Fusion

User Manual

Protochips
Quantifiably Better™

M-00003 1.2 06.17

Fusion

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Fusion 200, 350 & 500™

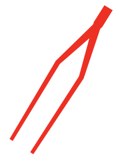
Tools Needed

Powder Free Gloves

Micro Screwdriver (included)

(Double Tilt Holders only)

Phillips Head Screwdriver



Carbon Tipped Tweezers

Inventory List (All Systems)

TEM Holder
P#1

Laptop with power cord
P#4

Ethernet Cable
P#7

AMP Dongle
P#2

Keithley Power Cord
P#5

Ground Eliminating Extender
P#8

Keithley Power Supply
P#3

Phoenix Cable
P#6

Green Grounding Cable
P#9

Inventory List (Optional Double Tilt Control)

External Double Tilt Controller
P#10

Grounding Eliminating Extender
P#12

Hirose Cable
P#14

Green Grounding Cable
P#11

Transformer
P#13

Tilt Controller Power Cord
P#15

Inventory List (All Systems)


Triaxial Cable
P#16


Laptop with power cord
P#4

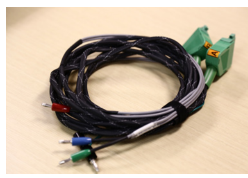

Ethernet Cable
P#7


AMP Dongle
P#2


Keithley Power Cord
P#5


Ground Eliminating Extender
P#8


Keithley Power Supply
P#3


Phoenix Cable
P#6


Green Grounding Cable
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Inventory List (Optional Double Tilt Control)


External Double Tilt Controller
P#10


Grounding Eliminating Extender
P#12


Hirose Cable
P#14


Green Grounding Cable
P#11


Transformer
P#13


Tilt Controller Power Cord
P#15

Step 1: Grounding the Keithley Power Supply, External Tilt Controller and Microscope

1: Loosen the Grounding Screw with the Philips Screwdriver, but do not fully remove. Attach the Green Grounding cable (P# 9) and then tighten it again to ensure a connection between Grounding Cable and Keithley (P# 3)

2: For double tilt setup: By hand unscrew the Grounding Bolt of the External Tilt Controller (P# 10) and attach the second Green Grounding Cable (P# 11) and then tighten it again to ensure a connection between Grounding Cable (P #11) and Tilt Controller (P #10)

3: Use a multimeter to locate the grounding plate, or grounded screw of your microscope

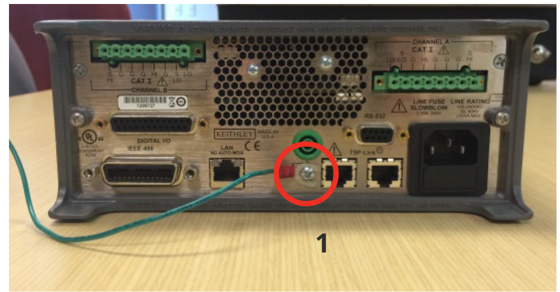
4: Connect the loose ends of the two Green Grounding Cables with the located grounding area of your microscope

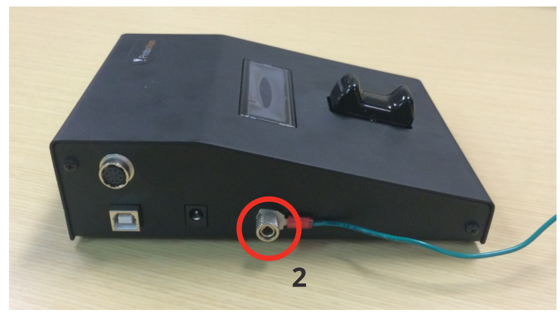
5: Connect the first Ground Eliminating Extender (P# 8) to the Keithley power cord (P# 5)

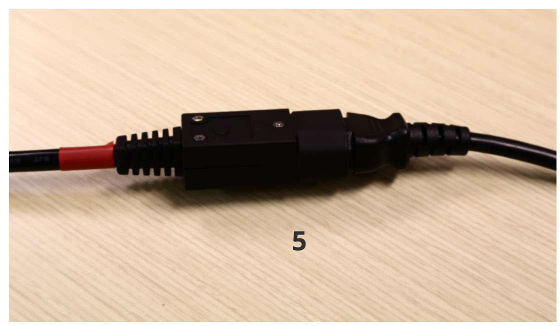
6: For double tilt setup: Use second Ground Eliminating Extender (P# 12) to connect the Tilt Controller Power cord (P# 15) and the Transformer (P# 13).

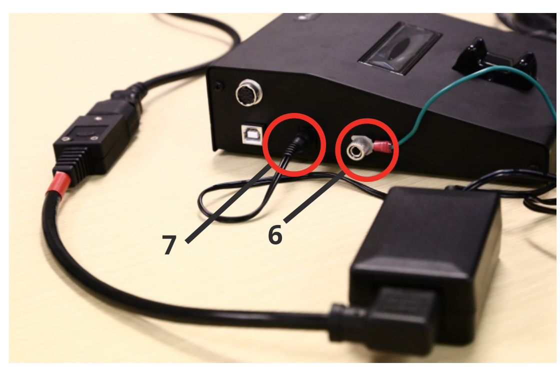
7: Attach the Transformer (P #13) to the Tilt Controller (P #10)

8: Plug the Keithley and the Tilt Controller Power Cords into an outlet and then turn on the Keithley in order to check the ground. Make sure Microscope, the Power Supply and optional Tilt Controller are grounded to the same ground. Use a multimeter to individually verify a <2 Ohm resistance between the Power Supply and the Column and the Tilt Controller and the Column. If higher than 2 Ohm re-evaluate ground. Turn off Keithley after the grounding test









Step 2: Setting up the Keithley Power Supply and Laptop

1: Connect AMP dongle (P #2 to the Keithley (P# 3) by hand screwing

2: Use the Ethernet cable (P# 7) to connect the Keithley (LAN: No Auto/ MDIX port) with the laptop (P# 4)

INFO: The Phoenix cables (P #6) are labeled A and B. The Fusion 200 only Cable A needs to be plugged in. Check that the letters on the cable are not upside down.

