



2015.5.26

Perovskite solar cells

1. Advice of the method for measurement

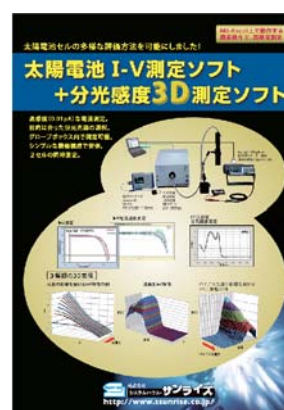
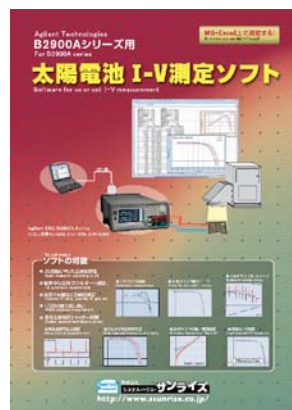
1

The solution of hysteresis

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



〒470-0125 愛知県日進市赤池一丁目1301番地
(株式会社システムハウス・サンライズ)



TEL 052-805-5177 FAX 052-805-5144

SYSTEMHOUSE SUNRISE Inc.
1-1301 Akaike, Nishin-shi, Aichiken 470-0125 Japan
Tel +81-52-805-5177 Fax +81-52-805-5144

<http://www.ssunrise.co.jp>



Advice to I-V measurement

When hysteresis as shown in the right figure occurs in I-V measurement, the characteristics obtained from this curve are not the right values.

The I-V characteristic without hysteresis is characteristics of a stationary state.

Since the I-V characteristic with hysteresis is the characteristic of transient state, it changes with time factors.

Two different hysteresis is intermingled in the example of a right figure.

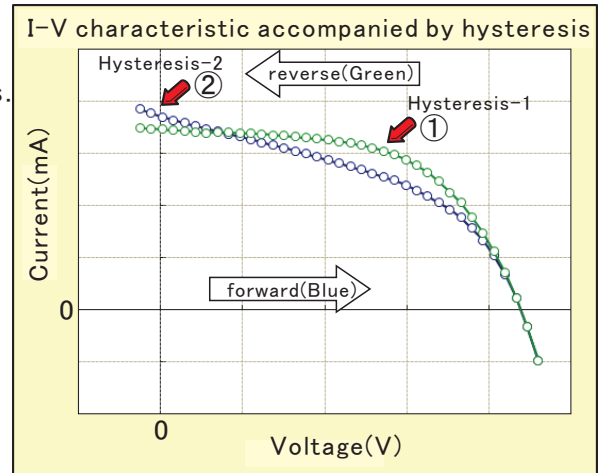


Fig.1 I-V characteristic accompanied by hysteresis

- ① Hysteresis of an inside region
- ② Hysteresis immediately after a start

Since ① and ② occur by a respectively separate factor, a separate solution is needed.

(notes)

This example cannot be adapted for the cell from which the I-V characteristic changes at every duplicate measurement. In advance, it is necessary to check that there is no change in the I-V characteristic by duplicate measurement.

First, ① is coped with.

In order to know the cause of generating of hysteresis, the current wave form under I-V measurement is measured. Overshooting of current occurs at each voltage step. Then, current transfers to a stable state. The waiting time for being in a stable state is required.

In order to make hysteresis into the minimum, it is important to measure current after transferring to a stable state.

Time to transfer to this stable state is peculiar to a cell, and it cannot decide on it uniformly. It may have been several seconds.

