oc} , I_{sc} , J_{sc} , P_{max} , V_{mpp} , I_{mpp} , FF, R_s , R_{sh} and η for the active area and the geometric area.
- Incident light intensity is measured during the scan and used to calculate the power conversion efficiency.

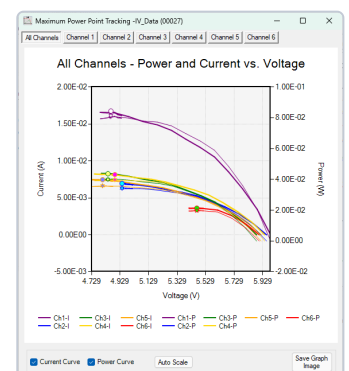
3 Advanced I-V and Programmed Continuous I-V

- Advanced I-V allows initial, middle and end-point holding times, with I vs. t transient plots.
- Programmed Continuous I-V takes a series of I-V curves at given time intervals.

4 Maximum Power Point Tracking ("MPPT" tab)

Each cell is tracked at its own maximum power point, continuously and independently.

- The analyzer searches for each cell's maximum power point (MPP) and keeps tracking it continuously.
- Plots P_{max} , V_{mpp} , I_{mpp} , conversion efficiency and energy vs. time for all connected cells, together with the light intensity.
- Tracking algorithms: Hill Climbing, Hill Climbing with automatic re-tracking after a large change in current, and Bisection.
- Ending options: manual stop for each channel, elapsed time, energy, efficiency drop or current drop.
- Current / power vs. voltage plots for each cell are displayed in a separate graph window during tracking.
- MPPT data are saved automatically at a user-set interval.



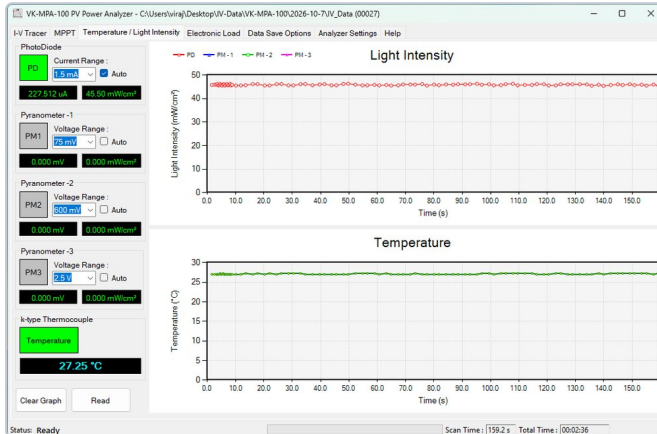
I-V and P-V plot window opened from the MPPT tab, showing each cell during tracking

SOLAR CELL CHARACTERIZATION

VK-MPA-100 — Control software

New in control software version 3 (October 2026)

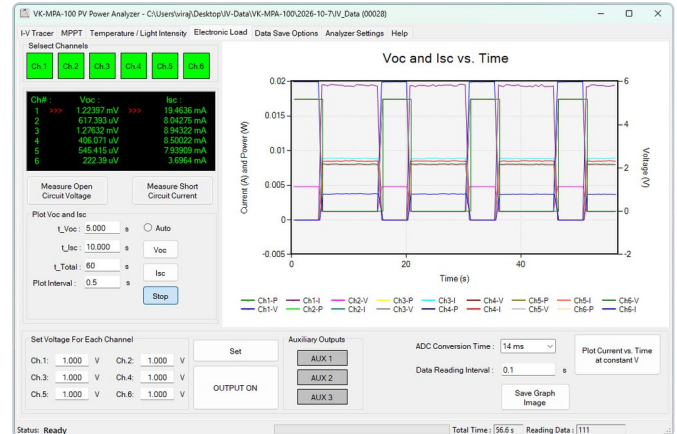
- ✓ Double-diode curve fitting of every forward and reverse I-V scan; R_s and R_{sh} are taken from the fitted curve
- ✓ Periodic full I-V scan during MPPT, at a set time interval
- ✓ Display language selection: English or Japanese
- ✓ “Plot V_{oc} and I_{sc} ” for all six channels on the Electronic Load tab



“Temperature / Light Intensity” tab

7 Light Intensity and Temperature (“Temperature / Light Intensity” tab)

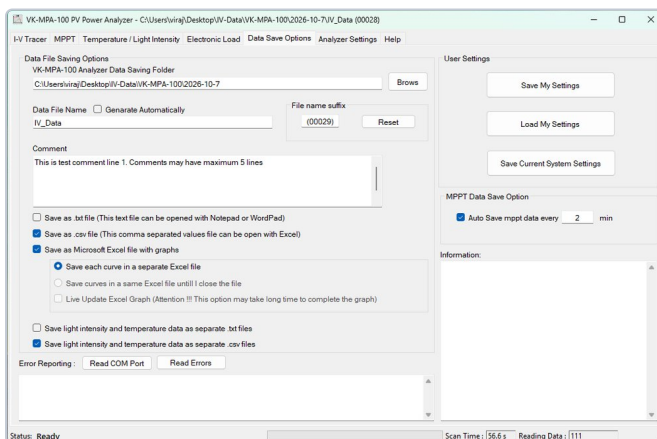
- The photodiode, three pyranometer channels and the thermocouple are switched on individually and plotted continuously against time.
- Manual or automatic range selection for each light-intensity channel.
- Sensor readings and the calculated light intensity (mW/cm^2) are displayed together.



“Electronic Load” tab — Voc and Isc vs. time

8 Electronic Load (“Electronic Load” tab)

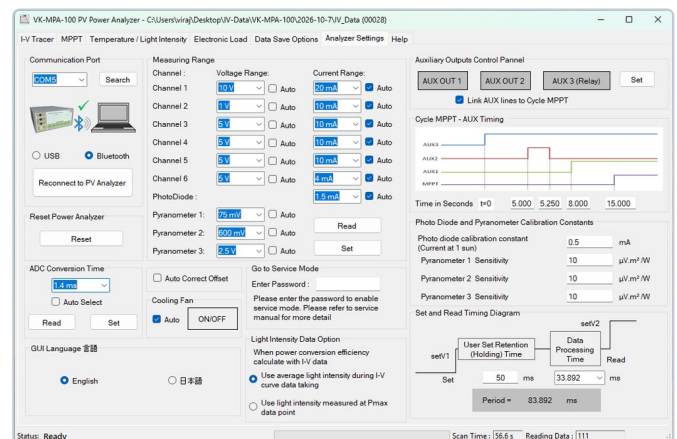
- Sets each PV channel to a desired voltage and plots current, voltage and power vs. time.
- Direct measurement of the open-circuit voltage and short-circuit current of all six channels.
- Plot V_{oc} and I_{sc} : keeps all active channels in the open-circuit or short-circuit condition, or alternates between the two automatically, and plots voltage and current vs. time.
- ON/OFF control of the three auxiliary outputs.



“Data Save Options” tab

9 Data Saving (“Data Save Options” tab)

- Data saved as text (.txt), comma-separated (.csv) or Microsoft Excel files with graphs.
- I-V data files include the fitted curve and all curve-fit parameters.
- Light-intensity and temperature data can be saved as separate files; MPPT data are auto-saved at a set interval.
- Graphs can be saved as images, and user settings can be saved and reloaded.



“Analyzer Settings” tab, with the GUI language selection

10 Analyzer Settings (“Analyzer Settings” tab)

- Voltage and current measuring ranges for every channel, with manual or automatic selection.
- Photodiode calibration constant and pyranometer sensitivities.
- Bluetooth / USB selection, ADC conversion time, auxiliary output control and Cycle MPPT – AUX timing.
- Efficiency can be calculated with the average light intensity during the I-V scan or with the light intensity measured at the P_{max} data point.
- GUI language selection: English or Japanese.

SOLAR CELL CHARACTERIZATION

VK-MPA-100 — Specifications

Number of channels	PV device: 6 (six sets of 4-wire sample connectors) Light-intensity inputs: 4 (1 Si photodiode, 3 pyranometers) Temperature input: 1 (K-type thermocouple) Auxiliary outputs: 3 (1 relay output 10 A, 2 open-drain outputs)
Measuring technique	The analyzer consists of six independent programmable electronic loads, so simultaneous I-V tracing is possible. During MPPT measurements, each sample is separately maintained at its maximum power point by the MPPT algorithm in the microcontroller firmware.
Maximum input	10 V and 1 A for each channel
Voltage ranges	6 ranges: 10 V / 5 V / 2 V / 1 V / 400 mV / 100 mV
Current ranges	16 ranges: 1.2 A / 600 mA / 300 mA / 140 mA / 60 mA / 40 mA / 20 mA / 10 mA / 4 mA / 2 mA / 1 mA / 600 μ A / 300 μ A / 100 μ A / 60 μ A / 20 μ A
Range selection	Manual or automatic, set individually for each channel
Maximum resolution	Current: 3 pA, Voltage: 16 nV, Voltage setting: 162 μ V (max. 6½ digits)
A/D and D/A converters	Two separate 24-bit ADCs for simultaneous voltage and current measurements Six separate 16-bit DACs for setting the cell voltages Light-intensity data are measured using a 24-bit ADC
Data acquisition	Incident light intensity and temperature data are obtained continuously during I-V tracing and MPPT measurements.
Si photodiode port	Built-in trans-impedance amplifier measures the short-circuit current of a calibrated Si photodiode; 6 current ranges (13 mA – 400 μ A). The Si photodiode is not provided with the system and needs to be ordered separately. Customers can also use their own photodiode after changing the calibration constant in the software.
Pyranometer port	Up to 3 pyranometers can be connected as light-measuring sensors. Voltage input 0 – 2.5 V with 6 ranges (2.5 V – 75 mV); the sensitivity of each sensor (μ V·m ² /W) is entered in the software.
Temperature	K-type thermocouple input (thermocouple supplied)
Auxiliary outputs	Three outputs switched from the control software for external equipment such as a solar-simulator shutter: relay output (10 A) × 1 and open-drain output × 2.
Control software	Dedicated, user-friendly computer software is provided to control all functions and data logging. Measurement data can be saved as a text file (.csv or .txt) and plotted directly as a Microsoft® Excel graph. The display language can be switched between English and Japanese.
PC requirement	The customer should prepare a Windows-based PC (with Bluetooth) to install the control software. A new laptop PC can be ordered from us as a separate option.
Communication	Measured data are transferred wirelessly to the PC through Bluetooth and displayed on graphs. A USB connection is also possible.
Power requirement	100 VAC (50–60 Hz) 2 A, 230 VAC (50–60 Hz) 1 A
Dimensions, weight	320 mm (W) × 450 mm (D) × 150 mm (H), approx. 7 kg
Electrical standard	 

Supplied accessories



PV cell cable × 6 (4-wire, with clips)



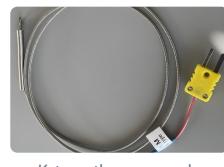
Auxiliary output cable (7-pin connector)



Pyranometer cable (6-pin connector)



Photodiode cable (2-pin connector)



K-type thermocouple

Power cable, control software and user manual · The Si photodiode is not included (to be ordered separately) — see the RC-3618 Calibrated Si Reference Cell.

Pioneers of MPPT solar cell characterization

SPD Laboratory was the first to introduce MPPT as a characterization technique for perovskite solar cells, beginning with the VK-PA-25. The first VK-PA-25 was delivered to the Research Center for Advanced Science and Technology (RCAST), The University of Tokyo, in 2015.

SOLAR CELL CHARACTERIZATION

VK-PA-100

PV Power Analyzer

Solar cell measurement system — one instrument,
five laboratory measurements



Product page

**Solar Cell I-V**
 V_{OC} , J_{SC} , FF, η , R_s , R_{sh}
**MPP Tracking**
 P_{max} & efficiency vs. time
**4-Quadrant I-V**

Dark I-V, cyclic voltammetry

**Four-Probe Ω**

Sheet resistance, resistivity

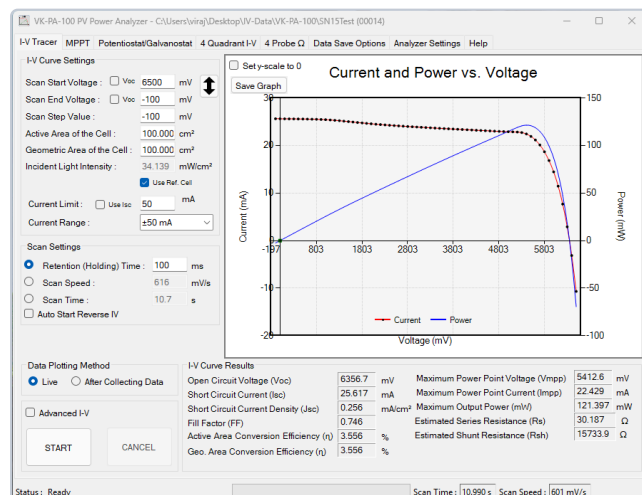
**Potentiostat**

Galvanostat mode included

Specifications

Measurement range	Voltage ± 10 V · Current 1 A (3 A pulse), 5½-digit resolution
Measuring technique	Digital source / measure
Inputs	Front: 4 probes for the PV device Rear: 4-wire connector for reference cell (light-intensity measurement)
A/D converters	16-bit — two independent converters for voltage and current
Software & data	Windows software controls every function and logs the data. Results save as a text file or plot directly into a Microsoft Excel® graph.
Communication	Bluetooth
Power requirement	100 – 240 V AC, 50 / 60 Hz
Compliance	 
Dimensions & weight	93 × 210 × 350 mm · 2.5 kg

Supplied software

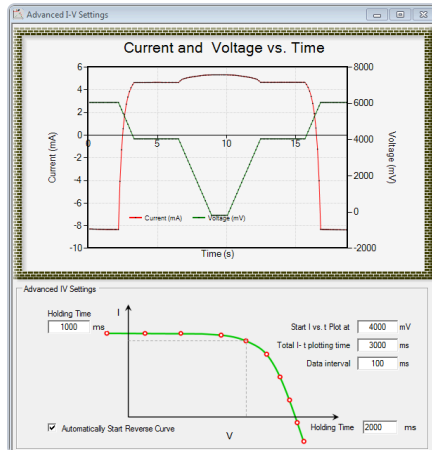


A Windows application is supplied with every instrument and drives all five measurement modes from one window. Measured curves appear live while the sweep runs.