3: Insert the green Phoenix connector (P# 6) into the Power Supply and screw tight with a flat head. The Grounding ports of the Phoenix cable can be plugged into each other. Then attach those to the Keithley

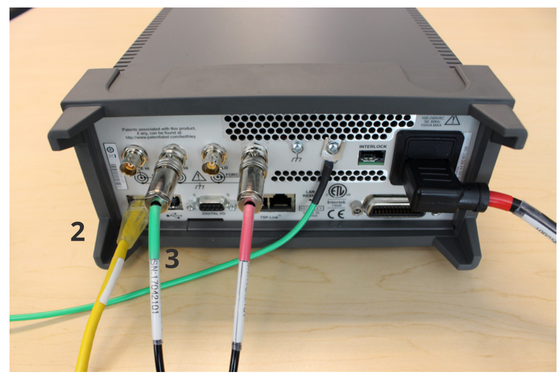
4: Connect the opposite end of the Phoenix cable with the Holder according the color codes

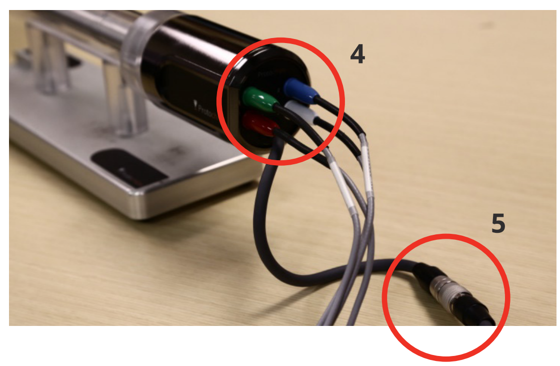
5: For double tilt setup: Use the Hirose Cable (P# 14) to connect the Tilt Controller with the Holder.

6: Turn on Keithley by pressing the Power Button

7: Wait until the Keithley is initialized

INFO: All control is done through the laptop that communicates with the Keithley





Step 2: Setting up the Keithley Power Supply and Laptop

1: Connect AMP dongle (P #2 to the Keithley (P# 3) by hand screwing

2: Use the Ethernet cable (P# 7) to connect the Keithley (LAN: No Auto/ MDIX port) with the laptop (P# 4)

INFO: The Phoenix cables (P #6) are labeled A and B. The Fusion 350 Cable A goes into the top right corner and B into the top Left corner. Check that the letters on the cable are not upside down.

3: Insert the green Phoenix connector (P# 6) into the Power Supply and screw tight with a flat head. The Grounding ports of the Phoenix cable can be plugged into each other. Then attach those to the Keithley

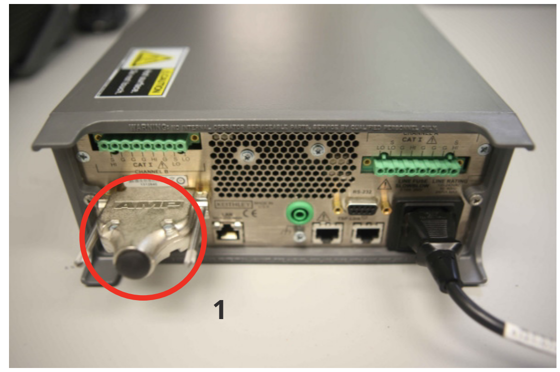
4: Connect the opposite end of the Phoenix cable with the Holder according the color codes

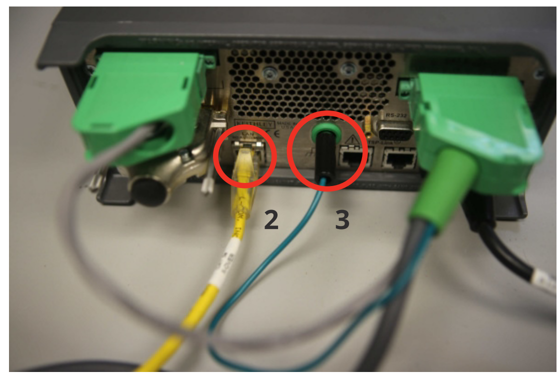
5: For double tilt setup: Use the Hirose Cable (P# 14) to connect the Tilt Controller with the Holder.

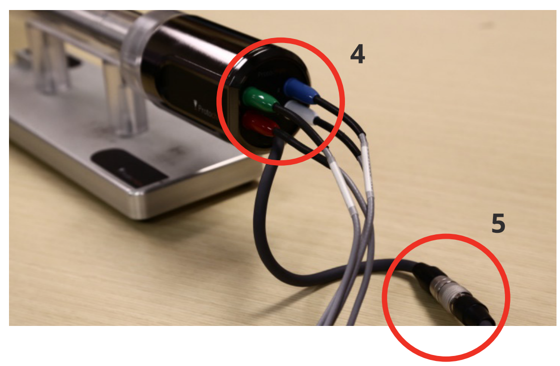
6: Turn on Keithley by pressing the Power Button

7: Wait until the Keithley is initialized

INFO: All control is done through the laptop that communicates with the Keithley







Step 3: Loading the E-chip

ON A SINGLE TILT HOLDER:

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

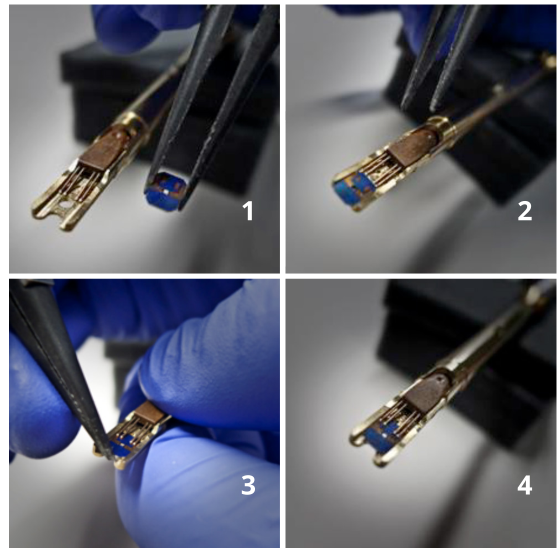
INFO: All sample preparation has to be done prior to loading the E-chip.

1: Remove E-chip from gel-pak, which has sample already prepared

2: Place the E-chip on the edge of the holder tip and gently slide it in until it hits the front of the pins.

3: Push down on the spring-loaded brown plastic rocker with your finger and simultaneously push the E-chip in under the pins until it reaches the backstop

4: Release the brown plastic.



INFO: The four pins should line up with the gold or platinum electrodes on the E-chip. If they do not line up correctly the E-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.

ON A DOUBLE TILT HOLDER:

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

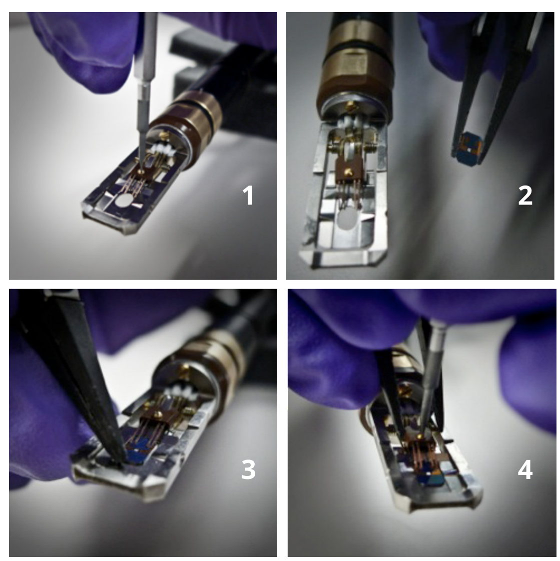
INFO: All sample preparation has to be done prior to loading the E-chip.

