

2018/7/11 9

Using Keithley 4200-SCS
Semiconductor Characterization System.
(LabVIEW training behemoth was too complex, limited).

Measurements to make:

- cut NWs between electrodes on NW#2. →
Done by hand, so some traces not good. (too long, sketchy).
Cut half of NWs on #1 w/ microscope microprobes.

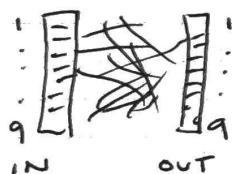
5-9 prob. good?

Measurements to make:

- Constant voltage, measure current across two electrodes
Goal: confirm exponential rise
- * If that works, make const. voltage measurements
Spaced out from one another to try to measure decay constant
- IV curve to confirm Ron/Roff?
- Microscope image to guess density, etc.

It's all based on const. V measurement.

Goal: Measure current when 0.01V applied to channel 9.



Put 0V on 9in, 0.01V on 9out,
observe curve.

can raise voltage, try diff electrodes, etc. later.

NW 2

EXP 1 Connected SMU 1 to 9in, SMU 2 to 9out, others disconnected.

using SMU2: 0V bias, 1mA max

SMU1: 0.01V bias, 1mA max, measure current

take 1000 measurements @ 1ms each

Looks like const. current ($\approx 20\ \mu A$)

Same, but 0.1V bias, 1mA max

Result: const. current ($\approx 200\ \mu A$)

Same, but 1V, 1mA max

Result: hit compl. current (1mA)

CH 9

EXP 4 Same, but 1V, 100mA max.

Result: current rose from $\approx 2\ \mu A$ to $\approx 2.4\ \mu A$, exp!

EXP 5 Same, 1V, 100mA, but 30s@1ms increments (4096 samples max)
(run ≈ 1 min after EXP4)

Result: current rose from $\approx 2.4\ \mu A$ to $\approx 2.45\ \mu A$, exp.

2V bias, 100mA max, 3s@1ms resolution

Result: rose exp. from $\approx 4.9\ \mu A$ to $\approx 5.5\ \mu A$

3V bias, 100mA max, 3s@1ms resolution

Result: rose exp. 8.4 mA to 9 mA

2018/7/19

EXP 8

CH 9

EXP 9

5V, 100mA max, 35°C / ms resolution.

Result: exp. rise 15 mA to 18 mA.

EXP 10

CH 8

EXP 11

CH 9

EXP 12

EXP 13

EXP 14

EXP 15

EXP 16

EXP 17

10V, same.

Result: rise, kinda linear kinda exp., 40 to 65 mA.

5V, CH 8, 100 mA max, 35°C / ms resolution.

Result: rise w/ dip from 8 to 11 mA.

same.Result: \approx const. 11 mASame, but CH 9.

Result: exp. rise 25 mA to 25.5 mA.

Same, but CH 5.

Result: no current

Same, but CH 6

Result: exp. rise 0.6 mA to 1.0 mA

same.Rose 1.0 to 1.7 mA, linearly.Same, but CH 7.

Result: Rose .8 to 1.7 mA

Same, but CH 9.

Result: exp. decrease 37 to 36 mA.

11:30 am

EXP 18

Same, ch. 9.

12:40.

Result: exp. decrease 36.8 to 35.6 mA

EXP 19

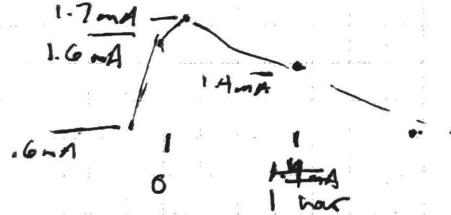
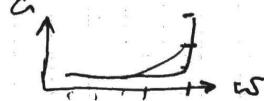
same.Result: same.

EXP 20

Rose 1.4 to ~~1.7~~ CH. 6, same.

Rose 1.4 to 1.7 mA.

Will rough calculate ch. 6 decay const:

 $I \propto G$ (conductance)

Conclusion: decay const. might be on order of hours (~1 day).

rise can be measured in ~ 1 min.

Plan: need to measure rise above @ different time durations. 1, 2, 3, 4, 5, 6 hours.

Should probably only use 1 electrode at a time.

EXP 21

Same ch. 6.

Rose 1.7 to 1.75 mA.

13:00.

Cut remained of NW bridges on NW 1.

EXP 22

2018/7/19 NW1 CH 1. 0.01 V, max 100mA. 3s @ 1ms resolution.

Result: const 80 μA.

EXP 23

NW1 CH 5 0.01 V 3s.

Result: N/C

EXP 24

NW1 CH 9 0.01V 3s.

Result: const 84 μA.

EXP 25

NW1 CH 2 0.01V 3s.

Result: const 28 μA.

EXP 26

NW1 CH 6 same...

Result: N/C

EXP 27

NW1 CH 3 same...

Result: const 6.5 μA

EXP 28

NW1 CH 7 same...

Result: const 25.7 μA.

EXP 29

NW1 CH 4 same...

Result: const 60 μA

EXP 30

NW1 CH 8 same...