- ✓ Live plotting of current and power against voltage
- ✓ Results saved as text or CSV, or written straight into a Microsoft Excel® graph
- ✓ Measurement conditions stored and recalled as user setting files
- ✓ Daily power-generation graph in W/m², with a full-screen display mode (option)
- ✓ Japanese and English user interface, switchable at any time

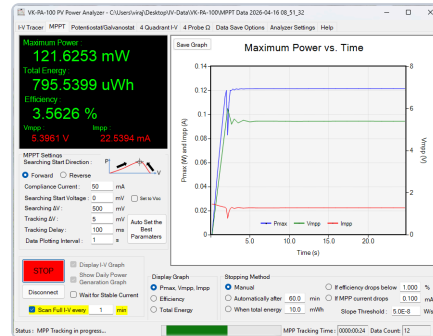
SOLAR CELL CHARACTERIZATION

VK-PA-100 — Measurement Functions & Software



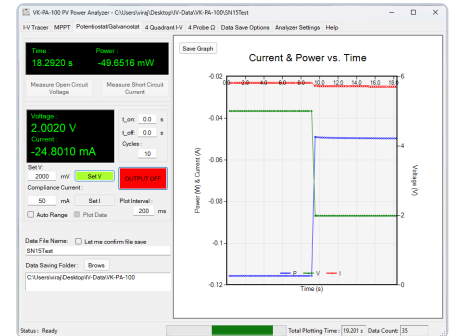
1 Solar Cell I-V Tracer

Start, end and step voltages are set by the user, and the instrument plots current and power against voltage. Calculated results include V_{oc} , I_{sc} , J_{sc} , P_{max} , V_{mpp} , I_{mpp} , FF , R_s , R_{sh} and the conversion efficiency for both active and geometric cell area. Scan speed, scan time or holding time may be specified; the advanced I-V option adds separate holding times at the start, middle and end of the sweep, together with an I-t transient plot for every data point or at one selected fixed voltage.



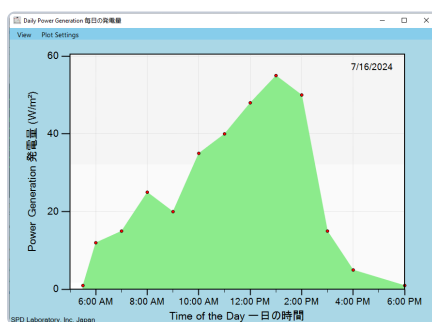
2 Maximum Power Point Tracking (MPPT)

The analyzer behaves as the optimum load for the cell, finding the maximum power point and then tracking it continuously. P_{max} , V_{mpp} , I_{mpp} and efficiency are plotted against time while current and power against voltage remain on display. Full I-V sweeps can be inserted automatically at a chosen interval during a tracking run, so long-term degradation and the I-V curve are recorded together.



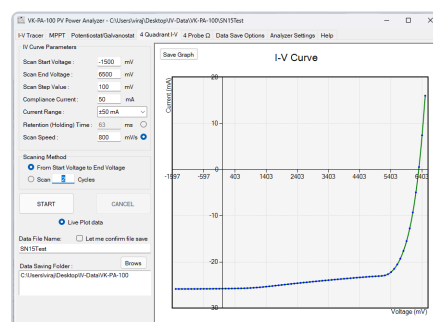
3 Potentiostat / Galvanostat

Plots voltage and current against time at a fixed output voltage or a fixed current. Open-circuit voltage and short-circuit current are measured directly, and a programmable electro-deposition function is included.



4 Daily Power Generation

Optional feature for MPPT runs. Power generation in W/m^2 is logged against the time of day, projected from the cell active area to one square metre, and written to a separate file for each day. Point, line or area plot, full-screen display, automatic or manually set time axis, and image export.



5 Full-Range 4-Quadrant I-V

Start, end and step voltages and the scan speed (mV/s) are user selectable. Current against voltage is plotted for a chosen number of sweep cycles in potentiostat mode, and a three-electrode liquid cell with reference electrode may be used.



6 Four-Probe Resistance

Three dedicated functions measure sheet resistance, resistivity and resistance. Geometrical correction factors are calculated automatically from the sample size and the probe position. Range 2.0×10^{-3} to $5.0 \times 10^6 \Omega$.

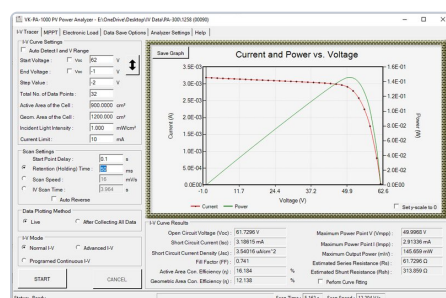
SOLAR CELL CHARACTERIZATION **NEW****VK-PA-1000****PV Power Analyzer for Module Testing**

I-V tracing and maximum power point tracking (MPPT) for solar cell modules up to 100 V and 1 A, with state-of-the-art control software.

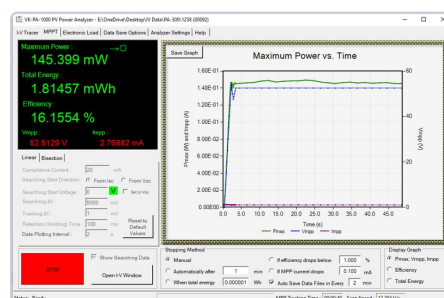
- ✓ I-V tracing and MPPT for solar cell modules up to 100 V and 1 A
- ✓ 8 voltage ranges (100 V – 500 mV) and 15 current ranges (1 A – 50 μ A)
- ✓ 24-bit A/D converters — resolution down to 110 nV and 9 pA (max. 6½ digits)
- ✓ Programmed continuous I-V and double-diode I-V curve fitting
- ✓ Electronic load with constant-voltage and constant-current operation
- ✓ Bluetooth communication with the PC

**Specifications**

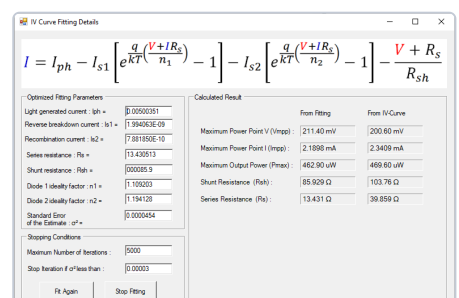
Measurement range	Voltage: 100 V – 500 mV (8 ranges) Current: 1 A – 50 μ A (15 ranges)
Minimum resolution (max. 6½ digits)	Set: 28 μ V, 5 nA Measure: 110 nV, 9 pA
Measuring technique	Electronic load type, with 4-probe connection to the device under test
Inputs	Front: 4 probes for the PV device
A/D converters	24-bit — two independent converters for voltage and current On-chip digital calibration eliminates offset and gain errors Integration time selectable from 16 values, 400 ms down to 33.3 μ s
Built-in voltage reference	Output voltage 2.500 $\pm$ 0.001 V Output voltage drift 3 ppm/°C (–40 °C to +85 °C) Output noise 100 nV/√Hz
User interface & data	Computer software controls every function and logs the data. Results save as a text file (.csv or .txt) or plot directly into a Microsoft Excel® graph. Windows-based PC required.
Communication	Bluetooth
Power requirement	100 V AC (50 – 60 Hz) / 230 V AC (50 – 60 Hz)
Electrical standard	 
Dimensions & weight	260 (W) × 350 (D) × 133 (H) mm, 5 kg

Control software

"I-V Tracer" tab



"MPPT" tab — maximum power vs. time



I-V curve fitting details (double-diode model)

Main functions**1 Solar Cell I-V Tracer**

Start, end and step voltages are set by the user, and the instrument plots current and power against voltage. Calculated results include V_{oc} , I_{sc} , J_{sc} , P_{max} , V_{mpp} , I_{mpp} , FF, R_s , R_{sh} and the conversion efficiency for both active and geometric cell area. Scan speed, scan time or holding time may be specified. The advanced I-V option adds separate holding times at the start, middle and end of the sweep, together with an I-t transient plot for every data point or at one selected fixed voltage.

2 Maximum Power Point Tracking (MPPT)

The analyzer behaves as the best load for the module, extracting the maximum power point and then tracking it continuously. P_{max} , V_{mpp} , I_{mpp} and efficiency are plotted against time while current and power against voltage remain on display. A run is stopped by hand, after a set time or total energy, or automatically once the efficiency or the MPP current falls below a chosen limit.

3 Programmed Continuous I-V

Takes a series of I-V curves automatically at a given time interval. Between sweeps the cell is held at short circuit, at open circuit, at the V_{pmax} of the last curve or at a chosen voltage.

4 I-V Curve Fitting

A dedicated curve-fitting function is part of the control software. Measured data are fitted to a double-diode model, and the fitted I_{ph} , I_{s1} , I_{s2} , n_1 , n_2 , R_s and R_{sh} are listed beside the values read from the curve.

SOLAR CELL CHARACTERIZATION **NEW****VK-PA-2000****PV Power Analyzer for Solar Modules up to 220 V / 2.5 A**

I-V tracing and maximum power point tracking (MPPT) for solar cell modules up to 220 V and 2.5 A, with state-of-the-art control software.

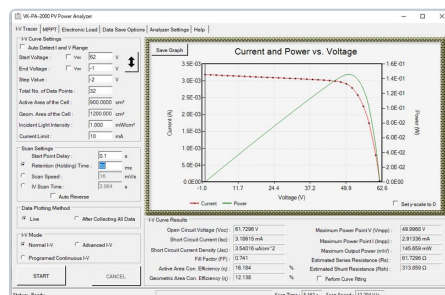
- ✓ I-V tracing and MPPT for solar cell modules up to 220 V and 2.5 A
- ✓ 8 voltage ranges (220 V – 1.6 V) and 15 current ranges (2.5 A – 60 µA)
- ✓ Continuous MPPT up to 1 A
- ✓ Three MPPT methods: SPD-MPPT, hill-climb and bisection
- ✓ Programmed continuous I-V and double-diode I-V curve fitting
- ✓ 24-bit A/D converters, two independent converters for voltage and current
- ✓ Bluetooth communication with the PC



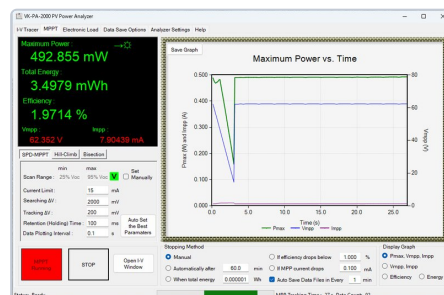
Product page

Specifications

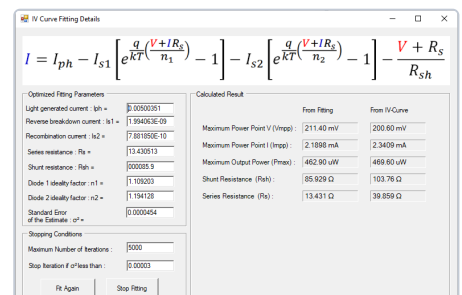
Measurement range	Voltage: 220 V – 1.6 V (8 ranges) Current: 2.5 A – 60 µA (15 ranges) Continuous MPPT up to 1 A
Voltage ranges	220 V · 110 V · 56 V · 28 V · 14 V · 7 V · 3.4 V · 1.6 V
Current ranges	2.5 A · 1.5 A · 750 mA · 200 mA · 100 mA · 50 mA · 25 mA · 14 mA · 4 mA · 2 mA · 1 mA · 500 µA · 250 µA · 140 µA · 60 µA
Measuring technique	Electronic load type, with 4-probe connection to the device under test
Inputs	Front: 4 probes for the PV device
A/D converters	24-bit — two independent converters for voltage and current On-chip digital calibration eliminates offset and gain errors Integration time selectable from 16 values, 400 ms down to 33.3 µs
Built-in voltage reference	Output voltage 2.500 ± 0.001 V Output voltage drift 3 ppm/°C (–40 °C to +85 °C) Output noise 100 nV/√Hz
User interface & data	Computer software controls every function and logs the data. Results save as a text file (.csv or .txt) or plot directly into a Microsoft Excel® graph. Windows-based PC required.
Communication	Bluetooth
Power requirement	100 V AC (50 – 60 Hz) / 230 V AC (50 – 60 Hz)
Electrical standard	 
Dimensions & weight	320 (W) × 450 (D) × 150 (H) mm, approx. 10 kg

Control software

"I-V Tracer" tab



"MPPT" tab — maximum power vs. time



I-V curve fitting details (double-diode model)

Main functions**1 Solar Cell I-V Tracer**

Start, end and step voltages are set by the user, and the instrument plots current and power against voltage. Calculated results include V_{oc} , I_{sc} , P_{max} , V_{mpp} , I_{mpp} , FF, R_s , R_{sh} and the conversion efficiency for both active and geometric cell area. Scan speed, scan time or holding time may be specified. The advanced I-V option adds separate holding times at the start, middle and end of the sweep, together with an I-t transient plot for every data point or at one selected fixed voltage.

2 Maximum Power Point Tracking (MPPT)

The analyzer behaves as the best load for the module, extracting the maximum power point and then tracking it continuously. P_{max} , V_{mpp} , I_{mpp} and efficiency are plotted against time while current and power against voltage remain on display. Three tracking methods can be selected: SPD-MPPT, hill-climb and bisection. A run is stopped by hand, after a set time or total energy, or automatically once the efficiency or the MPP current falls below a chosen limit.

3 Programmed Continuous I-V

Takes a series of I-V curves automatically at a given time interval. Between sweeps the cell is held at short circuit, at open circuit, at the V_{pmax} of the last curve or at a chosen voltage.

SOLAR CELL CHARACTERIZATION

VK-PA-300

PV Power Analyzer

I-V tracing, MPPT and cyclic voltammetry of solar cells up to ± 12 V and ± 2 A (± 4 A pulse), 24-bit.