1: Using a small flat-head screwdriver, gently unscrew the brown plastic contact block. Do not try to remove the screw (1–1.5 turns are sufficient)

2: Remove E-chip from gel-pak, which has sample already prepared

3: Place E-chip onto tilt table and gently slide underneath the four contact pins until it reaches backstop

4: Screw down the brown plastic contact block ensuring that the pins are aligned with the contacts on the E-chip



INFO: The four pins should line up with the gold or platinum electrodes on the E-chip. If they do not line up correctly the E-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.

ON AN SEM STAGE:

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

INFO: All sample preparation has to be done prior to loading the E-chip.

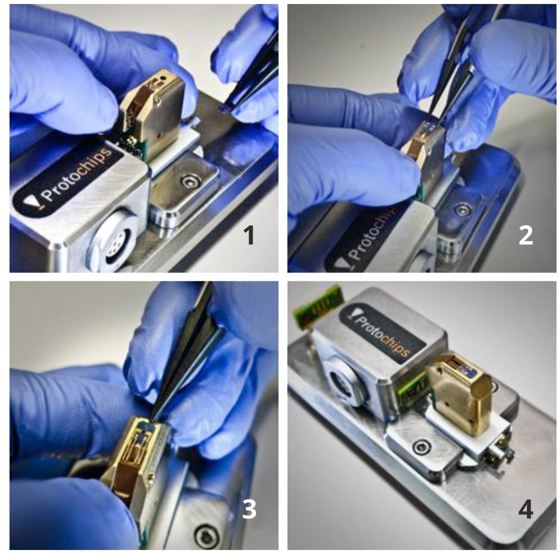
1: Remove E-chip from gel-pak, which has sample already prepared

2: Place the E-chip on the edge of the stage tip and gently slide it in until it hits the front of the pins

3: Push down on the spring-loaded Vespel® (brown plastic) rocker with your finger and simultaneously push the E-chip in under the pins until it reaches the backstop

4: Release the brown plastic

INFO: The four pins should line up with the gold or platinum electrodes on the E-chip. If they do not line up correctly the E-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.



FOR NION INSTRUMENTS

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

INFO: All sample preparation has to be done prior to loading the E-chip.

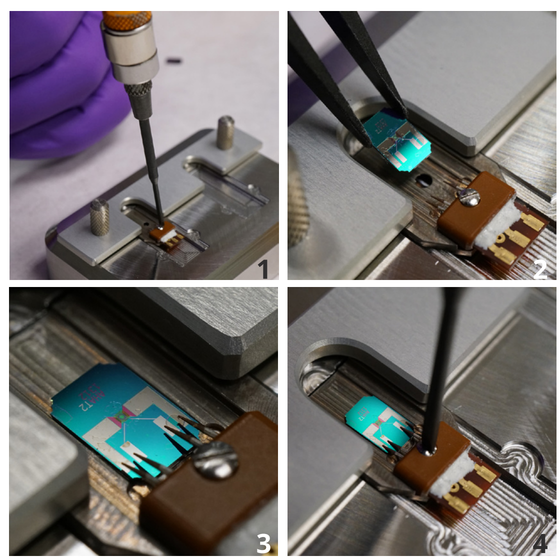
1: Load puck into NION loading stand and unscrew fusion contact pins

2: Place E-chip onto stage with E-chip electrical leads pointing torwards the contact pins.

3: Push E-chip to back of stage so that contact pins align with E-chip electrical leads

4: Screw down fusion contact pins so they contact E-chip.

INFO: The four pins should line up with the gold or platinum electrodes on the E-chip. If they do not line up correctly the E-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.



Step 4: Launching the Software

INFO: Keep the Laptop connected to an outlet during the experiment. The Laptop does not need to be on the same ground as the Keithley.

1: Start the Laptop. Password: Protochips

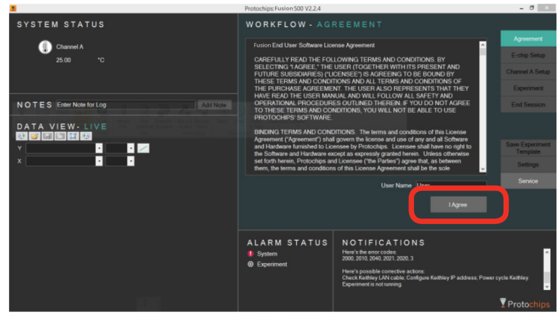
2: Launch the software, by double-clicking the Protochips icon on the desktop of the laptop

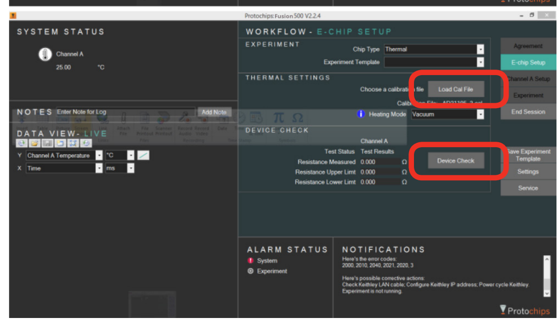
3: Type in your username and click the “I Agree” Button

4: For Thermal and Electrothermal experiments a calibration file has to be loaded and a device check has to be passed

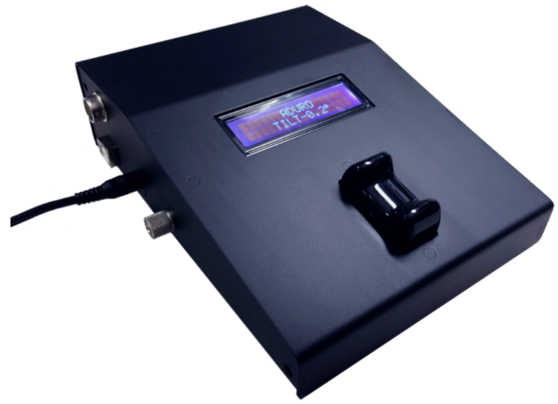
INFO: If a System Error occurs turn Keithley on and off.

5: Now experiment specific adjustments can be made





Optional: Operating External Double Tilt Controller



INFO: Please make sure that the Tilt Controller is grounded to the same ground as the microscope and power supply.

1: A soft touch of the controller equals a slow tilt speed a harder touch will result in a more rapid tilt process

2: Tilt alarm will automatically move the tip in the opposite direction for half a degree if contact is detected

3: Before removing the Holder it is important to reset the tilt angle to 0° on the Tilt Controller.