Result: const 35 μA

EXP 31

NW1 ~~CH 1~~ 0.01V same... IN 4 OUT 1

Result: const 43 μA.

EXP 32

NW1 ~~CH 5~~ same...

Result: const 8 μA.

EXP 33

NW1 CH 1 0.01V.

Result: const 86 μA.

EXP 34

NW1 CH 5 0.01V. 1s @ 1ms resolution

Result: N/C

EXP 35

NW1 CH 9 0.01 V

Result: const 83 μA.

EXP 36

NW1 CH 2

Result: const 28 μA.

EXP 37

NW1 ~~CH 6~~ 0.01V. 0.5s @ 1ms resn

IN 7 OUT 6 Result: 18 μA.

EXP 38

Res NW1 CH 6 same...

Result: N/C.

EXP 39

NW1 CH 3 same

Result: 12 μA

EXP 40

NW1 CH 7 same

Result: 25 μA

EXP 41

NW1 CH 4 same

Result: 60 μA

EXP 42

NW1 CH 8 same

Result: 35 μA

EXP 43

NW1 CH 1 same

Result: 85 μA

EXP 44

NW1 CH 5 same

Result: N/C

EXP 45

NW1 CH 9 same

Result: 83 μA

EXP 46

NW1 CH 2 same

Result: 27 μA

EXP 47

NW1 CH 6 same

Result: N/C

EXP 48

NW1 CH 3 same

Result: 11 μA

IN 8 OUT 5

EXP 49

NW1 CH 7

Result: 25.6 μA

EXP 50

NW1 CH 4

Result: 5.9 μA

EXP 51

NW1 CH 8

Result: 34.9 μA

CONCLUSION: NO SIG. CHANGE.
CH. 5,6 bad.

2018/7/19

14:22

EXP 51

NW1 CH 1, 5V, 100mA max, 4096 samples @ 1ms.

Result: exp. rise 48 mA to 52 mA

14:25 EXP 52 NW1 CH 1, same.

Result: exp. decrease 54 to 52-ish mA

14:28 EXP 53 NW1 CH 1, same

Result: exp. decrease 54 to 53-ish mA

14:30 EXP 54 NW1 CH 1, same

Result: exp. decrease 55 to 54-ish mA

14:32 EXP 55 NW1 CH 1, same

Result: exp. decrease 55.5 to 54-ish mA

14:35 EXP 56 NW1, CH 9, same

Result: exp. rise 48 to 58 mA

14:38 EXP 57 NW1, CH 9, same

Result: exp. decrease 58 to 57 mA.

14:41 EXP 58 NW1, CH 1, same, 0.01 V, 100 mA max.

Result: slight exp. increase .114 to .1144 mA

14:44 EXP 59 NW1, CH 1, same.

Result: about const 0.11443 mA.

14:46 EXP 60 NW1, CH 9, same.

Result: about const .1224 mA

14:48 EXP 61 NW1, CH 9, same.

Result: same.

14:50 EXP 62 NW1, CH 9, 5V.

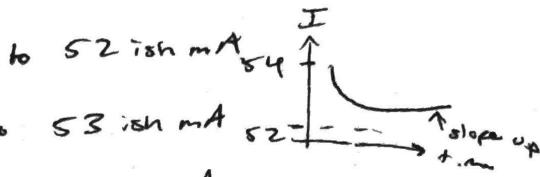
R: 60 to 58 mA.

14:54 EXP 63 NW1, CH 1, 5V.

R: 56 to 54 mA.

14:59 EXP 64 NW1, CH 1, 1mV,

100 samples @ 1ms.



R: 11 mA

15:02 EXP 65 NW1, CH 1, 1mV

R: noise. → too small?

15:03 EXP 66 NW1, CH 1, 0.1mV

R: noise → too small?

15:04 EXP 67 NW1, CH 1, 1 mV

R: 11 mA.

15:05 EXP 68 NW1, CH 5, same.

R: N/C

15:06 EXP 69 NW1, CH 9, same.

R: 12.0 mA.

15:07 EXP 70 NW1, CH 2:

5 mA.

15:08 EXP 71 NW1, CH 6:

N/C

15:09 EXP 72 NW1, CH 7:

5 mA.

15:10 EXP 73 NW1, CH 7, 5V, 4096 samples @ 1ms.

R: exp. rise 15 to 17.5 mA.

15:13 EXP 74 NW1, CH 9, 5V, ...

R: 61.5 to 59.5 exp. decrease (mA)

15:18 EXP 75 NW1, CH 1, same.

R: 56 to 54 mA.

15:21 EXP 76 NW1, CH 1, 1mV, 100 samples, 1ms

R: 11 mA

15:22 EXP 77 NW1, CH 9, same

R: 12.8 mA

15:23 EXP 78 NW1, CH 7

R: 7.1 mA

2018/7/19 OK. Have channels 1, 7, 9 initialized.
Will try to measure decay rate (already measured rise rate).

Two ways: give small voltage (1mV); measure current.
or measure rise time (needs many waits).