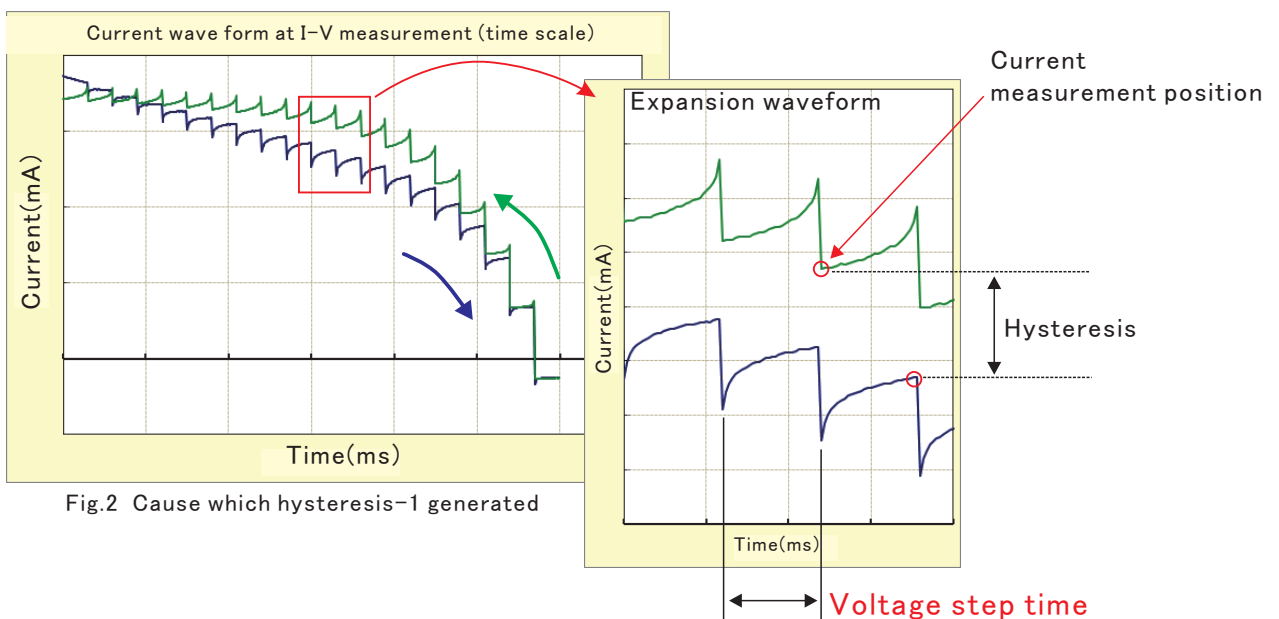
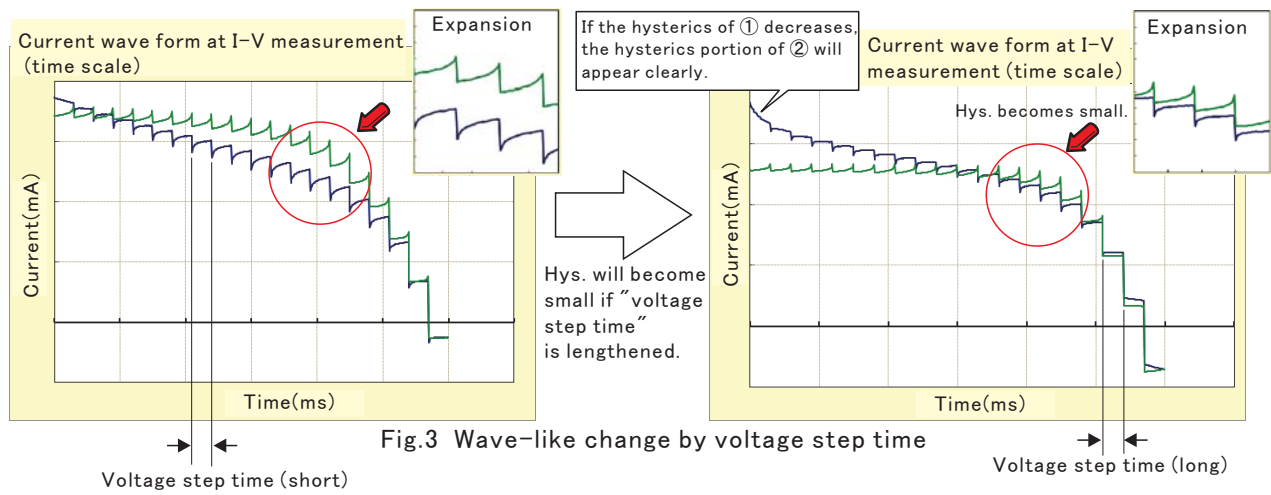