Step 1: Grounding the Keithley Power Supply, External Tilt Controller and Microscope

1: Loosen the Grounding Screw with the Philips Screwdriver, but do not fully remove. Attach the Green Grounding cable (P# 9) and then tighten it again to ensure a connection between Grounding Cable and Keithley (P# 3)

2: For double tilt setup: By hand unscrew the Grounding Bolt of the External Tilt Controller (P# 10) and attach the second Green Grounding Cable (P# 12) and then tighten it again to ensure a connection between Grounding Cable (P# 11) and Tilt Controller (P# 10)

3: Use a multimeter to locate the grounding plate, or grounded screw of your microscope

4: Connect the loose ends of the two Green Grounding Cables with the located grounding area of your microscope

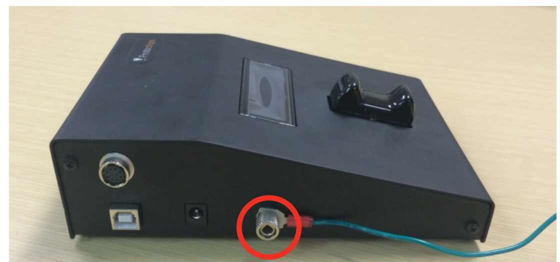
5: Connect the first Ground Eliminating Extender (P# 8) to the Keithley power cord (P# 5)

6: For double tilt setup: Use second Ground Eliminating Extender (P# 12) to connect the Tilt Controller Power cord (P# 15) and the Transformer (P# 11).

7: Attach the Transformer (P# 13) to the Tilt Controller

8: Plug the Keithley and the Tilt Controller Power Cords into an outlet and then turn on the Keithley in order to check the ground. Make sure Microscope, the Power Supply and optional Tilt Controller are grounded to the same ground. Use a multimeter to individually verify a <2 Ohm resistance between the Power Supply and the Column and the Tilt Controller and the Column. If higher than 2 Ohm re-evaluate ground. Turn off Keithley after the grounding test

1



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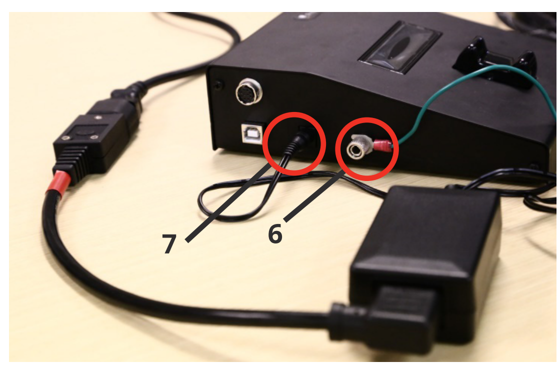


Step 2: Setting up the Keithley Power Supply and Laptop

1: Connect AMP dongle (P# 2) to the Keithley (P# 3) by hand screwing

2: Use the Ethernet cable (P# 6) to connect the Keithley (LAN: No Auto/ MDIX port) with the laptop (P# 4)

INFO: The Triaxial cables are color coded.

3: Connect the cables as show in the figure on the right. Left to Right: Blue, White, Red, Green

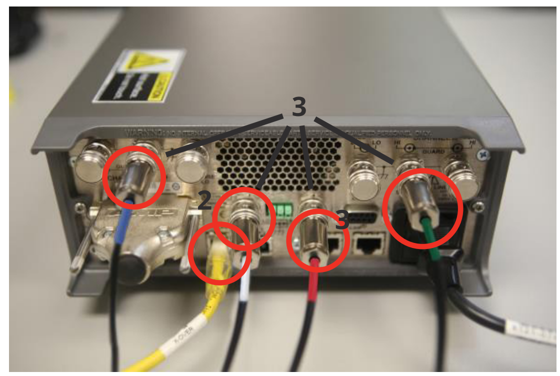
4: Connect the opposite end of the Triax cable with the Holder according the color codes

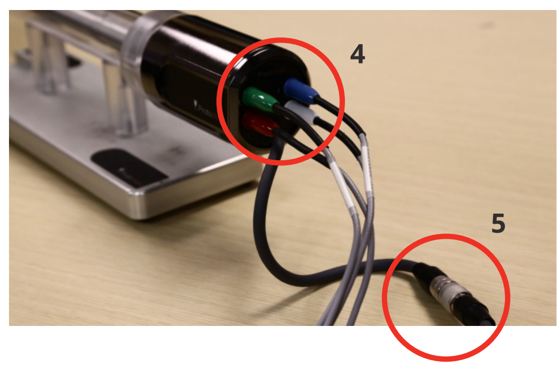
5: For double tilt setup: Use the Hirose Cable (P# 14) to connect the Tilt Controller with the Holder.

6: Turn on Keithley by pressing the Power Button

7: Wait until the Keithley is initialized

INFO: All control is done through the laptop that communicates with the Keithley





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ON A SINGLE TILT HOLDER:

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

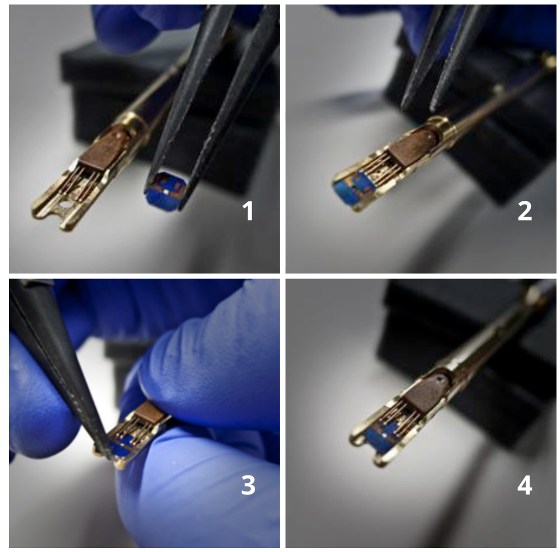
INFO: All sample preparation has to be done prior to loading the E-chip.

1: Remove E-chip from gel-pak, which has sample already prepared

2: Place the E-chip on the edge of the holder tip and gently slide it in until it hits the front of the pins.

3: Push down on the spring-loaded Vespel® (brown plastic) rocker with your finger and simultaneously push the E-chip in under the pins until it reaches the backstop

4: Release the Vespel rocker



INFO: The four pins should line up with the gold or platinum electrodes on the e-chip. If they do not line up correctly the e-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.

ON A DOUBLE TILT HOLDER:

INFO: Clean gloves should be worn to avoid contaminating the tip with brown plastic. Always use carbon tipped tweezers when handling E-chips.

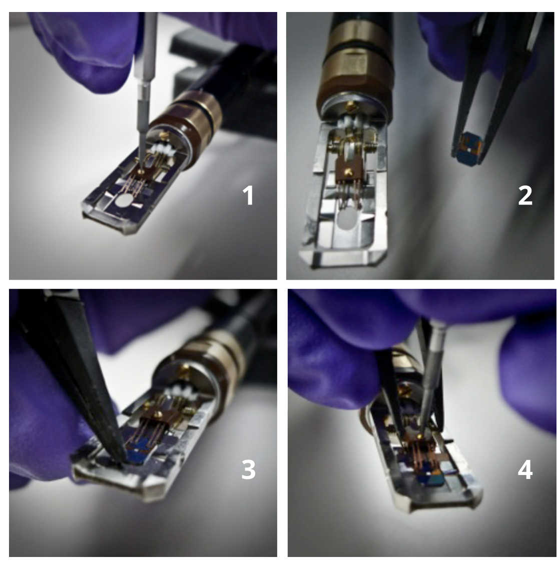
INFO: All sample preparation has to be done prior to loading the E-chip.