- ✓ Solar cell I-V curve tracing
- ✓ Maximum power point tracking
- ✓ Four-quadrant I-V / cyclic voltammetry
- ✓ 24-bit ADCs, ± 12 V / ± 2 A (± 4 A pulse)
- ✓ I-V curve fitting in software

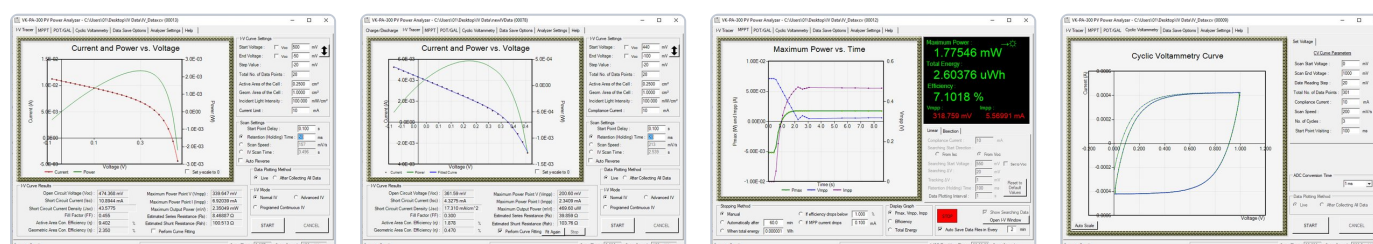


Product page

Specifications

Measurement range	Voltage: ± 12 V, Current: ± 2 A (± 4 A pulse), with $5\frac{1}{2}$ -digit resolution
Measuring technique	Digital source meter
Inputs	Front: 4 probes for the PV device
A/D converters	24-bit (2 independent ADCs for V & I)
User interface & data collection	Computer software is provided to control all functions and log data. Measurement data can be saved as text files and plotted directly as Microsoft® Excel graphs. (Windows PC required)
Communication	Bluetooth
Power requirement	100 – 240 VAC (50/60 Hz)
Electrical standard	 
Dimensions	133 × 260 × 350 mm
Weight	5 kg

Control software



I-V tracing

I-V with curve fitting

MPPT

Cyclic voltammetry

Main functions

1 Solar Cell I-V Curve Tracing

User-selectable START, END and STEP voltages. Plots current and power vs. voltage curves. Calculated results include V_{oc} , I_{sc} , J_{sc} , P_{max} , V_{mpp} , I_{mpp} , FF , R_s , R_{sh} , $\eta_{activeA}$ and η_{geoA} . Scan speed, scan time or holding time can be set as desired. The Advanced I-V option allows initial, middle and end-point holding times, and I vs. t transient plots for all data points and/or at a selected fixed voltage.

2 Maximum Power Point Tracking (MPPT)

The analyzer acts as the optimum load for the cell, extracting maximum power and continuously tracking the maximum power point (MPP). Plots P_{max} , V_{mpp} , I_{mpp} and efficiency vs. time, and displays current/power vs. voltage curves. Open-circuit voltage and short-circuit current can also be measured directly, and current vs. time can be plotted at a fixed output voltage.

3 Cyclic Voltammetry Analysis

User-selectable START, END, STEP voltages and scan speed (mV/s). Plots current vs. voltage for a given number of sweep cycles in potentiostat mode. Can be used with a 3-electrode liquid cell with a reference electrode.

SOLAR CELL CHARACTERIZATION

VK-PA-Pico

Pico-Ampere PV Power Analyzer

Pico-ampere range I-V tracing and pico-watt range MPPT, with 25 current ranges down to ± 600 pA.

- ✓ Pico-ampere range I-V tracing
- ✓ Pico-watt range MPPT
- ✓ Ideal ammeter mode (voltage drop < 5 μ V)
- ✓ Potentiostat and four-quadrant I-V
- ✓ 25 current ranges from ± 10 mA to ± 600 pA



Product page

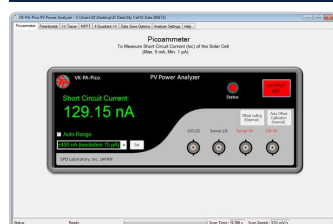
Specifications

Measurement range	Voltage: ± 10 V Current: max. ± 10 mA, min. 600 pA				
Current measuring ranges (resolution)	± 10 mA (300 nA) ± 300 μ A (10 nA) ± 7 μ A (250 pA) ± 230 nA (7 pA) ± 9 nA (0.3 pA)	± 5 mA (160 nA) ± 120 μ A (4 nA) ± 3.5 μ A (100 pA) ± 115 nA (4 pA) ± 4 nA (0.1 pA)	± 2.5 mA (80 nA) ± 60 μ A (2 nA) ± 1.8 μ A (60 pA) ± 55 nA (2 pA) ± 2 nA (70 fA)	± 1.25 mA (40 nA) ± 30 μ A (1 nA) ± 900 nA (30 pA) ± 35 nA (1 pA) ± 1 nA (35 fA)	± 600 μ A (20 nA) ± 15 μ A (500 pA) ± 450 nA (15 pA) ± 18 nA (0.6 pA) ± 600 pA (17 fA)
User interface & data collection	Computer software is provided to control all functions and log data. Measurement data can be saved as text files and plotted directly as Microsoft® Excel graphs. (Windows PC required)				
Communication	USB (Version 5) / Bluetooth (Version 6)				
Power requirement	100 – 240 VAC (50/60 Hz)				
Electrical standard	 				
Dimensions	88 × 210 × 350 mm				
Weight	3.0 kg				

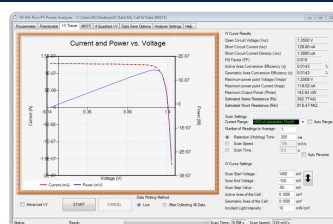
Main functions

- Pico Ammeter**
The analyzer works as an ideal ammeter (voltage drop < 5 μ V) to measure the short-circuit current of the cell.
- Potentiostat**
Biases the cell at a given constant voltage and measures current. Voltage, current, power or resistance is displayed on screen and can be plotted against time.
- Solar Cell I-V Curve Tracing**
User-selectable START, END and STEP voltages. Plots current and power vs. voltage curves. Calculated results include Voc, Isc, Jsc, Pmax, Vmpp, Imp, FF, Rs, Rsh, η_{activeA} and η_{geoA} . Scan speed, scan time or holding time can be set as desired. The Advanced I-V option allows initial, middle and end-point holding times, and I vs. t transient plots for all data points and/or at a selected fixed voltage.
- Maximum Power Point Tracking (MPPT)**
The analyzer acts as the optimum load for the cell, extracting maximum power and continuously tracking the maximum power point (MPP). Plots Pmax, Vmpp, Imp and efficiency vs. time, and displays current/power vs. voltage curves. Open-circuit voltage and short-circuit current can also be measured directly, and current vs. time can be plotted at a fixed output voltage.
- Four-Quadrant I-V Analysis**
User-selectable START, END, STEP voltages and scan speed (mV/s). Plots current vs. voltage for a given number of sweep cycles in potentiostat mode. Can be used with a 3-electrode liquid cell with a reference electrode.

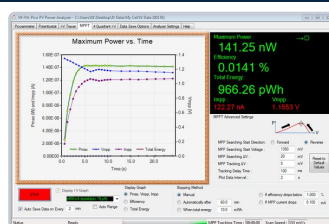
Control software



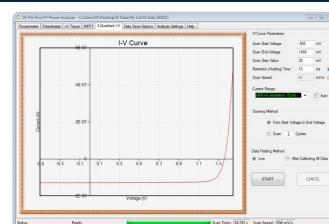
"Picoammeter" tab of the control software



"I-V Tracer" tab



"MPPT" tab



"4 Quadrant I-V" tab

SOLAR CELL CHARACTERIZATION

PV power analyzer selection guide

All six analyzers combine I-V curve tracing with true maximum power point tracking (MPPT) and are operated from supplied Windows software.



	VK-PA-100 p. 20	VK-PA-300 p. 24	VK-PA-1000 p. 22	VK-PA-2000 p. 23	VK-MPA-100 p. 16	VK-PA-Pico p. 25
Best suited for	Single cells; four measurements in one instrument	Cells needing higher current; curve fitting and CV	Solar cell modules up to 100 V	Solar modules up to 220 V and 2.5 A	Up to six cells measured at the same time	Very small currents, down to the pico-ampere range
PV channels	1	1	1	1	6	1
Voltage	±10 V	±12 V	100 V – 500 mV (8 ranges)	220 V – 1.6 V (8 ranges)	10 V max. per channel (6 ranges)	±10 V
Current	1 A (3 A pulse)	±2 A (±4 A pulse)	1 A – 50 µA (15 ranges)	2.5 A – 60 µA (15 ranges); continuous MPPT up to 1 A	1 A max. per channel (16 ranges down to 20 µA)	±10 mA – ±600 pA (25 ranges)
Measuring technique	Digital source / measure	Digital source meter	Electronic load	Electronic load	Six independent electronic loads	Trans-impedance pico-ammeter
A/D converters	16-bit	24-bit	24-bit	24-bit	24-bit	16-bit
Functions besides I-V and MPPT	Four-quadrant I-V, four-probe resistance, potentiostat / galvanostat, daily power generation (option)	I-V curve fitting, cyclic voltammetry, potentiostat / galvanostat	Programmed continuous I-V, I-V curve fitting	Three MPPT methods, programmed continuous I-V, I-V curve fitting, electronic load	I-V curve fitting, Cycle MPPT, electronic load, light-intensity and temperature logging	Pico-ammeter, potentiostat, four-quadrant I-V
Communication	Bluetooth	Bluetooth	Bluetooth	Bluetooth	Bluetooth (USB also possible)	USB (Version 5) / Bluetooth (Version 6)
Size (mm), weight	93 × 210 × 350, 2.5 kg	133 × 260 × 350, 5 kg	133 × 260 × 350, 5 kg	150 × 320 × 450, approx. 10 kg	150 × 320 × 450, approx. 7 kg	88 × 210 × 350, 3.0 kg

SOLAR CELL CHARACTERIZATION

VK-CA-1000

Solar Cell Capacitance Analyzer

Ultra-fast linear voltage ramp (up to 50,000,000 mV/s) to analyze capacitance and transient behavior of solar cells.



Product page



- ✓ Ultra-fast linear voltage ramp up to 50,000,000 mV/s
- ✓ Capacitance measurement under dark and illuminated conditions
- ✓ Hysteresis analysis with ultra-fast I-V scans
- ✓ Automatic range selection

Measuring technique	Analyzes cell current under an ultra-fast linear voltage ramp. The ramp (usually 0 V to the cell's Voc) changes the cell voltage within a few microseconds while V and I data are collected at up to 4 M samples/s with 16-bit resolution.
Usage	Solar cell capacitance under illuminated and dark conditions; hysteresis analysis with ultra-fast cyclic I-V scans.
User interface & data collection	Computer software is provided to control all functions and log data. Measurement data can be saved as text files and plotted directly as Microsoft® Excel graphs. (Windows PC required)
Communication	Bluetooth
Power requirement	100 – 240 VAC (50/60 Hz)
Dimensions	93 × 210 × 350 mm
Weight	2.5 kg

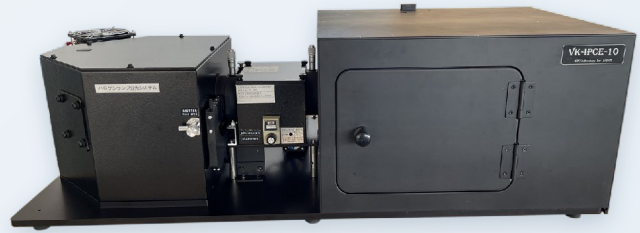
SOLAR CELL CHARACTERIZATION

VK-IPCE-10

IPCE & Spectral Response Measurement System

One-click IPCE and spectral response measurement with a double-beam, lock-in-free DSP design.

- ✓ Fully automatic IPCE measurement with one click
- ✓ No lock-in amplifier, source meter or lamp power supply needed
- ✓ Double-beam technique: sample & light intensity measured simultaneously
- ✓ 100 % digital signal processing with FFT
- ✓ Motorized sample stage and Bluetooth remote control



Product page

Overview

The VK-IPCE-10 measures the incident photon-to-electron conversion efficiency (IPCE) and spectral response (SR) of photovoltaic cells and photo-sensors.

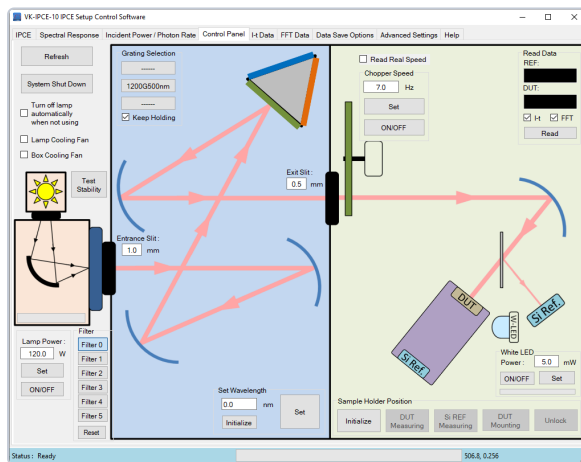
Conventional IPCE setups consist of a light source (halogen or xenon), monochromator, chopper, lock-in amplifier and calibrated Si photodiode. Operating them requires training and experience, and the monochromatic light intensity and the sample are measured in two separate steps — assuming the light source stays constant in between, which is never exactly true. Positioning of the reference cell and the sample also strongly affects accuracy.

The VK-IPCE-10 overcomes these drawbacks. All functions are controlled wirelessly from a single PC interface, and a measurement

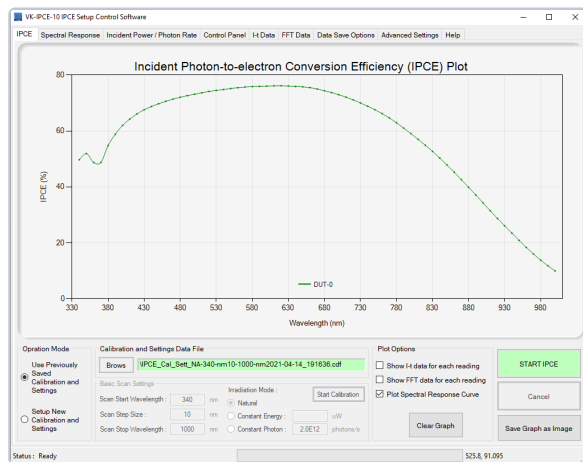
takes three simple steps: 1. mount the device on the sample stage, 2. open the desired measurement-setup file, 3. click [START SCAN]. All settings and calibration data are stored in the setup file, which automatically configures and turns on the required components. New setups can easily be created and saved.

It is a single integrated unit without external instruments such as a lock-in amplifier. A microcontroller-based digital signal processing technique synchronously detects extremely low current signals, and a beam-splitter-based double-beam technique measures the sample and the reference cell simultaneously for real-time light intensity correction.