Fig.2 Cause which hysteresis-1 generated

Since current will be in a stable state, "voltage step time" is lengthened.
 It is guessed from the current decay curve of Fig. 2 how much it lengthens.
 With the estimated value, the current wave form is measured again.
 The above is repeated several times and hysteresis determines the "voltage step time"
 which becomes the minimum.
 (It is difficult to make hysteresis into zero completely.)
 If suitable "voltage step time" is determined, it will become measurement delay time in
 case the time performs I-V measurement.



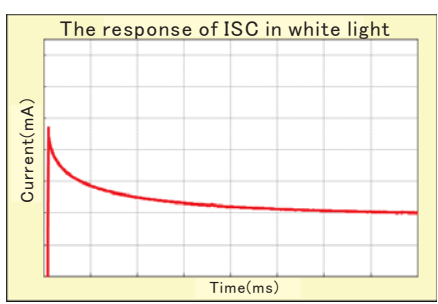
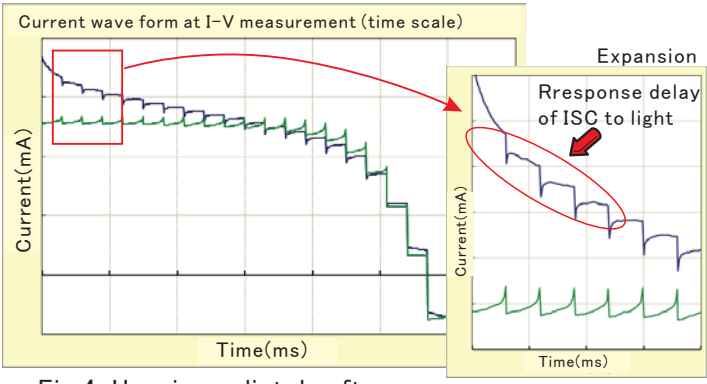
Removal of hysteresis-① adjusts measurement delay time.

Next, ② is coped with.

If the hysteresis ① is reduced, the hysteresis of ② will appear notably.
 It turns out that it cannot be coped with by measurement delay time like ① so that the
 hysteresis ② immediately after a measurement start may be understood from the
 following figure.

The cause of the hysteresis of ② originates in the photoelectric current ISC being
 delayed in a response to light.

It is checked from Fig. 5 that the response of photoelectric current is slow.



In order to avoid this hysteresis, it is necessary to adjust hold time. Hold time is in the state which irradiated with light and fixed the both ends of the cell to measurement starting potential, and is time to wait for photocurrent to be in a stable state. Then, I-V measurement is started. Although this time is time peculiar to a cell and it cannot decide on it uniformly, it may be tens of seconds from several seconds.

