



2015.5.26

# Perovskite solar cells

## 2. Advice of the method for measurement

# 2

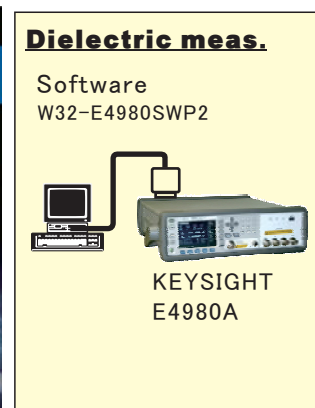
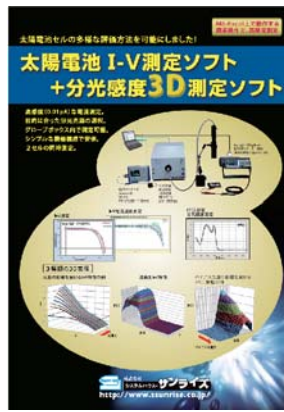
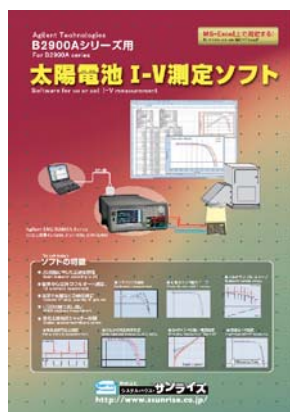
1. I-V measurement, Cyclic I-V measurement  
I-V measurement of light quantity variability
2. IPCE measurement
3. Responsive measurement of the photoelectricity.
4. Measurement of the dielectric constant.

The measurement data published in these data was measured with our following software.

<http://www.ssunrise.co.jp/img/pdf/pv2.pdf>

[http://www.ssunrise.co.jp/img/news\\_date/1401894756\\_18602\\_3.pdf](http://www.ssunrise.co.jp/img/news_date/1401894756_18602_3.pdf)

<http://www.ssunrise.co.jp/pdf/W32-E4980.pdf>



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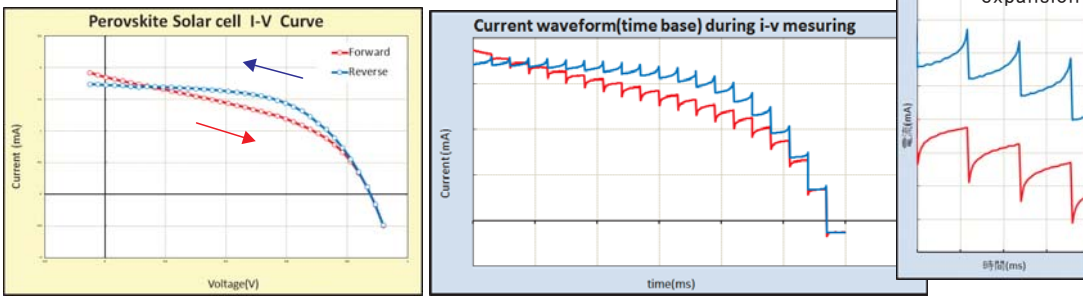
# ➡ Hysteresis of i-v characteristic and current waveform of perovskite solar cell

The hysteresis of various forms is observed by the I-V curve in I-V measurement of the perovskite solar cell under research and development.

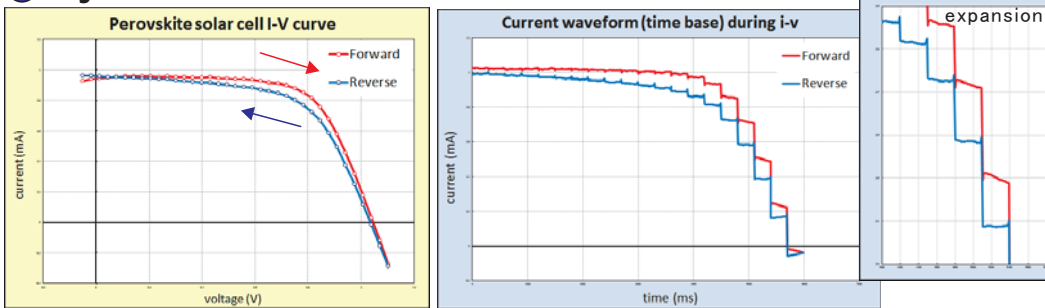
It roughly divides experientially and is classified into four kinds of following patterns. Evasion of the hysteresis of these I-V characteristics is generally performed by adjustment of the measurement delay time of I-V measurement.