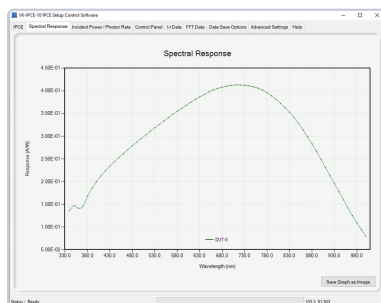
Control software



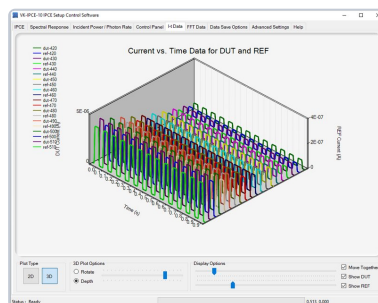
"Control Panel" tab: control sample stage, lamp current, chopper speed and filters, and measure sample and reference output at any wavelength



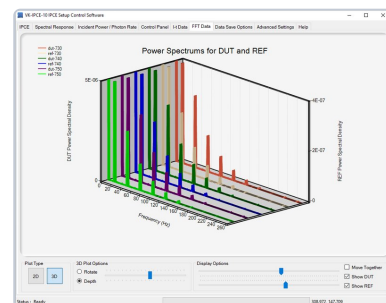
"IPCE" tab: set scan range, irradiation mode and plot options; open or create baseline calibration (Si photodiode as sample)



"Spectral Response" tab: spectral sensitivity (A/W) of a Si photodiode



"I-T Data" tab: time-domain data for each point, as 2D or 3D plot



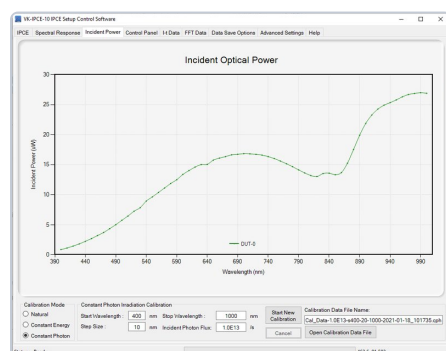
"FFT Data" tab: Fourier-transformed data for each point, as 2D or 3D plot

SOLAR CELL CHARACTERIZATION

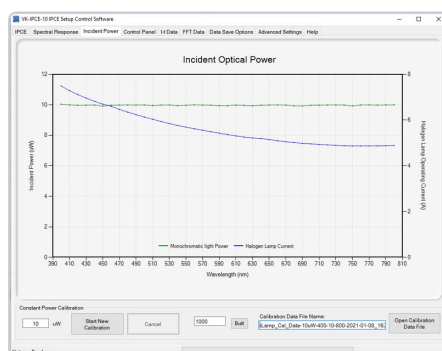
VK-IPCE-10 — Specifications

Type of measurement	Incident photon-to-electron conversion efficiency (IPCE), spectral response (A/W)
Wavelength range	340 – 1000 nm (calibrated photodiode limits); 0 – 1400 nm mechanical limit
Light source	Halogen photo-optic lamp (OSRAM XENOPHOT®) 3400 K. Lamp life is greatly extended by operating at less than half of the rated power.
Irradiation modes	Natural (halogen lamp spectrum), constant energy, constant photon — achieved by automatically calibrated control of the halogen lamp current.
Monochromatic light power on sample	1 to 100 μ W (400 – 1000 nm)
Measuring technique	An optically chopped (1 – 21 Hz) beam is split into two parts (double beam) incident on the device under test (DUT) and a calibrated Si reference cell (REF). The simultaneously digitized DUT and REF short-circuit currents are Fourier-transformed (FFT) to extract only the chopping-frequency component.
Grating	1200 G / 500 nm blaze
Filters	Up to 5 high-order cut filters can be installed (L-37 and R-64 installed)
Recommended sample size	10 mm $\times$ 10 mm
White (bias) light source	3 W white LED (output set via software)
Sample mounting stage	Motorized stage; switch between sample and standard Si photodiode remotely for baseline calibration or accuracy checks.
User interface & data collection	Free control software for all functions and data logging; data saved as text and plotted directly in Microsoft® Excel. Normal users only set the wavelength range; advanced users can control grating and filter positions, FFT bin size, and access raw I-t and FFT data.
Communication	Bluetooth
Power requirement	100 – 240 VAC (50/60 Hz), with input-voltage selection switch
Dimensions / Weight	91 $\times$ 47 $\times$ 29 cm / 20 kg
PC	A Windows PC is required for the control software (not included; available as an option).

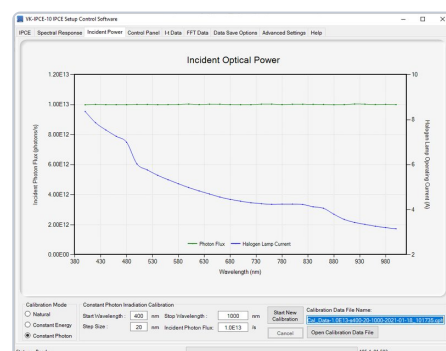
Irradiation modes



Incident optical power on the sample in natural irradiation mode (fixed lamp current)



Constant-energy calibration: 10 μ W on the sample (green) and lamp current (blue)



Constant-photon calibration: 1.0E13 photons/s on the sample (green) and lamp current (blue)

SOLAR CELL CHARACTERIZATION

VK-SS-50

LED Solar Simulator

Class A LED solar simulator with 22 independently controlled wavelengths and output from 0.0001 to 1.0 sun.

- ✓ Innovative solar simulator design using LED light sources
- ✓ Variable output from 0.0001 to 1.0 sun
- ✓ User-settable spectral control
- ✓ Self-calibrating with built-in intensity measurement
- ✓ More than 20,000 hours LED lifetime
- ✓ Motorized sample-mounting stage
- ✓ 30 mm × 30 mm output beam



Product page

Specifications

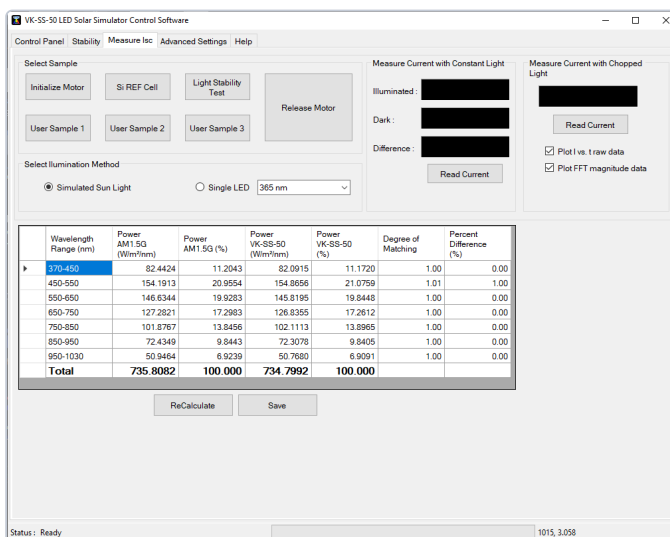
Simulator class	A (JIS C8912)
Independent LED control	Independently drives LEDs at 22 wavelengths spaced from 370 nm to 1030 nm
Illumination area and distance	50 mm × 50 mm, 200 mm
Irradiation intensity	70 mW/cm ² (integrated irradiance at 360 – 1030 nm)
Illuminance stability	Within ±1 % / h (after 30 minutes of lighting)
Illuminance distribution	Within ±5 % (25 × 25 mm effective area) Within ±2 % (10 × 10 mm effective area)
Irradiation direction	Downward
Software	PC communication via Bluetooth; the spectrum can be adjusted by changing all 22 LEDs individually
Cooling method	Forced air cooling
Input voltage	Single phase 100 V ± 5 %, 50/60 Hz
Dimensions	Light unit: 400 (W) × 400 (D) × 550 (H) mm Control box: 320 (W) × 450 (D) × 150 (H) mm
Weight	~20 kg



Control software



"Control Panel" tab — simulated spectrum compared with the AM 1.5 standard, with individual LED controls



"Measure Isc" tab — spectral match table by wavelength range

SOLAR CELL CHARACTERIZATION **NEW****PCM-201VK**

Perovskite Solar Cell (PSC) Model

Equivalent-circuit model that authentically reproduces the I-V hysteresis of perovskite solar cells.



Product page



- ✓ Reproduces PSC I-V hysteresis with a stable, repeatable device
- ✓ Based on SPD Lab's published equivalent-circuit model (2015)
- ✓ Ideal for validating I-V and MPPT measurement systems
- ✓ Active area 0.0162 cm²

The origin of hysteresis in the I-V curves of perovskite solar cells (PSC) was clarified by our group in 2015 using an equivalent-circuit model and simulation of their I-V curves (see "Key publications", p. 6).

Typical Parameters (PCM-201VK)

Active area	0.0162 cm ²
Illumination	1 sun (AM 1.5 simulated sunlight)
Scan start / end voltage	1100 mV / -50 mV
Scan step size / holding time	30 mV / 50 ms
Voc (reverse / forward)	888 mV / 601 mV
PCE (reverse / forward)	7.2 % / 4.9 %

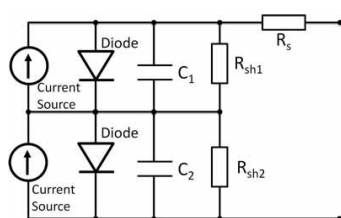


Figure 2. Equivalent circuit of a PSC

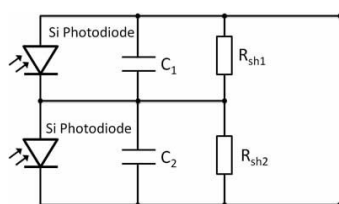


Figure 3. Equivalent circuit of the PSC model

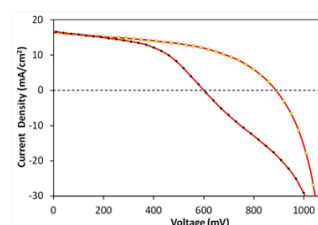


Figure 4. Measured forward and reverse I-V curves of the PSC model

SOLAR CELL CHARACTERIZATION **NEW****RC-3618**

Calibrated Si Reference Cell

Calibrated Si photodiode reference cell that monitors the light intensity of a solar simulator automatically during I-V curve tracing with the VK-PA-100 and VK-MPA-100 PV Power Analyzers.



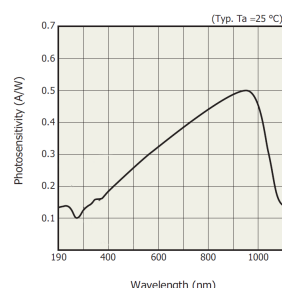
Product page



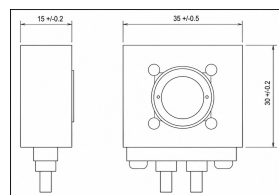
- ✓ Calibrated Si photodiode for solar simulator light-intensity measurement
- ✓ Calibrated under standard 1 SUN conditions (AM 1.5, 100 mW/cm²)
- ✓ Measurement range 0.001 to 1.3 Sun (0.1 to 130 mW/cm²)
- ✓ Hamamatsu Photonics Si photodiode with quartz window, 190 to 1100 nm
- ✓ Connects directly to the VK-PA-100 and VK-MPA-100 PV Power Analyzers
- ✓ Compact housing: 35 × 30 × 15 mm

Detector	Hamamatsu Photonics Si photodiode (TO-18, quartz window)
Photosensitive area	1.1 × 1.1 mm
Spectral response	190 to 1100 nm (peak 960 nm)
Photosensitivity at peak	approx. 0.5 A/W
Measurement range	0.001 to 1.3 Sun (0.1 to 130 mW/cm ²)
Equivalent illuminance	approx. 100 to 130,000 lx *
Housing dimensions	35 × 30 × 15 mm
Calibration condition	AM 1.5, 100 mW/cm ² (1 SUN)
Compatible analyzers	VK-PA-100 and VK-MPA-100 PV Power Analyzers

* The illuminance equivalent assumes an AM 1.5 solar spectrum (1 Sun ≈ 100,000 lx). The lx value varies with the spectrum of the light source.



Spectral response of the Si photodiode (typical, Ta = 25 °C)



Outside dimensions (mm)

SAMPLE HOLDERS & PROBE STATIONS

NEW

VK-SH-50

Solar Cell Sample Holder

Customizable holder with spring-loaded gold-coated contact probes for multi-electrode solar cell I-V and MPPT measurements.

- ✓ Spring-loaded, gold-coated electrical contact probes
- ✓ Designed for multi-electrode I-V and MPPT measurements
- ✓ Custom-made to fit your sample dimensions
- ✓ Tool-free disassembly — no mounting bolts
- ✓ Manual selector switch or automatic switching system



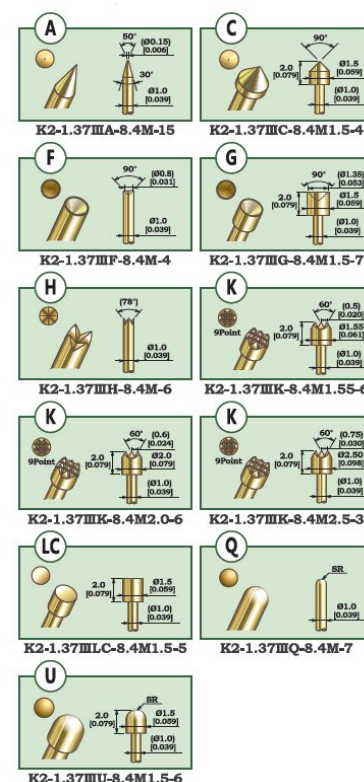
Product page

Overview

Looking for a sample holder that accommodates different sample sizes? Our holder with spring-loaded, gold-coated contact probes is specifically designed for multi-electrode solar cell I-V and MPPT measurements, ensuring accurate and reliable results every time. If you need a holder that fits your specific sample dimensions, simply contact us and we will make one for you.

As shown in the figure, we offer a range of probe shapes that can be tailored to your requirements — our team will work with you to determine the ideal probe shape and size for your application.

Unlike holders that require mounting bolts, ours can be disassembled quickly without any tools. For sample switching we offer both a simple manual selector switch and an automatic switching system that switches samples without user intervention.



SAMPLE HOLDERS & PROBE STATIONS

VK-SH-150

Sample Holder with Contact Probes

150 × 150 mm sample table with four independently adjustable spring-tensioned contact probes.