1: Using a small flat-head screwdriver, gently unscrew the brown Vespel contact block. Do not try to remove the screw (1–1.5 turns are sufficient)

2: Remove E-chip from gel-pak, which has sample already prepared

3: Place E-chip onto tilt table and gently slide underneath the four contact pins until it reaches backstop

4: Screw down the brown plastic contact block ensuring that the pins are aligned with the contacts on the E-chip



INFO: The four pins should line up with the gold or platinum electrodes on the E-chip. If they do not line up correctly the E-chip can be gently wiggled from side to side. The pins can also be wiggled gently from side to side as well. However, the pins are fragile, do not bend the pins.

ON AN SEM STAGE:

INFO: Clean gloves should be worn to avoid contaminating the tip with organic residue. Always use carbon tipped tweezers when handling E-chips.

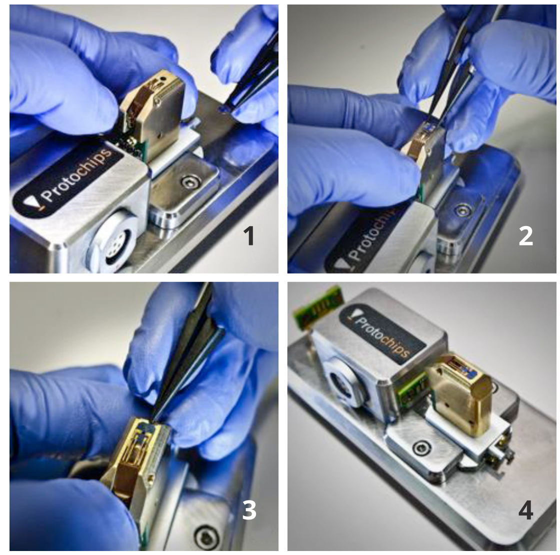
INFO: All sample preparation has to be done prior to loading the E-chip.

1: Remove E-chip from gel-pak, which has sample already prepared

2: Place the E-chip on the edge of the stage tip and gently slide it in until it hits the front of the pins

3: Push down on the spring-loaded Vespel® (brown plastic) rocker with your finger and simultaneously push the E-chip in under the pins until it reaches the backstop

4: Release the brown plastic rocker



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INFO: If a System Error occurs turn Keithley on and off.

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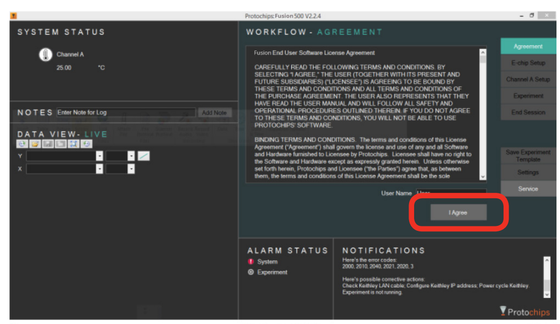
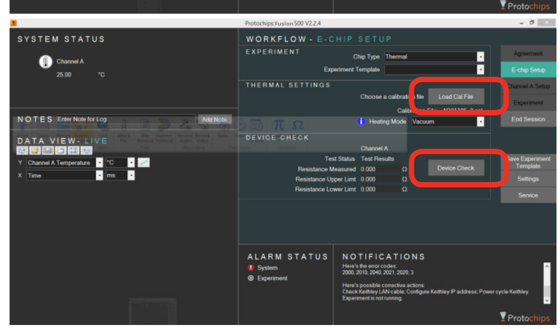
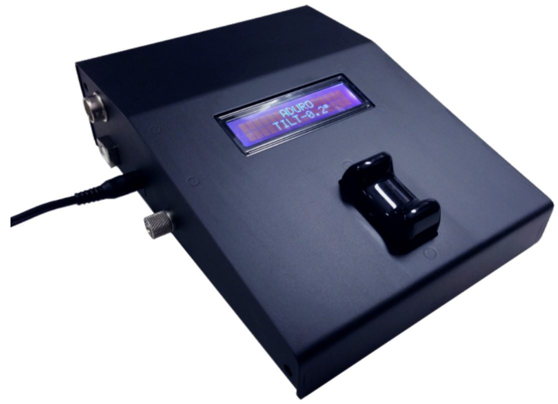




Optional: Operating External Double Tilt Controller



INFO: Please make sure that the Tilt Controller is grounded to the same ground as the microscope and power supply.

1: A soft touch of the controller equals a slow tilt speed a harder touch will result in a more rapid tilt process

2: Tilt alarm will automatically move the tip in the opposite direction for half a degree if contact is detected

3: Before removing the Holder it is important to reset the tilt angle to 0° on the Tilt Controller.

THERMAL E-CHIPS

Thermal E-chips and Electro-Thermal E-chips have an array of 9 holes (7 µm diameter) patterned on each membrane, see Figure 3. For very small particles, Protochips offers a holey carbon film or silicon nitride film over the array of holes. See the Fusion E-Chip Ordering Guide for more details.

Imaging: Samples must be placed over one or more of these holes before loading the E-chip into the TEM to ensure maximum electron transparency and unobstructed imaging.

Figure 3. Bottom: Fusion heating E-chip. Top: SEM image of the 9 holes in the heating membrane.

Figure 4. TEM images of the ceramic membrane. The top image shows a low magnification view of a hole in the membrane. The black particles in the hole are clusters of a sample that were dispersed on the surface. This E-chip has a layer of carbon for extra support. The bottom image is the membrane at higher magnification, and shows the polycrystalline grains of the membrane.

Samples can be prepared directly upon the membrane with common techniques including solvent dispersion, dry dip, thin film evaporation and both in situ & ex situ focused ion beam system (FIB) placement. Visit www.protochips.com for more information on sample preparation methods.