However, if a current wave form is observed, it turns out that there is a case in which it is difficult to avoid hysteresis only by time adjustment.

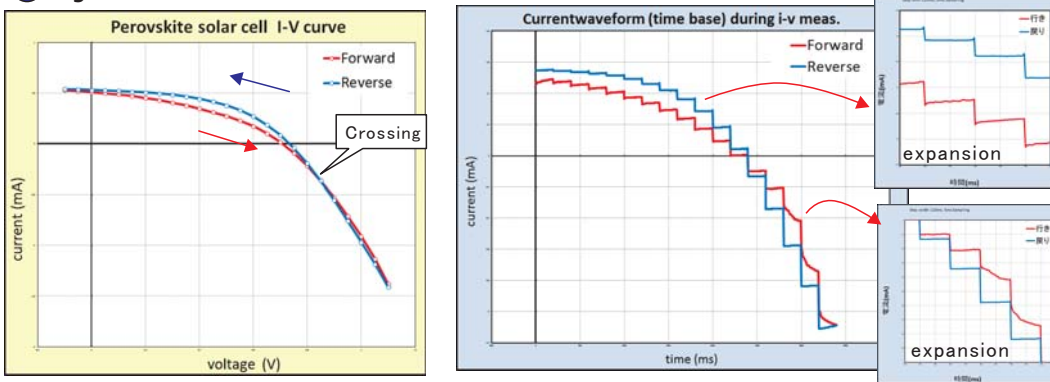
## ● Hysteresis-1



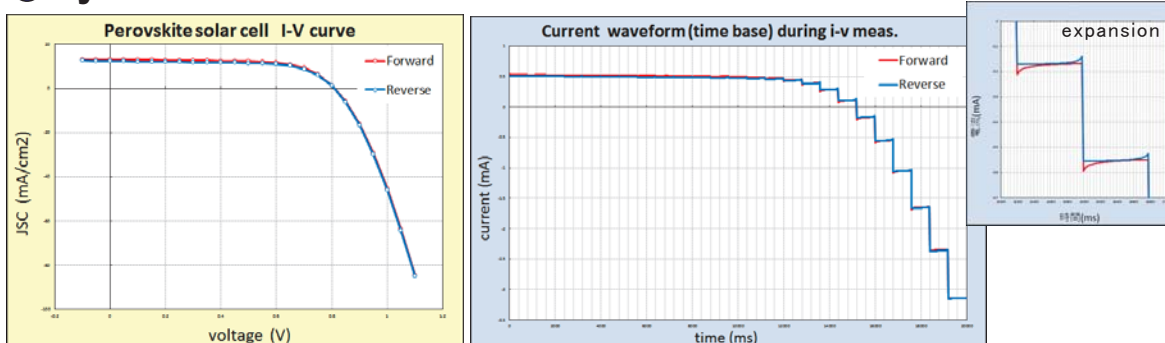
## ● Hysteresis-2 Hysteresis is measured adversely.