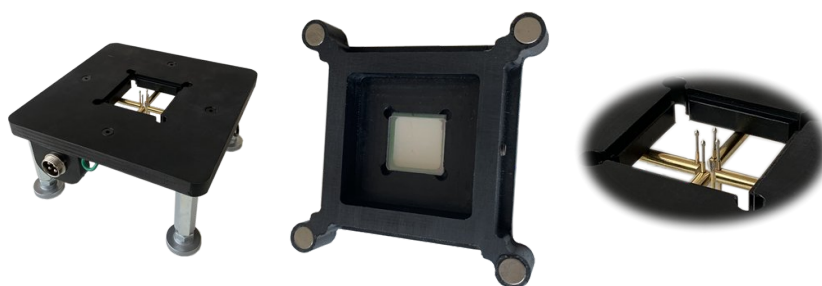


Product page



- ✓ Four spring-tensioned electrical contact probes
- ✓ Ideal for I-V, CV or capacitance measurements
- ✓ Independently adjustable probe positions
- ✓ Customizable for different sample sizes

Table size	150 × 150 mm
Sample size	Customizable
Number of contact probes	4 in the standard model; can be increased on request
Sample mounting method	Easily removable sample-mounting block with 4 magnets
Contact probe position	Each probe position can be freely adjusted
Type of contact probe	Customizable with different probe sizes and shapes



SAMPLE HOLDERS & PROBE STATIONS

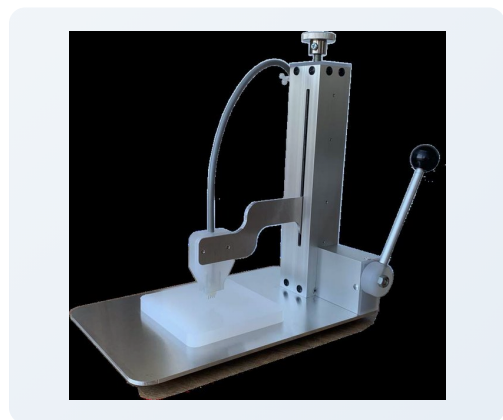
VK-PS-100

Four-Probe Station

Four-probe station for sheet resistance and resistivity measurements with customizable tips, gaps and arrangements.

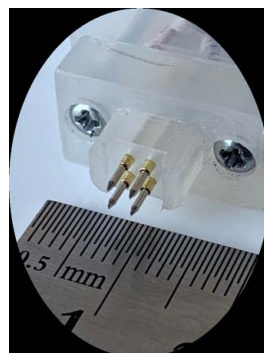
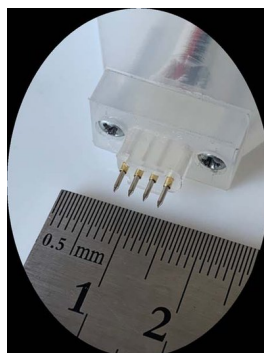


Product page



- ✓ For sheet resistance and resistivity measurements
- ✓ Customizable tip shapes, gaps and arrangements
- ✓ Excellent repeatability
- ✓ Pairs with the VK-PA-100 four-probe function

Four-probe arrangement	Linear or square (or as requested)
Probe gap	Customizable (minimum 1.6 mm)
Tip height adjustment	5 mm fine movement with side hand lever; table-top to tip distance adjustable from 10 to 100 mm with the top knob
Tip shapes	Customizable — choose from the available tip shapes



ENERGY STORAGE & ELECTRONICS

VK-CA-8000 (VMK-8000)

Capacitor & Battery Analyzer

Source and measure up to 20 V / 10 A for EDLC, battery and solar cell research, with automated curve fitting.

- ✓ Designed for EDLC, battery and solar cell research
- ✓ Source and measure up to 20 V and 10 A
- ✓ Automated curve fitting for capacitance, power, energy and cycle life
- ✓ Constant-current charge–discharge, cyclic voltammetry, self-discharge
- ✓ 4-probe potentiostat / galvanostat



Product page

Specifications

Measurement range	Max. voltage: 20 V Max. current: 10 A (pulse), 8 A (continuous) 5½-digit measuring resolution
Measuring technique	Digital source meter
A/D converters	24-bit (2 independent ADCs for V & I), up to 30,000 SPS
User interface & data collection	Computer software is provided to control all functions and log data. Measurement data can be saved as text files and plotted directly as Microsoft® Excel graphs. (Windows PC required)
Communication	USB
Power requirement	100 – 240 VAC (50/60 Hz), 3 A
Electrical standard	 
Dimensions	320 (W) × 150 (H) × 230 (D) mm
Weight	10 kg

Electric Double-Layer Capacitor (Supercapacitor) Analysis

- Constant-current charge–discharge test with given voltage compliance
- Cyclic voltammetry curves
- Curve fitting for the ideal RC model and the non-linear real model R-CPE (Q, α)
- Energy vs. time and energy vs. power (Ragone) calculations
- Self-discharge analysis
- Cycle-life testing

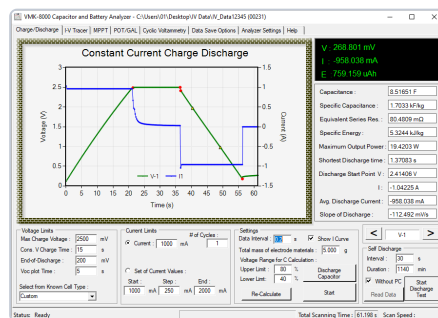
Battery Analysis

- Constant-current charge–discharge curves with given voltage compliance
- Analysis of both charge and discharge data
- Self-discharge analysis
- Cycle-life testing
- Limit-based analysis (voltage, current, temperature, ohmic value)

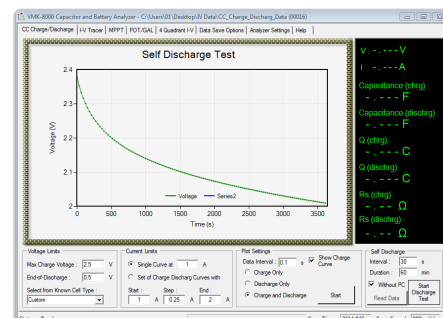
General Capabilities

- I-V tracing of solar cells
- 4-wire potentiostat and galvanostat
- 4-probe resistance measurement
- Lead-acid, Li-ion and Li-polymer battery charger up to 8 A and 20 V
- All data and graphs saved directly as Microsoft® Excel files
- All measurement parameters can be saved and reloaded to repeat experiments

Control software



Constant-current charge–discharge plots for a series of currents; capacitance and effective resistance calculated by automatic curve fitting



Supercapacitor self-discharge analysis

ENERGY STORAGE & ELECTRONICS

VK-DL-1256

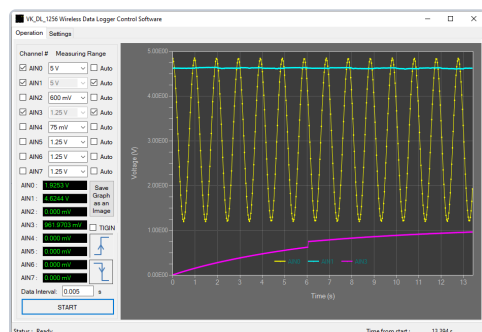
High-Resolution Wireless Data Logger



Product page



Reads up to 8 channels of voltage with 24-bit resolution and wirelessly transfers the data to PC software for display and plotting. A trigger input synchronizes data reading with external events. Comes with user-friendly control software and can be integrated with SPD Lab PV Power Analyzers and the Capacitor & Battery Analyzer.



"Operation" tab of the VK-DL-1256 control software

Voltage ranges (resolution)	5 V (596 nV)	2.5 V (298 nV)	1.25 V (149 nV)
	625 mV (75 nV)	312 mV (37 nV)	156 mV (19 nV)
	78 mV (9 nV)		
Number of analog input channels	8		
Data conversion rate	Up to 1120 SPS		
Input impedance	80 MΩ (< 50 SPS), 10 MΩ (> 2000 SPS)		
A/D resolution	24-bit		
Trigger input (0 – 3.3 V)	1 (voltage reading can be synchronized with this input)		
Control software	Supplied; can be integrated into VK-PA and VK-CA series analyzer software		
Communication	Bluetooth		
Power supply	DC 5 V (AC adaptor supplied)		
Electrical standard			
Dimensions	W149 × D170 × H54 mm		
Weight	350 g		

ENERGY STORAGE & ELECTRONICS

VK-SW-16

Remote Switching System

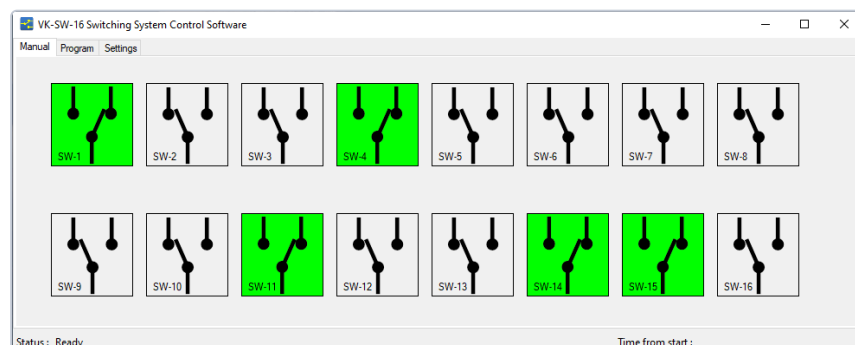


Product page



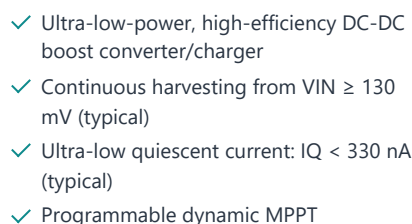
This unit consists of 16 two-way switches (relays) that can switch up to 10 A of current. Individual outputs of all 16 switches are available for users to wire as required, and each switch is controlled wirelessly (Bluetooth) from the software. Comes with user-friendly control software and can be integrated with SPD Lab PV Power Analyzers and the Capacitor & Battery Analyzer.

Number of channels	16
Maximum load current	10 A
Control software	Supplied; can be integrated into VK-PA and VK-CA series analyzer software
Communication	Bluetooth
Power supply	DC 12 V (AC adaptor supplied)
Electrical standard	
Dimensions	93 × 210 × 350 mm
Weight	2.3 kg



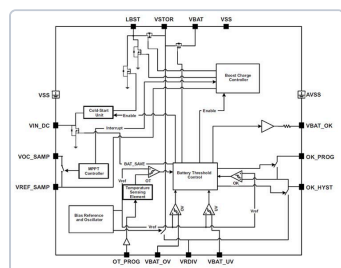
"Manual" tab of the VK-SW-16 control software

Product page



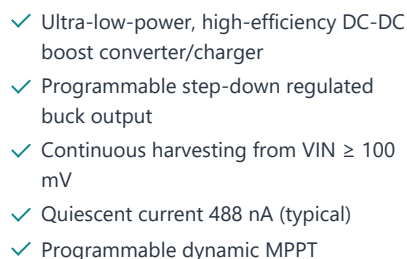
This circuit board collects and manages microwatt (μW) to milliwatt (mW) power generated from DC sources such as photovoltaic cells or thermoelectric generators. It implements a high-efficiency boost converter/charger for products and systems with tight power and operational requirements, and needs only microwatts of power to start working.

Energy source input voltage	0.13 – 3 V (cold-start voltage 600 mV); continues harvesting from VIN as low as 130 mV
Energy storage & voltage	Rechargeable Li-ion battery, thin-film battery, supercapacitor or conventional capacitor; 2.5 – 5.25 V (default 3.1 V, other voltages on request)
Operating temperature	–40 to 85 °C
Boost switching frequency	Up to 1 MHz
Working modes	Cold-start mode, boost mode, thermal-protection cut-off mode



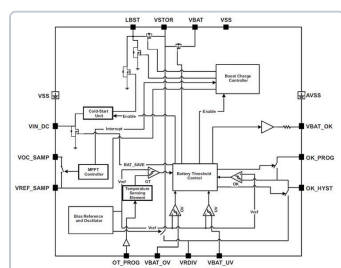
Functional block diagram of the main chip

Product page



This board collects and manages μW to mW power from DC sources such as solar cells or thermoelectric generators. In addition to the high-efficiency boost charger, it includes a high-efficiency nano-power buck converter at the output stage. A supercapacitor (0.22 F, 5.5 V) is installed on board as storage.

Energy source input voltage	0.1 – 5.1 V (cold-start voltage 600 mV); continues harvesting from VIN as low as 100 mV
Energy storage & voltage	0.22 F, 5 V supercapacitor on board; can also charge Li-ion, thin-film batteries, supercapacitors or capacitors; 1.3 – 5.3 V (set to your requirement)
Operating temperature	–40 to 85 °C
Switching frequency	Boost charger up to 1 MHz, buck converter up to 500 kHz
Working modes	Cold-start mode, boost mode, thermal-protection cut-off mode



Functional block diagram of the main chip

DSC FABRICATION EQUIPMENT

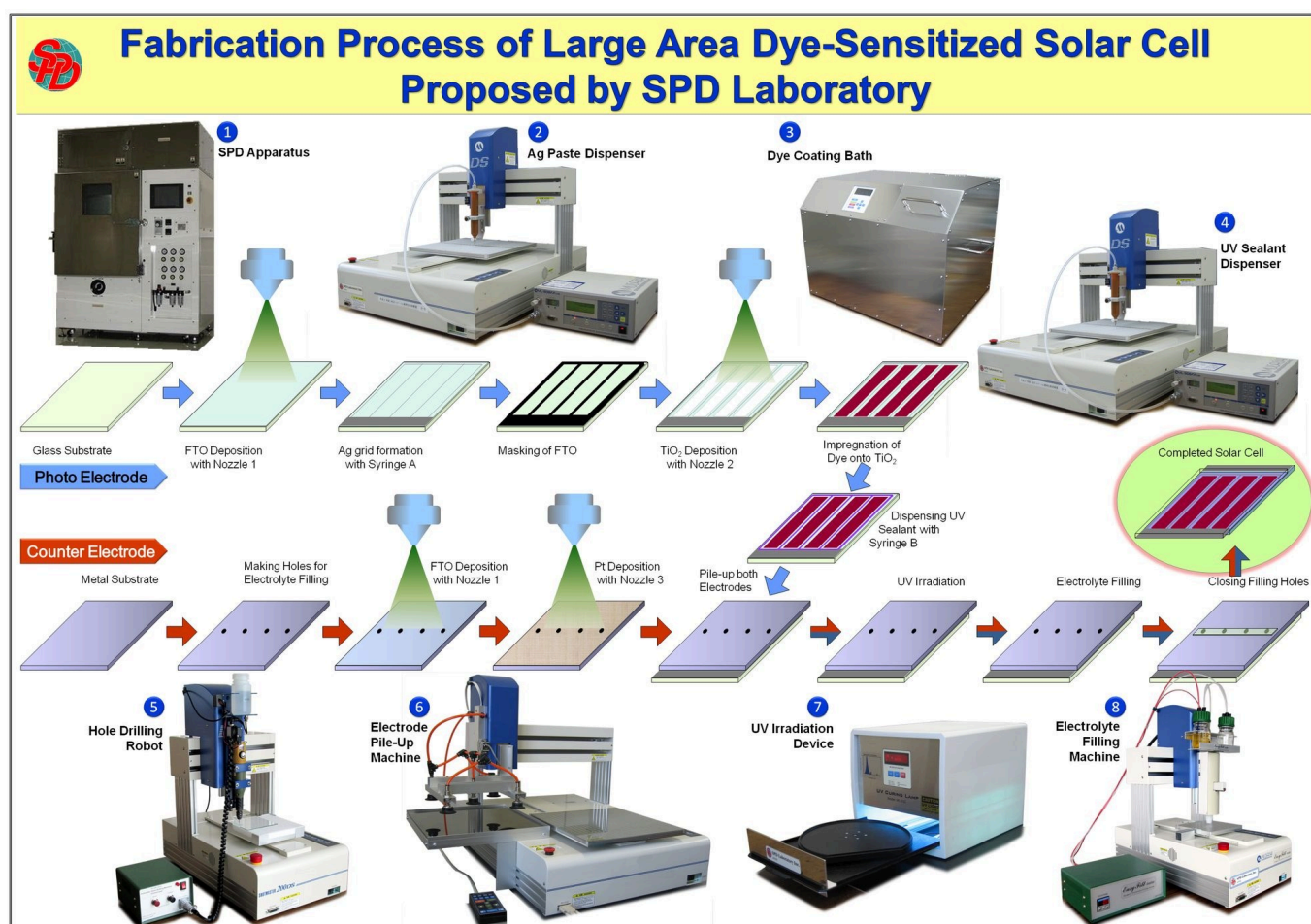
Dye-sensitized solar cell fabrication processes

Automated instruments covering every step of dye-sensitized solar cell production — from electrode printing to electrolyte filling.