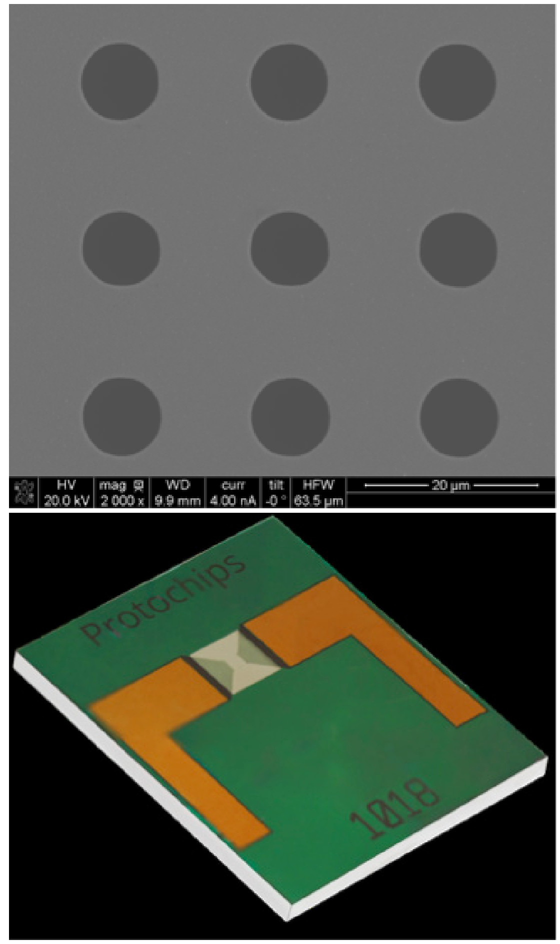


Figure 3.

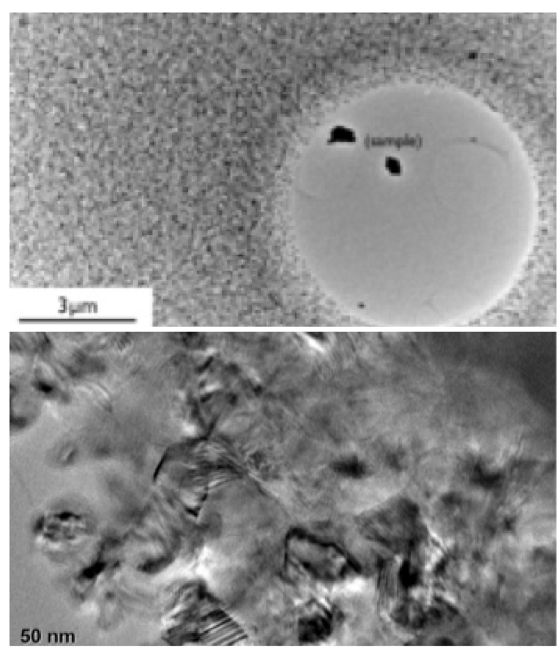


Figure 4.

ELECTRICAL E-CHIPS

Electrical E-chips have several patterns and features available to choose from. The complete list of available patterns and features is listed in the Fusion E-chip Ordering Guide.

Samples can be prepared directly upon the membrane with common techniques including solvent dispersion, dry dip, thin film evaporation and both in situ & ex situ focused ion beam system (FIB) placement. Visit www.protochips.com for more information on sample preparation methods.

Imaging: The membrane on Electrical E-chips is silicon nitride and electron transparent. Electrical E-chips with holes in the silicon nitride are also available. When using E-chips with holes, the sample should span a hole to maximize electron transparency for optimal resolution in the TEM.

Figure 5. Light microscope images of the silicon nitride membrane area on an electrical E-chip. In the top image the triangular shaped features are metal contact pads that were lithographically patterned onto the membrane. The bottom image shows a close up of the same type of pattern but with an array of holes in the center.

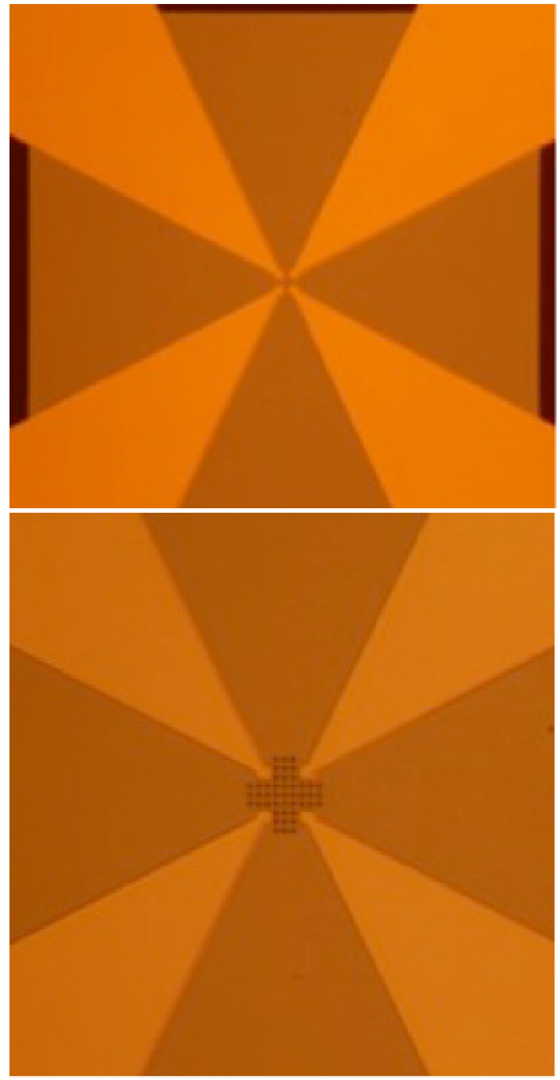


Figure 5.

1. INTRODUCTION

The Protochips Fusion Platform offers advanced capabilities for in situ electrical characterization with four modes of operation including current-voltage (I-V), four-point probe and DC current and voltage biasing. In situ thermal characterization can be performed at temperatures up to 1200 °C with programmable or manual modes of operation. This software manual describes the modes of operation, and software features that enable custom, individualized heating and electrical biasing experiments.

2. STARTING THE FUSION PROGRAM

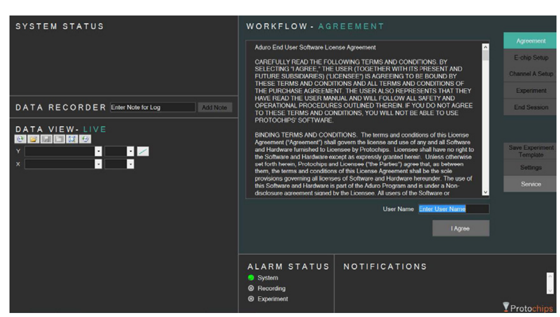
To launch the program double click on the Fusion icon located on the desktop:

When the software loads, it will attempt to configure the power supply. If the configuration is successful, the message **FUSION INITIALIZED** will display on the screen of the power supply. If the configuration of the power supply is not successful, check to make sure that the power supply is turned ON, the crossover cable is connected between the controller and power supply.

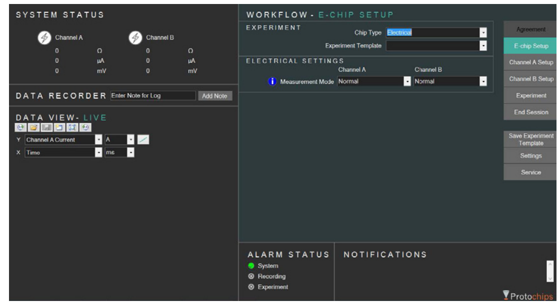
3. AGREEMENT

The first screen that appears after the software launch is the **Agreement** screen.

