

Type: VK-IPCE-10

- > This compact instrument with fully automatic operation allows user to perform IPCE measurement by one click.
- User-friendly simple operation interface allows to start measurement quickly without reading bulky manuals and setting up various parameters.
- State-of-the-art Bluetooth communication allows user to control all the functions remotely.
- > No attached equipments such as lock-in amplifier, source meter, and lamp power supply, only the main power switch needs to turn on.
- Utilize 100 % Digital Signal Processing (DSP) technique with Fast Fourier Transform (FFT) to measure synchronous current produced with chopped light beam.
- The double beam technique with a Si reference cell measures sample current & light intensity simultaneously.
- The motorized sample mounting stage aligns sample precisely.



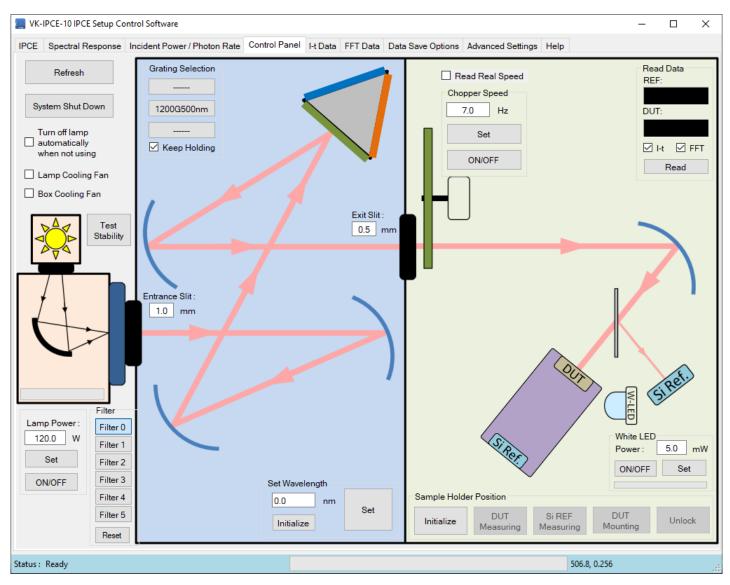
#### Specifications

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Type of Measurement	Incident Photon-to-electron Conversion Efficiency (IPCE), Spectral response (A/W)	Recommended sample size	10 mm x 10 mm	
Wavelength Range	340 - 1000 nm (calibrated photo diode limits). 0 - 1400 nm mechanical limit.	White light (bias) source	Three watts white LED (output power can be set through the software).	
Light Source	Halogen Photo Optic Lamp (OSRAM XENOPHOT®) 3400 K.	Sample mounting stage	This system equipped with motorized sample mounting stage. User can remotely switch the sample and standard Si photo diode in order to do baseline calibration or verify accuracy of measurements.	
Irradiation modes	Natural (Halogen lamp spectrum) Constant energy Constant photon (Constant energy or photon Irradiation mode is achieved by controlling the halogen lamp current. Automatic calibration process performs the calibration of lamp current to keep constant energy or photon output).	User Interface and data collection	Computer software is provided free of charge to control al the functions and data logging. Measurement data can be saved as a text file and directly plotted on <sup>®</sup> Microsoft Exce graph. User interface is designed such that normal user ca be performed measurements by setting just the scan wavelength range. Also advanced user can control hardwa settings such as grating and filter changing position FFT b size and also able to get raw I vs. t and FFT data.	
Irradiation monochromatic light power on sample	1 to 100 $\mu W$ (400 - 1000 nm range)	Communication	Bluetooth	
Measuring technique	easuring technique Optically chopped (1 – 21 Hz) light beam is split into two parts (double beam technique) then incident on Device-Under-Test (DUT), and calibrated Si reference (REF) cell. Simultaneously digitized DUT and REF signals (short circuit currents) were Fast Fourier		100 – 240 VAC (50-60 Hz) Input voltage selection switch available to set the correct input voltage range.	
	Transform (FFT) to obtain power spectrum (filter out only the chopped frequency component).	Dimensions Weight	91 cm x 47 cm x 29 cm, 20 kg	
Grating	1200G / 500nm blaze.			
Filters	Up to 5 different high-order light cut filters can be installed. L-37 and R-64 installed.	PC	Windows based PC is needed to install control software, despite not included to the standard setup and can be added as a option.	

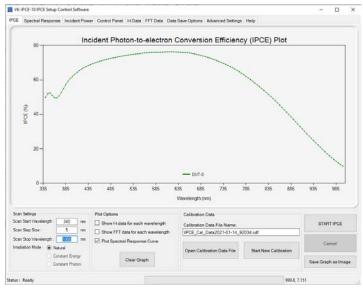
#### SPD Laboratory, Inc.