Large-Area Dye-Sensitized Solar Cell Fabrication Process

This fabrication process mainly depends on 8 automated instruments developed by SPD Laboratory:

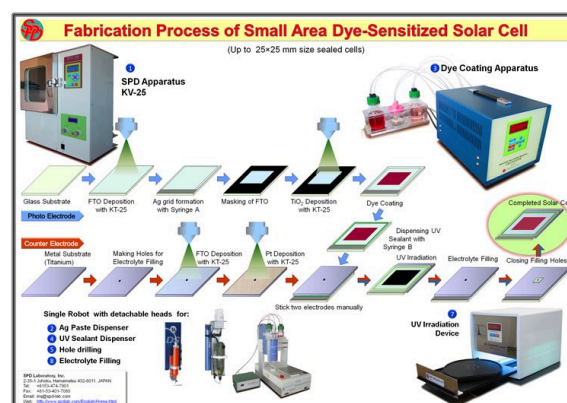
1 SPD apparatus KM-150 → p. 12	2 Ag paste dispenser VK-Ag-3030 → p. 41	3 Automated dye coating machine VK-DC-1010 → p. 40	4 UV sealant dispenser VK-SD-3030 → p. 41	5 Hole drilling robot VK-HD-3030 → p. 42	6 Electrode pile-up machine KVP-300 → p. 38	7 UV irradiation device VK-UV-1515 → p. 42	8 Electrolyte filling machine EasyFill → p. 37
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Small-Area Dye-Sensitized Solar Cell Fabrication Process

This fabrication process mainly depends on 4 automated instruments developed by SPD Laboratory, including a multipurpose robot with detachable heads for Ag paste dispensing, UV sealant dispensing, hole drilling and electrolyte filling.

1 SPD apparatus KV-25II → p. 10	2 Multipurpose robot with detachable heads (Ag paste, UV sealant, hole drilling, electrolyte filling)
3 Automated dye coating machine VK-DC-1010 → p. 40	4 UV irradiation device VK-UV-1515 → p. 42



DSC FABRICATION EQUIPMENT

EasyFill

Automatic Electrolyte Filling Machine Series

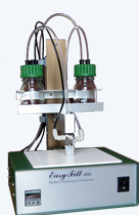
Vacuum-aided electrolyte filling of DSCs through a single hole, for cells from 1 × 1 cm to 30 × 30 cm.

- ✓ Patent-pending vacuum-aided filling through a single hole
- ✓ Any cell size from 1 × 1 cm to 30 × 30 cm
- ✓ Three filling modes: Full, Open Air and Basic
- ✓ Chemically resistant Teflon / SUS / silicone filling head
- ✓ Single-click filling from the PC; self-cleaning process



Product page

Models



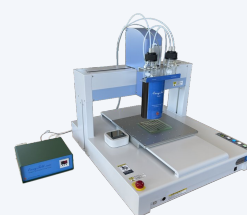
EasyFill-mini

For cell sizes up to 15 × 15 cm



EasyFill-master

For cell sizes up to 15 × 15 cm, with automatic multi-cell filling



EasyFill-jumbo

For cell sizes up to 30 × 30 cm, with automatic multi-cell filling

Main functions

1 Vacuum-Based Filling Technique

EasyFill's patent-pending vacuum-aided technique fills electrolyte into a closed cell through a single hole. Suitable for any cell size from 1 × 1 cm to 30 × 30 cm, it adjusts automatically for cell height and returns excess electrolyte to the bottle after filling.

3 Chemical-Resistant Filling Head

Handles a wide range of electrolytes with different solvents. Transport tubes, filling-tip assembly and filling-tip seal are made of Teflon, SUS and silicone rubber respectively.

5 Advanced Filling Options

Adjustable filling parameters allow optimized settings for special applications; factory defaults are optimized for standard DSC electrolytes.

2 Different Filling Modes

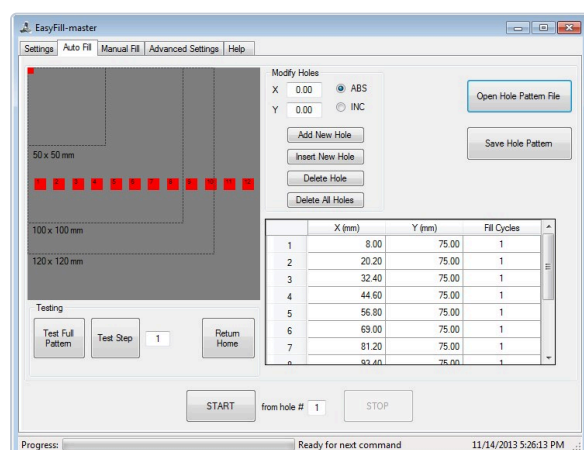
Three filling modes: "Full", "Open Air" and "Basic". In Full mode, filling is performed under inert gas (N₂, Ar, He); Open Air filling is done in the normal room environment. Basic mode needs no external vacuum pump — EasyFill uses its built-in ejector-type vacuum generator to evacuate the cell.

4 Single Mouse-Click Filling

Connect EasyFill to your PC via USB and control the filling process remotely. The graphical user interface lets users control all filling parameters and save custom settings; factory-default parameters are optimized for common DSC electrolytes.

6 Self-Cleaning Process

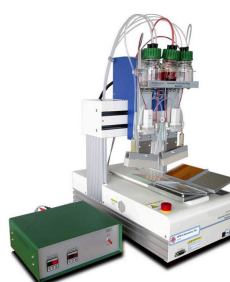
EasyFill's self-cleaning process washes out and dries all tubes, the filling head and the tip.



Auto Fill tab

ALSO AVAILABLE

Multi-Cell Electrolyte Filling Machine



- ✓ Fills 2 modules simultaneously
- ✓ No limitation on the number of cells in a module
- ✓ Filling rate: 2 modules/min
- ✓ Vacuum-aided filling technique
- ✓ Filling under N₂ environment
- ✓ For flexible plastic and glass modules

DSC FABRICATION EQUIPMENT

KVP-300

Automatic Electrode Pile-up Machine

Picks counter electrodes and places them precisely ($\pm 5 \mu\text{m}$) on sealant-coated photo-electrodes, for DSCs up to $300 \times 300 \text{ mm}$.

- ✓ Supports DSCs up to $300 \times 300 \text{ mm}$
- ✓ Automatically detects the interchangeable pick-up head and selects the right program
- ✓ Multiple counter electrodes can be loaded into the tray
- ✓ Alarm for empty or overloaded tray
- ✓ Automatic vacuum pump on/off
- ✓ Handheld keypad for full-auto or manual operation with fine adjustment
- ✓ Fully customizable pile-up patterns

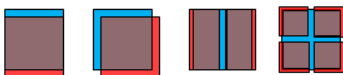


Product page

Overview

Combines the photo- and counter-electrodes of a dye-sensitized solar cell (DSC). The machine picks a counter electrode from the left-side tray and places it at the exact position on the UV-sealant-coated photo-electrode.

Specifications

Electrode pick-up method	Vacuum pads
Maximum electrode size	$300 \times 300 \text{ mm}$
Counter electrode aligning method	Pre-determined position on the photo-electrode
Positioning accuracy	$\pm 5 \mu\text{m}$
Supported photo-electrode sizes	300, 150, 100, 50, 25 mm square (custom sizes on request)
Supported counter-electrode sizes	300×300 , 300×150 , 200×200 , 200×100 , 150×150 , 150×75 , 100×100 , 100×50 , 50×50 , $25 \times 25 \text{ mm}$ (custom sizes on request). Interchangeable pick-up heads are available; the machine ships with one requested head and identifies the head size automatically.
Supported pile-up patterns	
Supported electrode thickness	0.5 – 5 mm
Control method	Control keypad (programs stored in the robot's flash memory)
PC interface (programming)	USB / RS-232
Required external items	Single- or double-stage rotary oil vacuum pump
Robot moving range	400 mm (X, Y), 55 mm (Z)
Power supply	100 – 240 V AC, 50/60 Hz
Dimensions (W × D × H)	500 × 710 × 568 mm
Weight	30 kg

DSC FABRICATION EQUIPMENT

VK-PUM-1010×4

Automatic Electrode Pile-up & Heat Curing Machine

Automatic pile-up and heat curing for flexible DSC production — 2 modules/min with 2-minute curing.

- ✓ Production rate: 2 modules/min (with 2 min curing time)
- ✓ Automatic top-electrode loading from tray (~135 sheets)
- ✓ Automatic unloading of finished modules (~70 modules)
- ✓ Four pile-up locations on the hotplate
- ✓ $\pm 5 \mu\text{m}$ robot positioning accuracy



Product page

Specifications

Loading method	Top electrodes: picked automatically from the loading tray (about 135 sheets at 0.2 mm thickness). Bottom electrodes: loaded manually onto the hotplate.
Unloading method	Completed modules are unloaded automatically to the unloading tray (about 70 modules at 0.4 mm thickness).
Electrode pick-up method	Vacuum pads (4); recommended max. service temperature 200 °C (absolute max. 230 °C)
Vacuum levels	Weight blocks: full pump vacuum. Flexible electrodes: adjustable via 2 flow-control valves until deformation disappears.
Electrode size	100 × 100 mm
Pile-up locations on hotplate	4
Top-electrode aligning	Pre-determined position on the bottom electrode (offset adjustable in the program)
Robot positioning accuracy	$\pm 5 \mu\text{m}$
Weight block size / thickness	100 × 100 mm / 0.1 – 15 mm (adjustable in the program)
Maximum block weight	1.2 kg
Supported electrode thickness	0.05 – 5 mm
Hotplate temperature	Normal 150 °C, max. recommended 230 °C
PC interface	RS-232 (USB-to-RS-232 converter supplied)
Power supply	100 V AC, 50/60 Hz
Dimensions (W × D × H)	500 × 710 × 568 mm
Weight	35 kg

DSC FABRICATION EQUIPMENT

VK-DC-1010

Automatic Dye Coating Machine

Dye adsorption, washing and drying of DSC electrodes under a controlled nitrogen atmosphere.

- ✓ Dye coating and washing under complete N₂ atmosphere
- ✓ Safe filling/removing ports — no need to open the machine
- ✓ Monitors washing-liquid purity by color
- ✓ External dye-coating vessel can be connected
- ✓ Up to 24 modules of 100 × 100 mm (customizable)



Product page

Main Functions

- **N₂ purging:** the system is evacuated and filled with dry N₂ just after inserting new samples.
- **Filling dye solution:** fills the dye-coating tank with dye solution.
- **Dye circulation:** circulates dye solution through the tank for the preset time while measuring temperature, concentration and volume; optionally keeps temperature and concentration at preset values.
- **Removing dye solution:** pumps the dye solution back to the storage tank.
- **Washing:** fills acetonitrile to wash residual dye; measures the color of the washing liquid and prompts replacement when it exceeds a preset value.
- **Removing acetonitrile:** pumps the acetonitrile back to the storage tank.
- **Drying:** dries samples by vacuum and N₂ purging.

Specifications

Supported DSC module size	Up to 100 × 100 mm (can be changed to customer requirements)
Maximum number of modules	24 (can be changed to customer requirements)
Coating bath capacity	2.8 L (without modules)
Internal dye / acetonitrile storage	3.2 L / 3.2 L
Control method	Microcontroller with LCD and keypad
User-controllable parameters	Dye coating time, temperature, circulation rate, magnetic stirring, number of washing and drying cycles
Dye solution temperature	0 – 80 °C (above 45 °C a reflux condenser may be needed with acetonitrile)
Temperature control	Dual (cascade) PID with 2 temperature sensors
Dye circulation rate	0 – 100 ml/min (interval 0 – 99 min)
Dye concentration monitor accuracy	1 % of initial concentration (factory calibrated for 0.3 mM N-719)
Required external items	Nitrogen or dry-air supply (max. 0.6 MPa)
Materials	Storage bottles: brown glass · Bath: polypropylene · Sample holder: Teflon · Tubes: EXLON ultra-pure PFA
Power supply	100 V AC, 50/60 Hz
Dimensions (W × D × H)	600 × 450 × 450 mm
Weight	33 kg

DSC FABRICATION EQUIPMENT

VK-Ag-3030

Silver Grid Formation Apparatus



Product page



Draws silver grid patterns on photo- and counter-electrodes by dispensing silver paste according to a pre-programmed pattern.

- ✓ Virtually any silver grid pattern
- ✓ Program via PC software or teaching pendant
- ✓ More than 100 patterns in built-in flash memory
- ✓ 100 % paste consumption efficiency — no screen-printing cleanup
- ✓ Wide range of nozzle sizes for the required line width

Maximum electrode size	300 × 300 mm
Dispensing method	Syringe with compressed air
Paste cartridge size	50 ml
Nozzle sizes (Φ mm)*	0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.6, 0.7, 0.84, 1.19, 1.6
Number of moving axes	3 (X, Y, Z)
Maximum moving range	400 mm (X, Y), 65 mm (Z)
Moving accuracy / max. speed	10 μm / 300 mm/s
Pattern programming	PC or teaching pendant
Program storage capacity	100 grid patterns (900 sub-programs)
Rated air pressure**	0.6 MPa
PC interface	RS-232, USB
Power supply	100 – 240 V AC, 50/60 Hz
Dimensions (W × D × H)	500 × 710 × 568 mm
Weight	30 kg

* Supplied with a standard 0.4 mm nozzle; other sizes can be ordered separately. ** Requires a compressed-air supply (air compressor not included; can be ordered separately).