## ● Hysteresis-3 Hysteresis intersects in the middle of a curve.



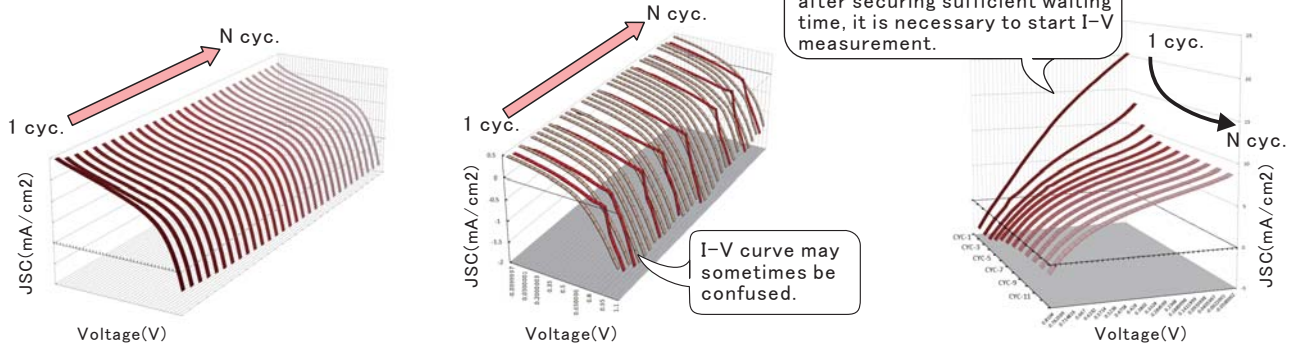
## ● Hysteresis-4 There is almost none of the outbreak of the hysteresis.



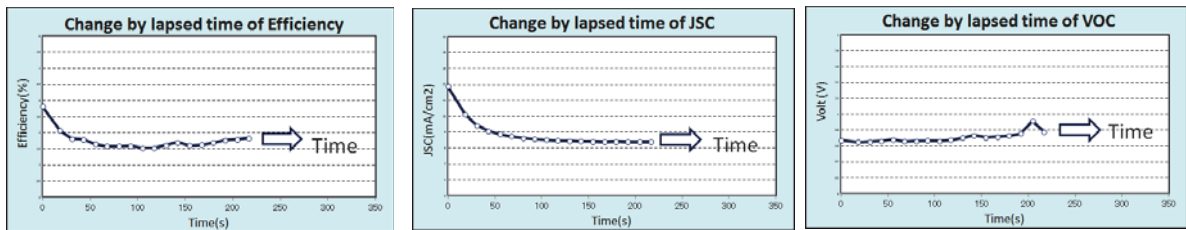
## Evaluation of the stability by repetition i-v measurement

When measuring a perovskite solar cell, it is necessary to evaluate stability and to check that a measurement result has reproducibility by performing duplicate measurement.

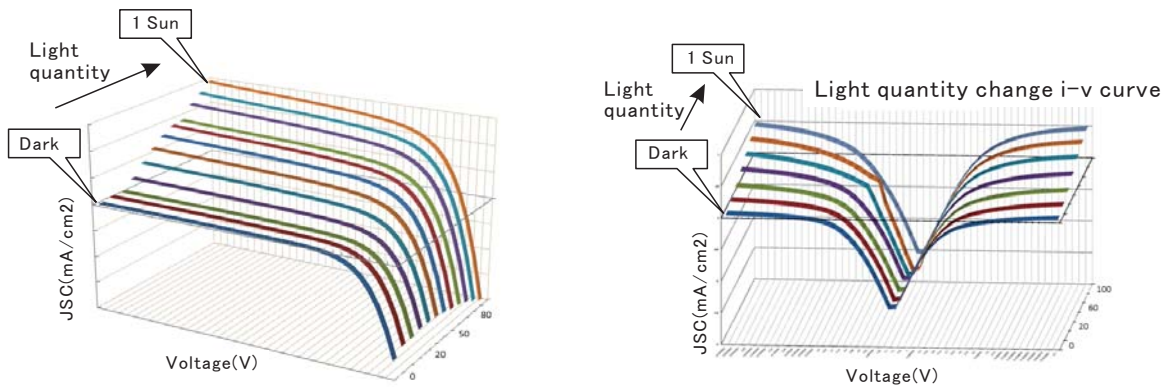
### Measurement of the reproducibility of the I-V characteristic



