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Response to "Comment on 'Depletion width measurement in an organic Schottky contact using a metal-semiconductor field-effect transistor' " [Appl. Phys. Lett. 97, 096101 (2010)]

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6430 Sub-Femtoamp Remote SourceMeter® Instrument

specifications

CONDENSED MEASURE SPECIFICATIONS [1]

VOLTAGE MEASUREMENT ACCURACY (4-WIRE SENSE) [3]

Range	Max. Resolution	Input[2] Resistance	Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + volts)
200.000 mV	1 μV	$>10^{16}\Omega$	0.012% + 350 μV
2.00000 V	10 μV	$>10^{16}\Omega$	0.012% + 350 μV
20.0000 V	100 μV	$>10^{16}\Omega$	0.015% + 1.5 mV
200.000 V	1 mV	$>10^{16}\Omega$	0.015% + 10 mV

TEMPERATURE COEFFICIENT (0°–18°C and 28°–40°C): ±(0.15 × accuracy specification)/°C.

ADDITIONAL MEASURE SPECIFICATIONS

OUTPUT SETTLING TIME (typical to 10% of final value): <2s, 1pA and 10pA ranges; <50ms, 100pA through 10nA ranges; <5ms, 100nA through 100mA ranges.

CURRENT NOISE: When observed over 1 minute intervals, peak to peak noise will be within 400aA during 90% of the intervals using Autofilter (5s 10% to 90% rise time), with triax connec-

CURRENT MEASUREMENT ACCURACY (2- OR 4-WIRE SENSE) [4]

Range	Max. Resolution	Voltage Burden[5]	Accuracy (23°C ± 5°C) 1 Year ±(%rdg + amps)
1.00000 pA	10 aA	< 1mV	1.0 % + 7 fA
10.0000 pA	100 aA	< 1mV	0.50 % + 7 fA
100.000 pA	1 fA	< 1mV	0.15 % + 30 fA
1.00000 nA	10 fA	< 1mV	0.050 % + 200 fA
10.0000 nA	100 fA	< 1mV	0.050 % + 2 pA
100.000 nA	1 pA	< 1mV	0.050 % + 20 pA
1.00000 μA	10 pA	< 1mV	0.050 % + 300 pA
10.0000 μA	100 pA	< 1mV	0.050 % + 2 nA
100.000 μA	1 nA	< 1mV	0.025 % + 6 nA
1.00000 mA	10 nA	< 1mV	0.027 % + 60 nA
10.0000 mA	100 nA	< 1mV	0.035 % + 600 nA
100.000 mA	1 μA	< 1mV	0.055 % + 6 μA

FIG. 1. (Color online) A table from Keithley 6430 datasheet which indicates the error in current measurement for 1 μA range.

There are two comments in the reviewer comments: (1) unacceptable offset error in an instrument with high accuracy in current measurement and (2) suggesting to investigate the effect of light on the device as a possible source of error in the measurement.

We agree with the reviewer comment about not expecting a few hundred nano-Ampere error in an instrument which is capable to measure current with ~1 fA accuracy. However, the accuracy of current measurement at 1 μA range for the instrument (Keithley 6430) is expressed as 0.05%+300 pA in its datasheet (see Fig. 1). 300 pA offset current is the same error as we have experienced in our measurements. Since the forward current in the diode exceeded 100 nA (see Fig. 3 in Ref. 2) the current range was set at 1 μA in our experiments. A common solution is to use the auto range feature of the instrument but many spikes were observed in the recorded data when the instrument switched back and forth between two adjacent ranges particularly when the device was in the reverse bias. Therefore, we used constant range mode for our measurements. The datasheet of the instrument is available at Keithley website.[1]

We are well aware about the effect of light on the I-V curve of an organic Schottky junction. Although photocurrent can shift the I-V curve of an organic diode similar to the observed result, it is very unlikely that the sample was affected by light. Because the sample was in a metal box located inside a glovebox during the measurements (see Fig. 2). In addition, the error in current measurement for both diode and the resistive film is the same (0.3 nA). There is no reason to have a photocurrent in a resistive film with Ohmic contacts.

FIG. 2. (Color online) A picture of the metal box used for shielding the sample and eliminating the effect of light during I-V measurement.

In conclusion we believe that the source of error in the measurement was the instrument. For a more accurate result application of a semiconductor parameter analyzer, such as Agilent 4156C, is recommended instead of Keithley instruments.

[1]Datasheet of Keithley-Model 6430 Sub-Femtoamp Remote SourceMeter Instrument (http://www.keithley.com/products/dcac/currentvoltage/lowcurrent/?path=6430/Documents#4).

[2]A. Takshi, A. Dimopoulos, and J. Madden, Appl. Phys. Lett. **91**, 083513 (2007).

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