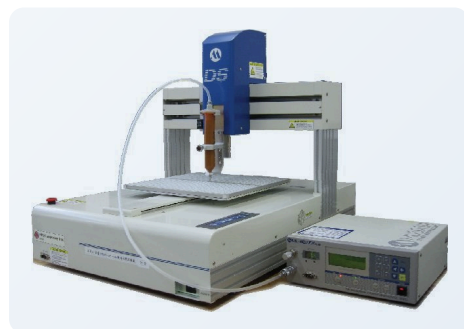
DSC FABRICATION EQUIPMENT

VK-SD-3030

Sealant Dispensing Apparatus



Product page



Prints UV- or heat-curing resin patterns on an electrode in order to bond two electrodes, dispensing the resin according to a pre-programmed pattern.

- ✓ Virtually any pattern — straight lines or splines
- ✓ Program via PC software or teaching pendant
- ✓ More than 100 patterns in built-in flash memory
- ✓ 100 % resin consumption efficiency
- ✓ Nozzle sizes for the required line width and thickness

Maximum electrode size	300 × 300 mm
Dispensing method	Syringe with compressed air
Cartridge size	50 ml
Nozzle sizes (Φ mm)*	0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.6, 0.7, 0.84, 1.19, 1.6
Number of moving axes	3 (X, Y, Z)
Maximum moving range	400 mm (X, Y), 65 mm (Z)
Moving accuracy / max. speed	10 μm / 300 mm/s
Pattern programming	PC or teaching pendant
Program storage capacity	100 patterns (900 sub-programs)
Rated air pressure**	0.6 MPa
PC interface	RS-232, USB
Power supply	100 – 240 V AC, 50/60 Hz
Dimensions (W × D × H)	500 × 710 × 568 mm
Weight	30 kg

* Supplied with a standard 0.5 mm nozzle; other sizes can be ordered separately. ** Requires a compressed-air supply (air compressor not included; can be ordered separately).

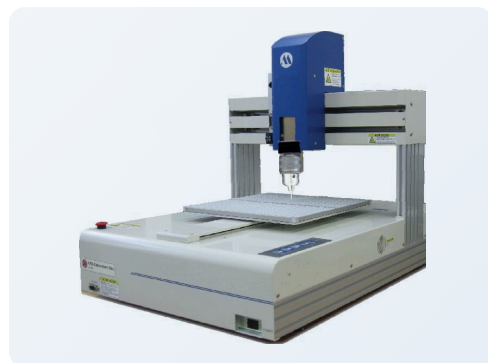
DSC FABRICATION EQUIPMENT

VK-HD-3030

Hole Drilling Robot



Product page



Makes holes in the counter electrode at precisely programmed locations. These holes are used to fill electrolyte after sealing the cell.

- ✓ Automatically adjusts the drilling force
- ✓ Hole locations programmed via PC software or teaching pendant
- ✓ Water coolant/lubricant — easy cleaning after drilling
- ✓ Drills glass sheets up to 3 mm thick
- ✓ Hole diameter 1 – 2.5 mm

Maximum cell size	300 × 300 mm
Hole making method	Diamond-coated drill bit (for glass)
Hole size	1 mm diameter (1.5, 2.0, 2.5 mm bits available on request)
Drill head moving method	Automatically drills at pre-programmed locations
Number of moving axes	3 (X, Y, Z)
Maximum moving range	400 mm (X, Y), 65 mm (Z)
Positioning accuracy	10 μm
Hole location programming	PC or teaching pendant
Program storage capacity	100 patterns
PC interface	RS-232, USB
Power supply	100 – 240 V AC, 50/60 Hz
Dimensions (W × D × H)	500 × 710 × 568 mm
Weight	31 kg

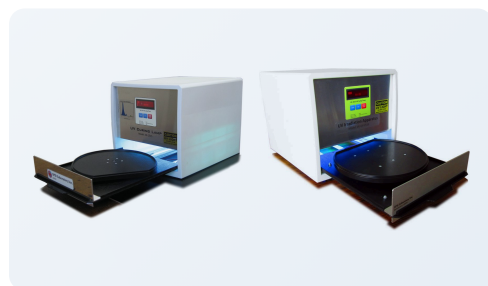
DSC FABRICATION EQUIPMENT

VK-UV-1515

UV Irradiation Apparatus



Product page



The ultraviolet irradiation system hardens the UV-curing resin used to bond the photo-electrode and counter-electrode of a solar cell.

- ✓ Samples up to 150 × 150 mm
- ✓ Rotating table for uniform irradiation
- ✓ UVA output (300 – 420 nm) suitable for most commercial UV resins
- ✓ Microcontroller timer; records total lamp usage
- ✓ Customizable for conveyor-line integration and remote operation

Power supply	100 – 240 V AC, 50/60 Hz
UV output	UVA radiation 300 – 420 nm
Sample holder	Rotating table (200 mm diameter), 10 rev/min
Supported sample size	Up to 150 × 150 mm
Number of discharge lamps	15
Lamp lighting method	High-frequency electronic inverter
Average lamp lifetime	2000 hours (warning message displayed at the 2000 h limit)
Cooling system	Forced air cooling (fan)
Dimensions (W × D × H)	273 × 360 × 255 mm
Weight	5 kg

MATERIALS **NEW**

Transparent Conductive Glass

FTO Glass and ITO Glass Substrates

- ✓ FTO glass (fluorine-doped tin oxide) and ITO glass (tin-doped indium oxide)
- ✓ FTO glass sheet resistance: 7, 10, 15 and 18 Ω/sq as standard — other values from 4 Ω/sq to several hundred $\text{k}\Omega/\text{sq}$ on request
- ✓ High transparency: 80.3 % total transmittance (glass + FTO film, 400 – 800 nm) at 7.4 Ω/sq
- ✓ Coated on EAGLE XG® Glass — total thickness 1.1 mm
- ✓ Standard sizes: 300 × 300 mm, 150 × 150 mm, 100 × 100 mm and 25 × 25 mm
- ✓ Coated in-house in Japan with our own spray pyrolysis deposition (SPD) systems
- ✓ Other sizes and patterned FTO / ITO glass available through our coating service



Product page

Sheet resistance and transmittance of our FTO glass (measured data)

Sheet resistance (Ω/sq)	Total transmittance, 400 – 800 nm (%)
4.6	76.2
5.7	79.0
7.4	80.3
9.4	80.9
10.6	81.3
14.2	83.3
18.8	83.7

Transmittance is the total transmittance of the glass plus the FTO film, measured over the 400 – 800 nm range. Standard sheet resistance values are 7, 10, 15 and 18 Ω/sq ; other values from 4 Ω/sq to several hundred $\text{k}\Omega/\text{sq}$ can be supplied to suit your needs.

What to tell us for a quotation

- ✓ Film type: FTO glass or ITO glass
- ✓ Sheet resistance for FTO glass: 7, 10, 15 or 18 Ω/sq , or the value you need
- ✓ Size and quantity
- ✓ Required delivery date and destination

Physical properties of our FTO film (example)

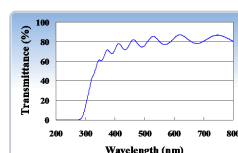
Property	Value
Film thickness	800 nm
Sheet resistance	6 Ω/sq
Resistivity	$2.83 \times 10^{-4} \Omega\cdot\text{cm}$
Carrier concentration	$5.75 \times 10^{20} \text{ cm}^{-3}$
Mobility	$38.4 \text{ cm}^2/\text{V}\cdot\text{s}$
Transmittance	80 %
Grain size (SEM)	about 50 nm

Data for an FTO film about 800 nm thick made by spray pyrolysis deposition, presented at the 8th International Conference on Coatings on Glass and Plastics (ICCG8), 2010.

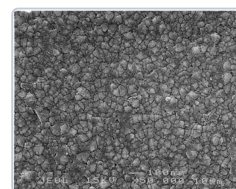
FTO glass and ITO glass specifications

Conductive film	FTO: fluorine-doped tin oxide ($\text{SnO}_2:\text{F}$) ITO: tin-doped indium oxide ($\text{In}_2\text{O}_3:\text{Sn}$)
Glass substrate	EAGLE XG® Glass
Total thickness	1.1 mm
Sheet resistance (FTO glass)	Standard: 7, 10, 15 and 18 Ω/sq ($\Omega/\square$) Other values from 4 Ω/sq to several hundred $\text{k}\Omega/\text{sq}$ on request
Total transmittance (FTO glass)	76.2 % at 4.6 Ω/sq to 83.7 % at 18.8 Ω/sq (measured) 80.3 % at 7.4 Ω/sq , 81.3 % at 10.6 Ω/sq Glass plus FTO film, measured over 400 – 800 nm
ITO glass	Film properties on request — please contact us
Standard sizes	300 mm × 300 mm 150 mm × 150 mm 100 mm × 100 mm 25 mm × 25 mm
Coating method	Spray pyrolysis deposition (SPD), coated in-house
Other sizes and patterns	Custom sizes up to 300 mm × 300 mm and patterned FTO / ITO films are available through our coating service.

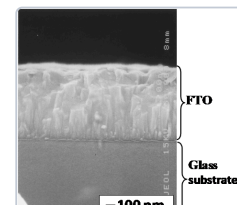
EAGLE XG is a registered trademark of Corning Incorporated.



Transmittance spectrum of the FTO film (about 800 nm thick)



SEM image of the FTO film surface — grain size about 50 nm



SEM cross section of the FTO film (about 800 nm) on glass

Typical applications

- ✓ Perovskite solar cells and dye-sensitized solar cells
- ✓ Gas sensors
- ✓ Transparent electrodes for electronic and optoelectronic devices
- ✓ Display panels and electromagnetic-shielding glass

MATERIALS

SPD Spray Solutions

FTO, ITO & TiO₂ Precursor Solutions for Spray Pyrolysis

Ready-to-use raw-material (spray) solutions for forming FTO, ITO and TiO₂ films with spray pyrolysis deposition machines.

- ✓ FTO 15-02 solution: Sn 0.2 mol/l, F 0.3 mol/l (500 ml)
- ✓ ITO spray solution
- ✓ TiO₂ colloidal spray solution for porous films (300 ml)
- ✓ Dense TiO₂ stock solution — makes 1000 ml of spray solution (100 ml)
- ✓ Prepared by the developers of SPD technology



Product page

Overview

SPD Laboratory supplies the raw-material solutions (spray solutions) used to form FTO, ITO and TiO₂ thin films by spray pyrolysis deposition. They are prepared in-house by the team that developed our SPD machines and coating processes, so you can start depositing films without spending time on precursor chemistry.

The solutions can be used with our KV-25II, KV-100, KM-150 and KM-300 SPD systems, as well as other spray pyrolysis equipment. Contact us for quantities, pricing and advice on deposition conditions.

When ordering, please tell us

- ✓ Film type (FTO, ITO or TiO₂) and quantity
- ✓ SPD machine to be used (SPD Laboratory model or other)
- ✓ Target film properties, if any (e.g. thickness, sheet resistance)

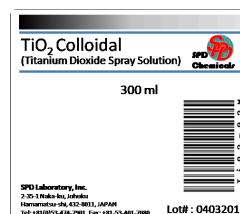
Available solutions

FTO 15-02 — Fluorine-Doped Tin Oxide Solution

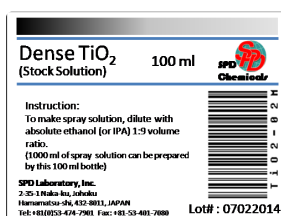
Volume	500 ml
Assay	min. 97.0 %
Atomic concentrations	Tin 0.2 mol/l, fluorine 0.3 mol/l
Use	Ready-to-spray solution for FTO transparent conducting films

TiO₂ Colloidal — Titanium Dioxide Spray Solution

Volume	300 ml
Use	Porous TiO ₂ films (e.g. photo-electrodes of dye-sensitized solar cells)

Dense TiO₂ — Stock Solution

Volume	100 ml
Preparation	Dilute with absolute ethanol (or IPA) at a 1 : 9 volume ratio to make the spray solution. One 100 ml bottle makes 1000 ml of spray solution.
Use	Dense (compact/blocking) TiO ₂ layers for perovskite and dye-sensitized solar cells



ITO — Tin-Doped Indium Oxide Spray Solution

Use	ITO transparent conducting films
Details	Please contact us for specifications

MATERIALS

SPD Pastes & Sealants

Masking Paste, Silver Paste, UV Sealant & Insulating Polymer

Dispensable pastes and sealants for patterned films and solar cell fabrication — the same materials used in our own processes.

- ✓ Masking paste — for patterned FTO, washes off after coating
- ✓ Silver paste — for silver grid electrodes
- ✓ UV sealant — bonds electrodes, cured by UV light
- ✓ Insulating polymer — insulating layers after annealing
- ✓ 50 ml each; suited to dispensing robots



Product page

Masking Paste

Volume 50 ml

Instructions For patterned FTO: dispense the pattern on glass and allow to air-dry overnight. After FTO coating, wash out the mask with soapy water.

Use with KV-PPS-25, SPD systems



Silver Paste

Volume 50 ml

Instructions Dispense or screen-print the required silver grid pattern and allow to air-dry for several hours before sintering at 500 °C.

Use with VK-Ag-3030



UV Sealant

Volume 50 ml

Instructions Dispense on one surface, press with the second surface and irradiate with UV light to cure.

Use with VK-SD-3030, VK-UV-1515



Insulating Polymer

Volume 50 ml

Instructions After dispensing, allow to air-dry for 30 minutes, then anneal at 280 °C for 15 minutes.



MATERIALS

SPD Fine Chemicals

TiO₂ nanopowders (anatase and rutile) and titanium phosphates.



Product page

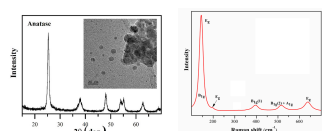
Titanium(IV) oxide, anatase (TiO₂)

CAS 1317-70-0

Particle size (TEM) < 15 nm

Ti content (metal basis, XRF) ~91 % (major impurity Si)

Formula weight 79.87 g mol⁻¹

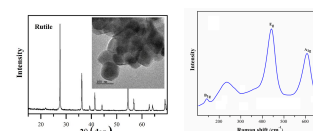
Titanium(IV) oxide, rutile (TiO₂)

CAS 13463-67-7

Particle size (TEM) < 60 nm

Ti content (metal basis, XRF) ~91 % (major impurity Si)

Formula weight 79.87 g mol⁻¹

Alpha-bis titanium(IV) orthophosphate monohydrate (α-Ti(HPO₄)₂·H₂O)

Formula weight 257.84 g mol⁻¹

Titanium(IV) phosphate (Ti₃(PO₄)₄)

Uses of TiO₂: Paints, plastics, papers, inks, medicines, semiconducting materials, photocatalysts and thin films.