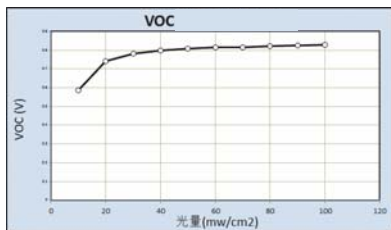
### Durable evaluation



## Light quantity dependence of I-V characteristic

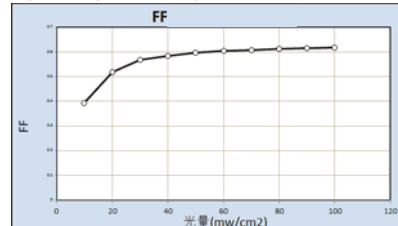


Optical power dependence of VOC



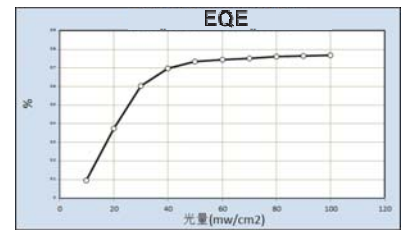
→ Light quantity

Optical power dependence of FF



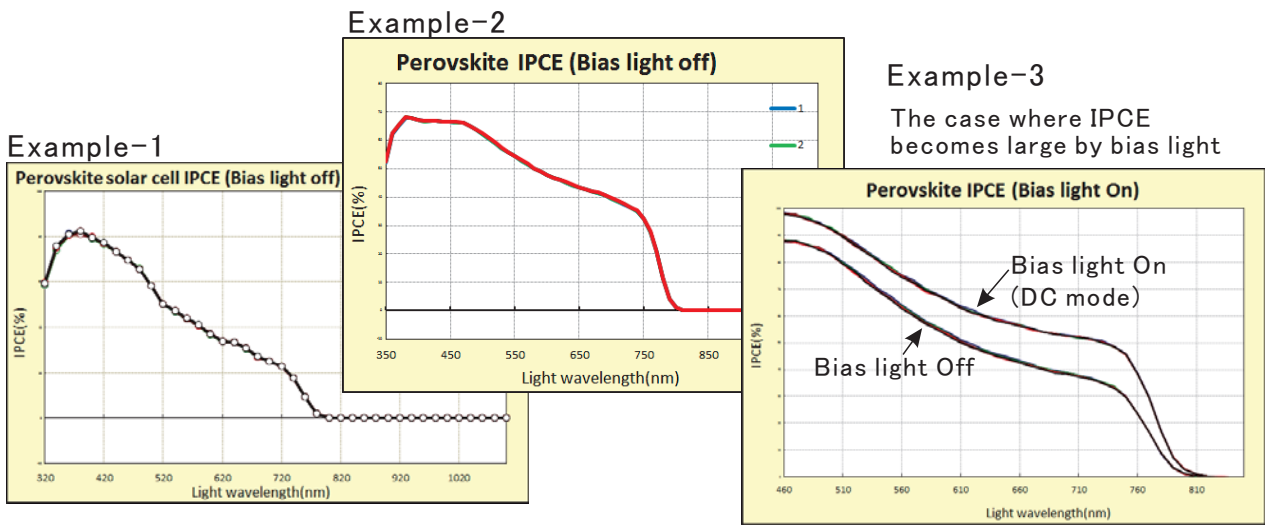
→ Light quantity

Optical power dependence of Efficient



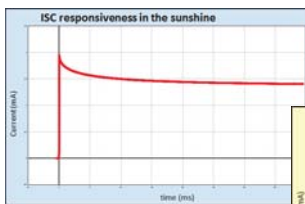
→ Light quantity

## Measurement of IPCE (External quantum efficiency)

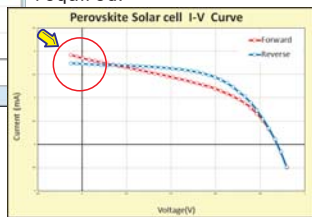


## Photoelectric current response in white light

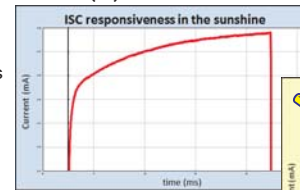
Response pattern of ISC(1)



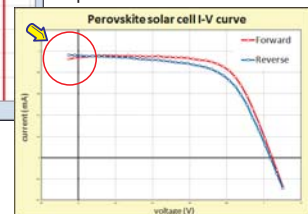
In the case of the cell which shows such a response pattern, ISC is more greatly measured by I-V measurement. Because of the evasion, sufficient waiting time before measurement is required.