Please enter your **user name** and then press the **I Agree** button in order to comply with Protochips' terms and conditions. This step will be necessary for every session with Fusion software.



4. E-CHIP SETUP



After agreeing to the terms and conditions the E-chip Setup opens up. Additional modes for experiments are available for upgraded software.

1. This screen allows you to choose your E-chip Type. The options are Electrical, Thermal or ElectroThermal
2. When conducting an Electrical experiment following Experiment Templates can be chosen:

   1. Electrical DC Current Bias
   2. Electrical DC Voltage Bias
   3. Electrical Four Point Probe
   4. Electrical I-V
   5. Browse for a locally saved Template

NOTE: *The custom templates save previous units, channel and waveform setups. This enables you to repeat experiments precisely for validation and quality assessments.*

When performing a **Thermal** experiment either a Temperature Template or a locally stored template can be picked.

The third chip type possibility is **ElectroThermal**. In this setting the following Experiment Templates are available:

1. Electro-Thermal DC Current Bias
2. Electro-Thermal DC Voltage Bias
3. Electro-Thermal I-V
4. Browse for a locally saved Template

NOTE: *A change in the E-chip Setup is only possible in-between sessions and not during. As the E-chip setup has to match the E-chip consumable device, a change during the session is redundant, unless you wish to run a different experiment with a different device.*

5. TEMPLATE OVERVIEW

NOTE: *In case of a Template selection, the necessary adjustments will be pre-loaded by the Fusion software. Changes to the Channel setup loaded by the templates can still be. The custom templates can be used to save customer uses.*

NOTE: *All the parameters measured, are actual measures or calculated results from measurements. No intended stimuli are reported.*

5.1 ELECTRICAL DC CURRENT BIAS

This template is used to apply a current bias to a sample via a constant value, ramp, step or pulse. The parameters that can be measured are time, current, voltage and resistance.

5.2 ELECTRICAL DC VOLTAGE BIAS

This template is used to apply a voltage bias to a sample, via a constant value, ramp, step or pulse. The parameters that can be measured are time current, voltage and resistance.

5.3 ELECTRICAL FOUR POINT PROBE

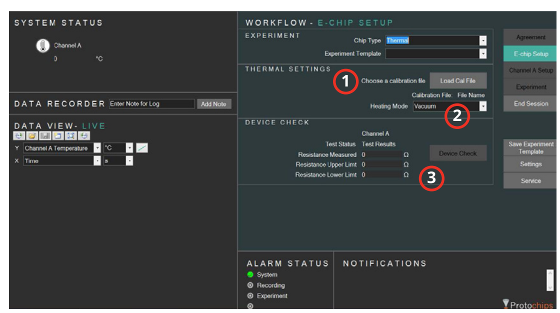
This template uses **Channel A** and **Channel B** to measure the local resistance of a sample, without regarding the rest of the impedance build up in the total resistance. Current is sourced through **Channel A**, and voltage is sensed with **Channel B**. This template eliminates the contribution of contact resistance in the measurement so only the inherent total resistance of the sample itself is measured. Using **Channel A**, a current bias is applied to a sample with a ramp or step. **Channel B** only measures voltage. The software calculates the total resistance in real time and can be plotted in the Data View section.

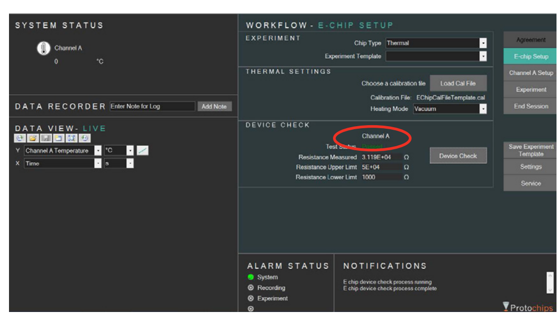
5.4 ELECTRICAL I-V

This template is used to measure the current-voltage characteristics of a sample. It can apply a current or voltage bias to a sample via a constant value, ramp, step or pulse. The parameters that can be measured are voltage, current and resistance. **Channel A** or **B** can source and measure current or voltage independently. As a result the lowest current evoking a stable resistance can be determined.

6. THERMAL EXPERIMENTS

1. Before the start of every Fusion software session you have to load a locally stored calibration file.
2. When conducting a thermal experiment two Heating Modes are available, **Vacuum** and **Environmental**. In order to use the **Environmental Heating** Mode, a closed loop chip with a closed loop calibration file has to be used.
3. As a last step a **Device Check** has to be performed. The check will be passed, when the E-chip has been loaded correctly and that the sample preparation will not affect the heating profile.



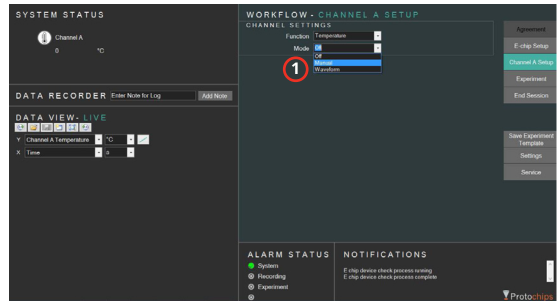


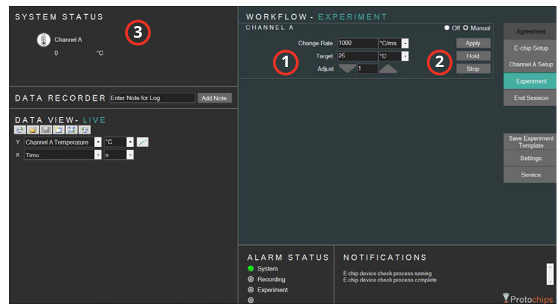
6.1 MANUAL MODE

The manual mode of the Fusion software executes individual temperature changes to the heating membrane on a thermal E-chip

Choose **Manual** in the dropdown menu in order to proceed with a session executing individual temperature changes.

1. In Manual mode you are free to set a **Target Temperature** and a **Change Rate**, which will function as a ramp.
2. Once the desired settings are appointed the stimuli can be started by clicking the **Apply** button. During the experiment a stimuli can be **hold** at a certain level by pressing Hold. The experiment will be continued by pressing **Resume** at any time. The **Stop** button will end stimuli to the chip and the data logging of the experiment.
3. The **System Status** informs you of the current state of your session.