RESEARCH & INTELLECTUAL PROPERTY

Publications

Journal articles

- 1** Improving the efficiency and stability of perovskite solar cells through a multi-cycle methylammonium iodide spin coating approach assisted by the Ostwald ripening method
T. Wanigasekara, D. Wijekoon, S. Kaneko, M. Shimomura, H. Ikeda, M. Okuya — *Journal of the Ceramic Society of Japan* 133 (11), 684–692 (2025)
- 2** Impact of compact TiO₂ interface modification on the crystallinity of perovskite solar cells
S. Takahashi, S. Uchida, P. V. V. Jayaweera, S. Kaneko, H. Segawa — *Scientific Reports* 13, 16068 (2023)
- 3** Recent Progress on Extended Wavelength and Split-Off Band Heterostructure Infrared Detectors
H. Ghimire, P. V. V. Jayaweera, D. Somvanshi, Y. Lao, A. G. U. Perera — *Micromachines* 11 (6), 547 (2020)
- 4** Longitudinal analysis of molecular alteration in serum samples of dextran sodium sulfate-induced colitis mice by using infrared spectroscopy
U. Perera, H. Ghimire, P. V. V. Jayaweera — *Infrared Physics & Technology* 97, 33–37 (2019)
- 5** Determination of unique power conversion efficiency of solar cell showing hysteresis in the I-V curve under various light intensities
L. Cojocar, S. Uchida, K. Tamaki, P. V. V. Jayaweera, S. Kaneko, J. Nakazaki, T. Kubo, H. Segawa — *Scientific Reports* 7, 11790 (2017)
- 6** Effect of TiO₂ surface treatment on the I-V hysteresis of planar structure perovskite solar cells prepared on rough and flat FTO substrates
L. Cojocar, S. Uchida, P. V. V. Jayaweera, S. Kaneko, H. Wang, J. Nakazaki, T. Kubo, H. Segawa — *Energy Technology* 5, 1–5 (2017)
- 7** Reply to comment on “Simulation of current–voltage curves for inverted planar structure perovskite solar cells using equivalent circuit model with inductance”
L. Cojocar, S. Uchida, P. V. V. Jayaweera, S. Kaneko, Y. Toyoshima, J. Nakazaki, T. Kubo, H. Segawa — *Applied Physics Express* 10, 059102 (2017)
- 8** Simulation of current–voltage curves for inverted planar structure perovskite solar cells using equivalent circuit model with inductance
L. Cojocar, S. Uchida, P. V. V. Jayaweera, S. Kaneko, Y. Toyoshima, J. Nakazaki, T. Kubo, H. Segawa — *Applied Physics Express* 10, 025701 (2017)
- 9** Versatile synthesis of fluorine-doped tin (IV) oxide one-dimensional nanostructured thin films
A. Bandara, K. Murakami, R. M. G. Rajapakse, P. V. V. Jayaweera, M. Shimomura, H. M. N. Bandara, D. Liyanage, E. V. A. Premalal — *Thin Solid Films* 621, 229–239 (2017)
- 10** Electroanalytical investigation of the losses during interfacial charge transport in dye-sensitized solar cell
P. Yadav, K. Pandey, B. Tripathi, P. V. V. Jayaweera, S. Kaneko, M. Kumar — *Solar Energy* 129, 207–216 (2016)
- 11** Origin of the Hysteresis in I-V Curves for Planar Structure Perovskite Solar Cells Rationalized with a Surface Boundary Induced Capacitance Model
L. Cojocar, S. Uchida, P. V. V. Jayaweera, S. Kaneko, J. Nakazaki, T. Kubo, H. Segawa — *Chemistry Letters* 44 (12), 1750–1752 (2015)
- 12** Synthesis of various F-doped tin oxide nanostructures on the glass substrate by the atomized spray pyrolysis deposition for DSSC application
R. M. G. Rajapakse, D. Liyanage, P. V. V. Jayaweera, E. V. A. Premalal, V. M. Mohan, H. M. N. Bandara, M. Shimomura, K. Murakami — *IEICE Technical Report* 113 (449), 37–42 (2014)
- 13** Ethylene Glycol Assisted Synthesis of Fluorine Doped Tin Oxide Nanorods Using Improved Spray Pyrolysis Deposition Method
D. Liyanage, H. M. N. Bandara, V. Jayaweera, K. Murakami — *Applied Physics Express* 6, 085501 (2013)
- 14** Preparation of high quality spray-deposited fluorine-doped tin oxide thin films using dilute di(n-butyl)tin(IV) diacetate precursor solutions
E. V. A. Premalal, N. Dematage, S. Kaneko, A. Konno — *Thin Solid Films* 520, 6813–6817 (2012)
- 15** Development of Quality FTO Films by Spray Pyrolysis for Dye-sensitized Solar Cell
E. V. A. Premalal, N. Dematage, S. Kaneko, A. Konno — *Electrochemistry* 80, 624–628 (2012)
- 16** Fabrication of Automatic Electrolyte Filling Machine for Dye-Sensitized Solar Cells
P. V. V. Jayaweera, S. Kaneko — *Instrumentation Science and Technology* 40 (6), 490–503 (2012)
- 17** Large Area Dye-sensitized Solar Cells with Titanium Based Counter Electrode
G. R. A. Kumara, S. Kawasaki, P. V. V. Jayaweera, E. V. A. Premalal, S. Kaneko — *Thin Solid Films* 520 (12), 4119–4121 (2012)
- 18** Photo Induced Reductive Leaching of Iron from Ilmenite in Hydrochloric Acid Solutions
P. M. Jayaweera, P. V. V. Jayaweera, U. L. Jayasundara, C. D. Jayaweera, G. S. Peiris, E. V. A. Premalal — *Mineral Processing and Extractive Metallurgy* 120 (3), 191–196 (2011)
- 19** Comparative evolved gas analyses of crystalline and amorphous titanium(IV)oxo-hydroxo-acetylacetonates by TG-FTIR and TG/DTA-MS
J. Madarász, S. Kaneko, M. Okuya, G. Pokol — *Thermochimica Acta* 489 (1–2), 37–44 (2009)
- 20** Photocatalytic ability of TiO₂ porous film prepared by modified spray pyrolysis deposition technique
O. Sugiyama, M. Okuya, S. Kaneko — *Journal of the Ceramic Society of Japan* 117 (1362), 203–207 (2009)
- 21** A high efficiency indoline-sensitized solar cell based on a nanocrystalline TiO₂ surface doped with copper
T. R. C. K. Wijayarathna, G. M. L. P. Aponsu, Y. P. Y. P. Ariyasinghe, E. V. A. Premalal, G. R. A. Kumara, K. Tennakone — *Nanotechnology* 19 (48), 485703 (2008)
- 22** Solid-state Solar Cells Sensitized with Indoline Dye
A. Konno, G. R. A. Kumara, S. Kaneko, B. Onwona-Agyeman, K. Tennakone — *Chemistry Letters* 36 (6), 716–717 (2007)
- 23** Initial growth of SnO₂ thin film on the glass substrate deposited by the spray pyrolysis technique
K. Murakami, K. Nakajima, S. Kaneko — *Thin Solid Films* 515 (24), 8632–8636 (2007)
- 24** Effect of the Addition of Ti³⁺ into TiO₂ Film on the Performance of Dye Sensitized Solar Cells
J. H. Xiang, Z. L. Zhang, F. S. Zhang, S. Kaneko, M. Okuya, H. Zhang — *Key Engineering Materials* 336–338, 2337–2339 (2007)
- 25** TG/DTA-EGA-MS studies on titania precursors with low content of organics for porous thin films of TiO₂
J. Madarász, M. Okuya, P. P. Varga, S. Kaneko, G. Pokol — *Journal of Analytical and Applied Pyrolysis* 79 (1–2), 479–483 (2007)

Journal articles (continued)

- 26 Large area dye-sensitized solar cells: material aspects of fabrication**
G. R. A. Kumara, S. Kaneko, A. Konno, M. Okuya, K. Murakami, B. Onwona-Agyeman, K. Tennakone — *Progress in Photovoltaics: Research and Applications* 14 (7), 643–651 (2006)
- 27 Shiso leaf pigments for dye-sensitized solid-state solar cell**
G. R. A. Kumara, S. Kaneko, M. Okuya, B. Onwona-Agyeman, A. Konno, K. Tennakone — *Solar Energy Materials and Solar Cells* 90 (9), 1220–1226 (2006)
- 28 Fabrication and Performance of Pulse-Current Sintered Si–Ge Thermoelectric Couples**
M. Otake, K. Sato, O. Sugiyama, S. Kaneko — *Journal of The Electrochemical Society* 152 (11), A2148 (2005)
- 29 Sensitization of Nanocrystalline SnO₂ Films with Indoline Dyes**
B. Onwona-Agyeman, S. Kaneko, A. Kumara, M. Okuya, K. Murakami, A. Konno, K. Tennakone — *Japanese Journal of Applied Physics* 44 (5L), L731 (2005)
- 30 Dye-sensitized Solar Cells with an Extremely Thin Liquid Film as the Redox Electron Mediator**
G. R. A. Kumara, S. Kaneko, A. Konno, M. Okuya, K. Tennakone — *Chemistry Letters* 34 (4), 572–573 (2005)
- 31 Comparative online coupled TG-FTIR and TG/DTA-MS analyses of the evolved gases from thiourea complexes of SnCl₂**
J. Madarász, P. Bombicz, M. Okuya, S. Kaneko, G. Pokol — *Journal of Analytical and Applied Pyrolysis* 72 (2), 209–214 (2004)
- 32 Dye-sensitized solid-state solar cells made from magnesium oxide-coated nanocrystalline titanium dioxide films: enhancement of the efficiency**
G. R. A. Kumara, M. Okuya, K. Murakami, S. Kaneko, P. V. V. Jayaweera, K. Tennakone — *Journal of Photochemistry and Photobiology A: Chemistry* 164 (1–3), 183–185 (2004)
- 33 Fabrication of dye-sensitized solar cells by spray pyrolysis deposition (SPD) technique**
M. Okuya, K. Nakade, D. Osa, T. Nakano, G. R. A. Kumara, S. Kaneko — *Journal of Photochemistry and Photobiology A: Chemistry* 164 (1–3), 167–172 (2004)

Preprints

- 1 In Situ Flux-Mediated Grain Growth in Aqueous Spray-Pyrolyzed AgBiS₂ for Self-Powered Photodetection**
T. Dedova, P. V. V. Jayaweera, L. Cojocar, S. Ohta, A. Katerski, S. Uchida, S. Kaneko — SSRN preprint (2026)

Conference proceedings & abstracts

- 1 Multi-ch Maximum Power Point Tracking (MPPT) Integrated PV Power Analyzing System to Overcome Evaluation Challenges of Perovskite Solar Cells**
S. Maeshima, P. V. V. Jayaweera, S. Uchida, S. Kaneko, H. Segawa — *Proceedings of the 20th "Next Generation Photovoltaic Power System" Symposium (3rd Annual Meeting of the Japan Photovoltaic Society)*, p. 37 (2023)
- 2 Direct Measurement of Junction Capacitance in the Perovskite Solar Cells**
S. Uchida, H. Tobita, K. Nonomura, P. V. V. Jayaweera, S. Kaneko, L. Cojocar, H. Segawa — *ECS Meeting Abstracts MA2020-02, H02: Photovoltaics for the 21st Century* 16 (2020)
- 3 Evaluation of interface junction capacitance of perovskite solar cells by direct current measurement**
S. Uchida, L. Cojocar, H. Tobita, P. V. V. Jayaweera, S. Kaneko, H. Segawa — *Asia-Pacific International Conference on Perovskite, Organic Photovoltaics and Optoelectronics (IPEROP20)*, Tsukuba (2020)
- 4 Characterization Techniques in the Field of the Solar Energy Storage Device**
P. V. V. Jayaweera, S. Kaneko, K. Murakami — *International Conference on Advanced Materials for Clean Energy and Health Applications (AMCEHA 2019)*, University of Jaffna (2019)
- 5 Fabrication of low cost ilmenite/lithium polysulfide/graphite rechargeable batteries**
G. K. Jayasekara, N. D. H. Arachchi, P. V. V. Jayaweera, P. M. Jayaweera — *Third Biennial International Symposium on Polymer Science and Technology* (2017)
- 6 Dye-Sensitized Solar Cell Fabrication Process by Spray Pyrolysis Deposition as a Thin Film Formation Technique**
S. Kaneko, P. V. V. Jayaweera, S. Kawasaki, G. R. A. Kumara — *The Electrochemical Society Meeting Abstracts* (2011)

Technical articles (in Japanese)

- 1 Dye-sensitized solar cell manufacturing technology by the SPD method (special issue: latest trends in photovoltaic technology)**
S. Kaneko — *Denshi Zairyo (Electronic Materials)*, June 2009
- 2 Nano-coating by the spray method (special issue: manufacturing in nanotechnology)**
S. Kaneko — *Kikai no Kenkyu (Science of Machine)*, 2005

RESEARCH & INTELLECTUAL PROPERTY

Patents

JP 4841574	Dye-sensitized solar cell module and its fabrication method SPD Laboratory, Inc. and others
JP 4945491	Multilayered electrode and dye-sensitized solar cell using the electrode SPD Laboratory, Inc.
JP 5227194	Multilayered electrodes SPD Laboratory, Inc.
JP 5743591	Thin-film formation method and apparatus, and dye-sensitized solar cell fabrication process and production system SPD Laboratory, Inc.
JP 5743599	Liquid injection apparatus and method, and dye-sensitized solar cell fabrication process using them SPD Laboratory, Inc.
JP 5963902	Dye-sensitized solar cell fabrication process and its production system SPD Laboratory, Inc.
JP 5979656	Ultraviolet irradiation and curing apparatus SPD Laboratory, Inc.

Patent applications

JP Appl. 2026-095132	Steady-state maximum power point evaluation apparatus for hysteresis-affected solar cells (2026)
JP Appl. 2026-014557	Global maximum power point voltage estimation for photovoltaic arrays using a machine learning model (2026)
JP Appl. 2025-282338	Environmental information-based MPPT control device for photovoltaic modules (2025)



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