2-35-1 Johoku, Hamamatsu, 432-8011, JAPAN Tel: +81-53-474-7901 Fax: +81-53-401-7080 Email: <u>inq@spd-lab.com</u> Web: <u>http://www.spdlab.com/English/VK-IPCE-10.html</u>

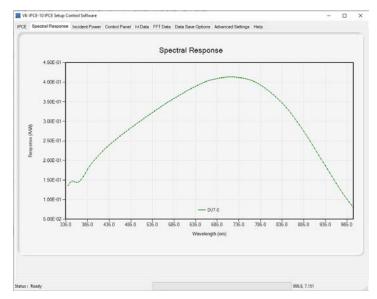




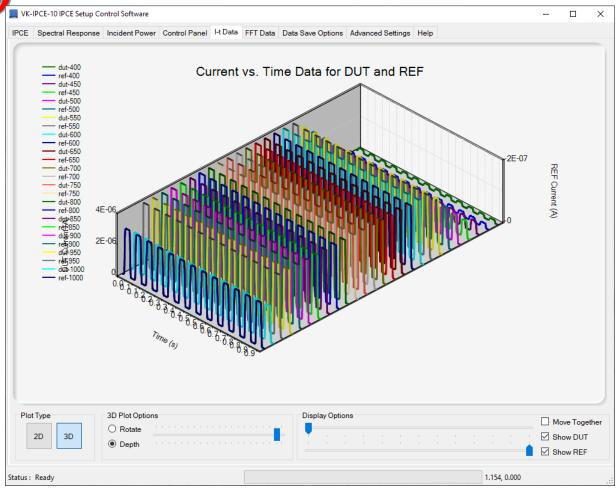
"Control Panel" tab allows user to control all of functions such as sample stage position, lamp current, chopper speed, and filters. Also user can measure both output of the sample and reference at desired wavelength.



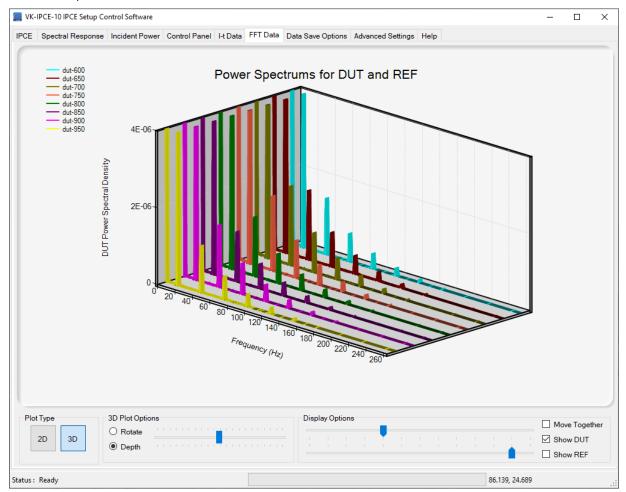
"IPCE" tab of the control software allows user to set scan range, Irradiation mode, and plot options. Also user can open previously saved baseline calibration curve or start new calibration curve. Si photo diode was used as a sample for reference.



"Spectral Response" tab shows the spectral sensitivity (A/W) curve of measured sample. Si photo diode was used as a sample in this example.

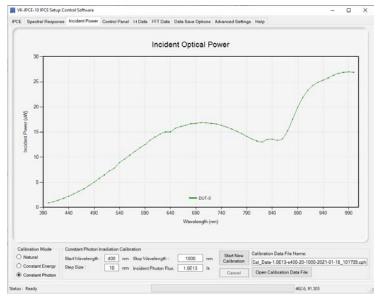


"I-t Data" tab shows the time domain data taken for each measurement point. User can view data as 2D or 3D plot for select number of measurement points.

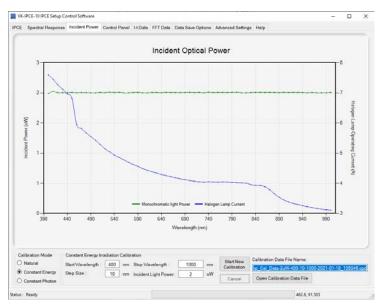


"FFT Data" tab shows the Fourier transformed data for each measurement point. User can view data as 2D or 3D plot for select number of measurement points.

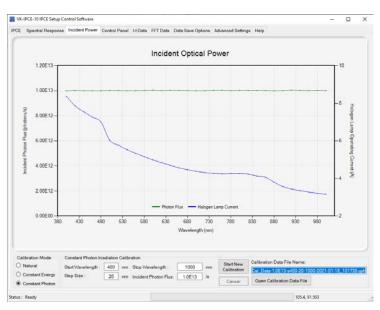




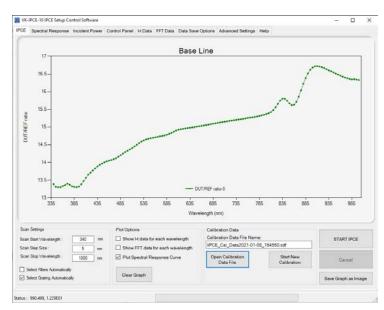
Incident optical power on the sample during an IPCE measurement with natural irradiation mode. In this mode halogen lamp operating current keeps at a user set fixed value.