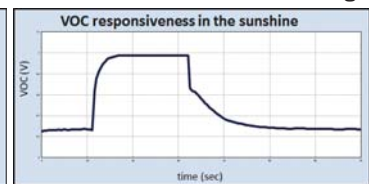
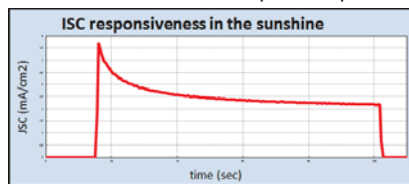
Response pattern of ISC(2)



In the case of the cell which shows such a response pattern, ISC is small measured by I-V measurement. Because of the evasion, sufficient waiting time before measurement is required.

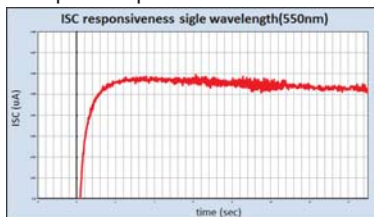


Difference in the response pattern of ISC and VOC of white light



## Measurement of the ISC response of monochromatic light

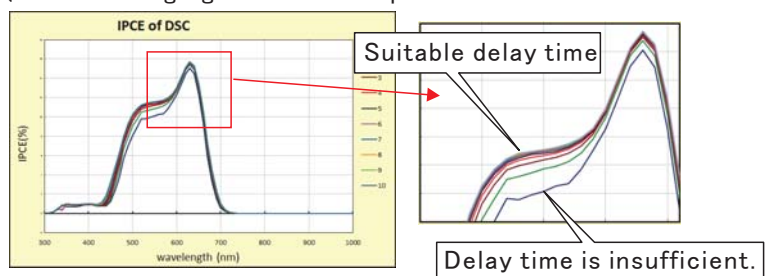
Response pattern of ISC



Notes

It is guessed that the photoelectric current response of a perovskite solar cell is not dependent on a wavelength, and it is dependent on light volume.

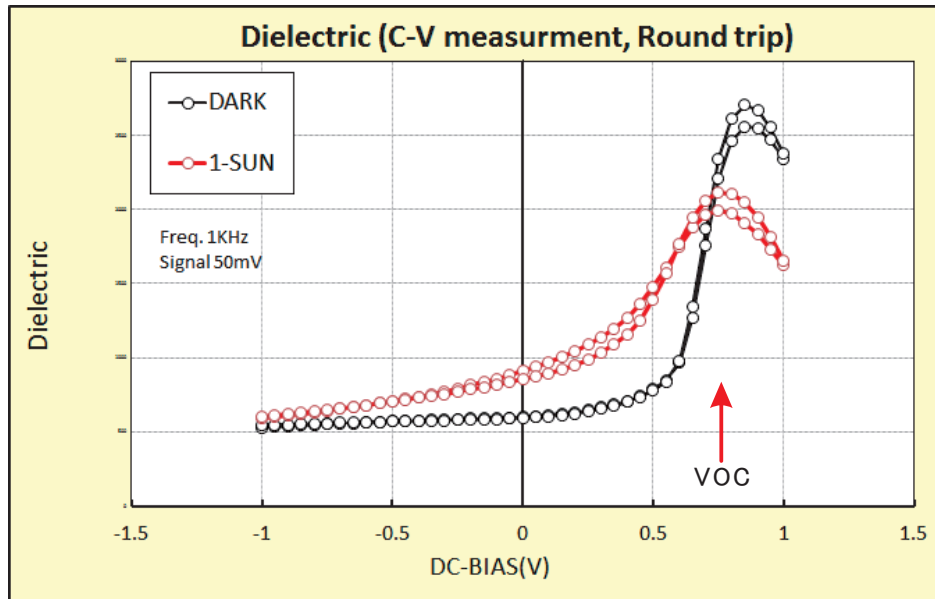
When it is a cell which has the response delay of photoelectric current by monochromatic light, sufficient measurement delay time is required of IPCE measurement for every wavelength. In order to determine suitable delay time, it is important to measure a response as shown in the left figure in advance. (The following figure is an example of measurement data in DSC.)





## Dielectric of perovskite solar cells

Change of the dielectric constant was measured in each of a DARK state and a white light irradiation state, changing the bias voltage of cell both ends.



Change of the dielectric constant was measured in each of a DARK state and a white light irradiation state, changing measurement frequency.