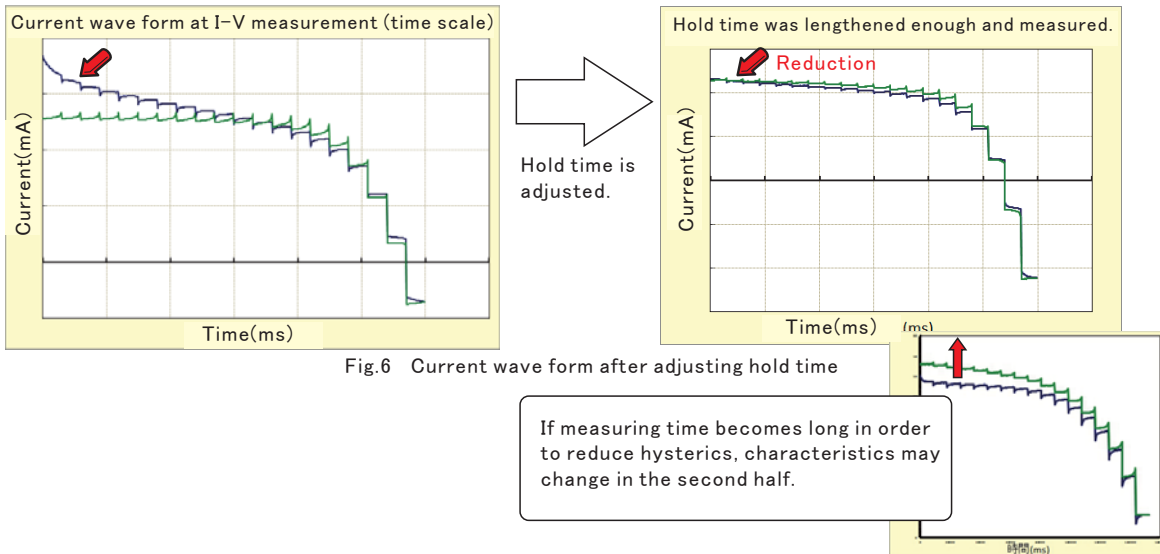


Fig.6 Current wave form after adjusting hold time

The hysteresis ② before a measurement start is adjusted by hold time!

The comparison before and behind adjustment of measurement conditions

In the I-V measurement with hysteresis, a current value is always measured greatly. Moreover, also ISC It is computed greatly. Two conditions, hold time and measurement delay time, are adjusted, hysteresis is made into the minimum, and I-V measurement is performed.

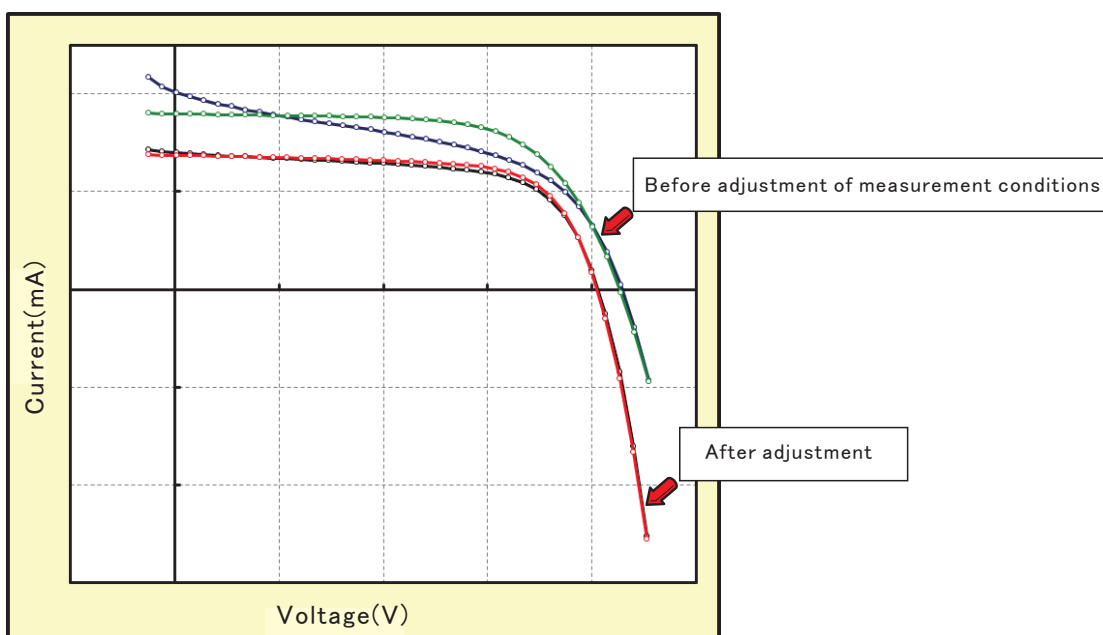


Fig.7 I-V characteristics comparison before and behind measurement condition adjustment