Lamp calibration curve taken for constant energy irradiation mode. Green curves shows 2  $\mu W$  constant incident optical power on the sample and blue curve shows the halogen lamp current variation for keeps constant power on the sample.



Lamp calibration curve taken for constant photon irradiation mode. Green curves shows  $1.0 \times 10^{13} \text{ s}^{-1}$  constant photon flux on the sample and blue curve shows the halogen lamp current variation to keep the constant photon flux on the sample.



The optical power dividing ratio of sample to reference is measured and stored as a baseline calibration curve. This figure shows an example of the baseline calibration curve.



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IPCE	Spectral Response Incident Power Control Panel I-t Data FFT Data Data Save Options Advanced Setting	s Help							
	Data File Saving Options User Settings IPCE Setup Data Saving Folder								
	C:\Users\01\Desktop\IV Data Brows								
	Data File Name  Genarate Automatically File name suffix		Save My Settings						
	My_Cell_IPCE			_					
	Comment (00038) Reset		Load My Settings						
	This is test comment.								
	↓       Save as .bt file (This text file can be opened with Notepad or WordPad)       Save as .csv file (This comma separated values file can be open with Excel)       Save as .csv file (This comma separated values file can be open with Excel)								
	Save as Microsoft Excel file with graphs								
	Save each curve in a separate Excel file		Open csv data file						
	○ Save curves in a same Excel file untill I close the file								
Baseline Calibration File Save last curve again									
IF	CE Setup Baseline Calibration Data Saving Folder								
0	:\Users\01\Desktop\\V Data\CalData Brows								
					^				
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Status	: Ready		382.3, 17.575						

"Data Save Options" tab allow user to specify data file and calibration file saving folders in the computer. Also user can select desired output file formats in this screen.

🧱 VK-IPCE-10 IPCE Setup Control Software			- 🗆 X						
IPCE Spectral Response Incident Power Control Panel I-t Data FFT Data Data Save Options Advanced Settings Help									
Communication Port Measuring Ra	nge	FFT Settings	Access critical parameters						
COM4 V Search DUT : 7.5	ōuA ∨	Size of FFT data set : 1024  v	Specific Hardware Parameters						
REF: 20	0 nA ~	No of chopper cycles for FFT Data set : 13	ADC V Ref: 3.0000 V Rsh - DUT : 100.600 kohm						
	Auto Range	CheckBox1	DAC V Ref: 3.0000 V Rsh - REF : 911.000 kohm						
Conected to IPCE	-		Halogen Lamp Current Formula :						
Setup Read	Set	Current Monitoring Settings Data reading Interval : 1 ms	-5.6718830E-01 + 4.0960400E-01 IA						
			+ -4.8996150E-02 IA <sup>2</sup> + 4.4065830E-03 IA <sup>3</sup>						
ADC Parameters		ng Possitions	W-LED Current Formula :						
ADC Clock : 36 MHz ~	Change	Filters Automatically	6.539778E-01 + 4.564892E-03 ImA						
Sampling Time : 1.5 ADC clock cycles ~	Filter 1 :	0.0 to 0.0 nm	Filter micro-step positions :						
ADC Conversion Time : 284.4444 us	Filter 2 :		0 1 2 3						
Read Set			0 2055 4110 6165						
	Filter 3 : Filter 4 :	551.0 to 900.0 nm 901.0 to 1500.0 nm	4 5 6 7						
Scanner Position			8220 10275 12330 14385						
36.739 % Read	Custom 1:		Sample stage micro-step positions :						
	Custom 1 :		Init DUT REF Mount Unlock						
Read System Errors	Custom 2 :	0.0 to 0.0 nm	0 4000 16400 20750 6000						
Error Reporting :	Wavelength to abs_pos multiplication constant : 800.000								
^			Chopper Hz to stp/s multiplication constant : 25.000						
	Chopper signal to data reading start shift : 0.300								
	Serial # : 201015001								
	G2 - 1 um :	2500.0 nm Set	Read Constants Save to EEPROM						
		Ger	Send Constant Read Variables						
· ·									
Status : Ready 382.3, 17.575									

Status : Ready

"Advanced Settings" tab has several important machine parameters such as communication port, measuring ranges, FFT sample size, ADC speed. Parameters such as filter and grating changing position were not need to modify during normal operation.