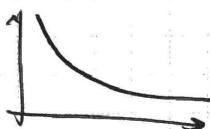
Suppose width decreases exponentially. What is the expected resistance profile?

Suppose we measures a voltage $V \pm 1\%$, and a current $I \pm 1\%$. Then:

$$R = \frac{V}{I} = \frac{V \pm 1\%}{I \pm 1\%}$$

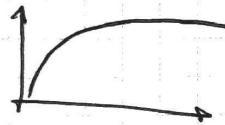
then.

If width:

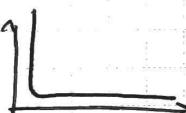


then

$$R :$$



$$\frac{1}{R} :$$



That graph makes me feel uncomfortable, but I can't say why. I'll try a plain I-V measurement.

16:00 **TEX79** NW1, CH 7, 1mV, 100 samp. @ 1ms

$$R: 7 \text{ mA}$$

16:00 **EX80** NW1, ~~CH 1~~ CH 1

$$R: 11.4 \text{ mA}$$

16:01 **EX81** NW1, CH 9

$$R: 12.8 \text{ mA}$$

16:15 **EXP82** NW1, CH 9

$$R: 12.76 \text{ mA}$$

16:16 **EXP83** NW1, CH 1

$$R: 11.34 \text{ mA}$$

16:17 **EXP84** NW1, CH 7

$$R: 7 \text{ mA}$$

16:32 **EXP85** NW1, CH 7

$$R: 6.9 \text{ mA}$$

16:34 **EXP86** NW1, CH 1

$$R: 11.28 \text{ mA}$$

16:35 **EXP87** NW1, CH 9

$$R: 12.7 \text{ mA}$$

17:10 **EXP88** NW1, CH 9

$$R: 12.66 \text{ mA}$$

17:11 **EXP89** NW1, CH 1

$$R: 11.23 \text{ mA}$$

17:12 **EXP90** NW1, CH 7

$$R: 6.8 \text{ mA}$$

Goal: Run Ch. 1 overnight.

~10 hrs.

300 samples - 60 min

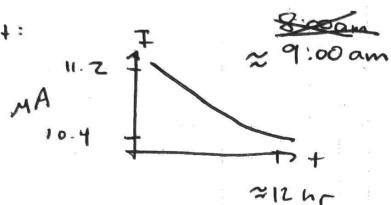
5 samples / min ?

Try 900 samples @
1 sample / min.

17:16 **EXP91** NW1, CH 1, 1mV, 4096 samples
at 60s intervals.

2017/7/7 20 Stopped EX91, started EX92 immediately w/ same parameters.

Result:



$$10 \text{ mV} \rightarrow 80 \mu\text{A}$$

$$1 \text{ mV} \rightarrow 8 \mu\text{A}$$

Still progressing well.

Presented research to group. Good feedback. Will simplify talk for Friday.

11:00: opened sample box to take picture. Will see whether affects data.

15:40: Stopped EX92 started EX93 immediately w/ same params. Looks like yes, current increases $\approx 1\%$.

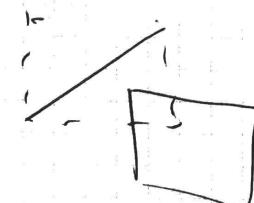
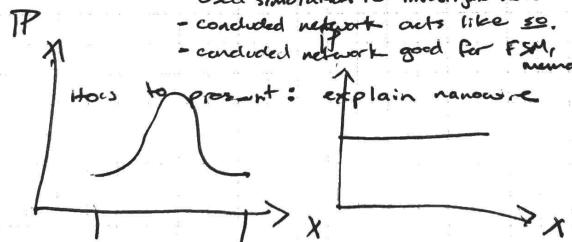
Plans for next week: work on final presentation (next Friday). Will also need to submit a paper and poster eventually for NNCI; can do that, too.

Presentation: 20 min + 10 min questions. In order to use time, plan for extra slides for questions. Audience not familiar w/ topic.

Thesis: simulate nanowire networks to investigate dynamics

Results: created simulation, matched experiment

- used simulation to investigate network
- concluded network acts like SR
- concluded network good for FSM, memory. "startx": 5 "starty": 7



2018/7/25 Checking on experiment.

97

10:30 AM. Stopped Ex 93, started Ex 94 w/ same settings.
good curve!

Ex 95 NWI CH 1 5V 4096 samples @ 1 ms.
w/1 obsene response after decay.

Result: ex. rise up

Ex 96 NWI CH 9 5V 4096 samples @ 1 ms. Start to repeat
measurements.

Result: rose a bit w/ some noise

same

11:00 Ex 97 1 mv, 4096 samples @ 1 ms.

Ex 98

記入者

確認者

日付 年 月 日

2018/7/24 stopped [Ex98], started [Ex99] w/ same params.

Looks like same exp. decrease.

11:34 Stopped EX 99

Started EX 100: NW1 CH 9, 5V, 1 ms @ 4096 samples.
finished.

Stopped experiments.

Pct NW mount electrode jig back.

Took macro, micro images of NWs.