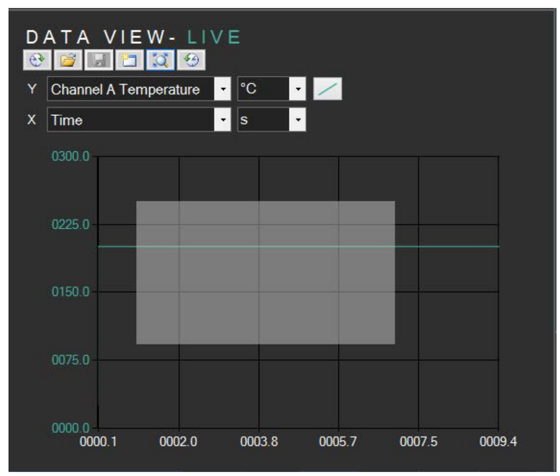




6.1.1 DATA VIEW

This feature allows you to interact with a graph illustrating the progress of your session. You are free to choose the desired dimension and unit for the **X** and **Y** axis.

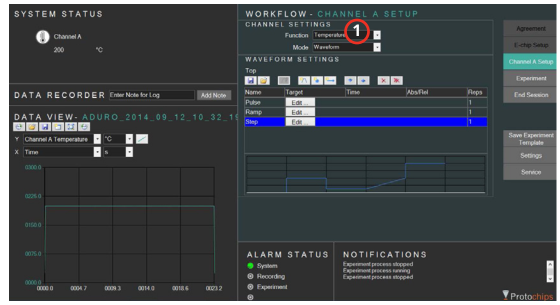
1. Data View gives you the option to zoom into the graph by a left click and drag with your cursor. In order to go back to the full graph click the Zoom Extends button  located above the graph.
2. In order to compare up to three different sections of the graph, press the New Window button 



After every session Fusion software creates a log file marked with the current time and date. When exiting the software you will be asked which files are supposed to be deleted and which to be saved.

NOTE: *Notes allows you to add entries to your log file. Please keep in mind that notes added after the stimuli have been stopped will be attached to the next experiment.*

6.2 WAVEFORM



This mode allows you to create and execute custom, pre-programmed piecewise temperature changes to the heating membrane on a thermal E-chip. After a program plan is created, you can run the plan without interruption and save it for later use. Program plans can also be saved, loaded, and run repeatedly. After choosing **Waveform** in the dropdown menu, the **Top Level Waveform Settings** are loaded

1. In the Top Level the Add Waveform button gives you the option to choose from following forms:
   1. Pulse
   2. Ramp
   3. Step
   4. Custom
   5. Browse...

Pressing the **Add Point** button allows you to include those into your session. Pressing the **Add End Point** allows you to insert either a **Hold** or a **Stop** point to your experiment

With the **Move Up** and **Down** buttons you can change the sequence of the forms

Also you can delete the selected or all forms in the Top Level Setting by pressing .

After selecting the desired forms you can set the wanted number of repetitions.

In order to specify a Waveform click the **Edit** button Edit ... next to the waveform.

Customized sequences of Waveforms can be saved locally and be reused in following experiments.

At the **Waveform level** you can adjust certain variables of each form according to a target parameter and timeframe.

Pulse: This waveform allows you to define a target high and low, which can be specified by a high and low hold time

1. Rise: Defined Target High
2. High: Defined High Hold Time
3. Fall: Defined Target Low
4. Low: Defined Low Hold Time

Ramp: This waveform allows you to define a target high and a low target time

1. Begin: Defined Target High
2. End: Defined High Hold Time

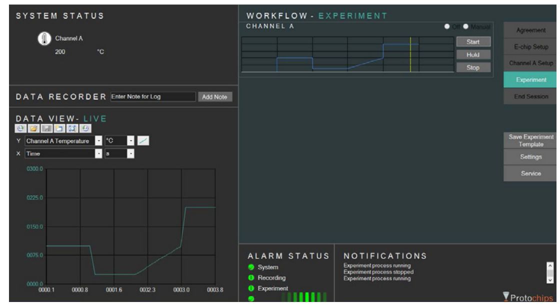
Step: This waveform allows you to define a high target and a high hold time

1. Rise: Defined Target High
2. Run: Defined High Hold Time

> **NOTE:** *Each variable can be set as an absolute value or a relative value, which takes the delta to the last measurement.*

In order to return to the **Top level** click on , Top > located under the **Waveform Settings**.

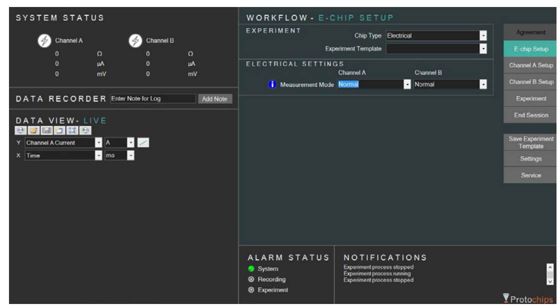
The same **Apply, Hold/ Resume, Stop** and **log file functions**, as in the **Manual Mode** apply when the experiment is started. A thick yellow bar indicates the progress of each session.



7. ELECTRICAL EXPERIMENTS

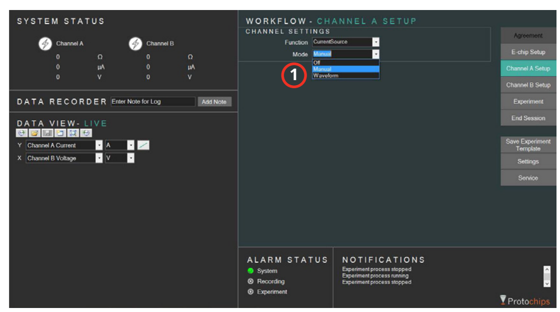
After choosing the Electrical Setup for the E-chips, you can select different **Measurement Modes for Channel A** and **B**.

1. High speed (25 ms): Shortest sampling rate, best for ultra-fast transitions
2. Normal (100 ms): An optimized combination of short sampling rates and high accuracy, best for most applications. This includes little AC integration and a little settle time.
3. High accuracy (500 ms): Longest sampling rate, best for nanoamp/ picoamp measurements. This includes a full AC integration period and an extended settle time between measurements.



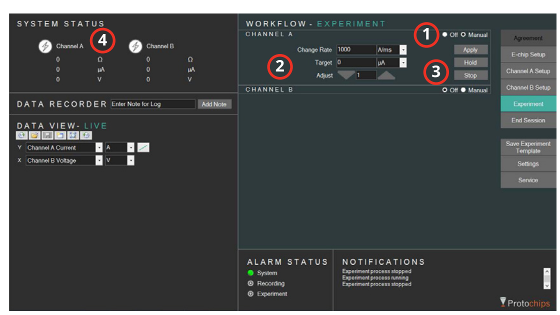
1. The **Electrical mode** also offers the options to run a **Manual** or a **Waveform** experiment

The setup for **Channel A** is identically to the **Channel B** Setup.



7.1 MANUAL MODE

To adjust settings in the **Manual Mode** please select the **Experiment** tab.



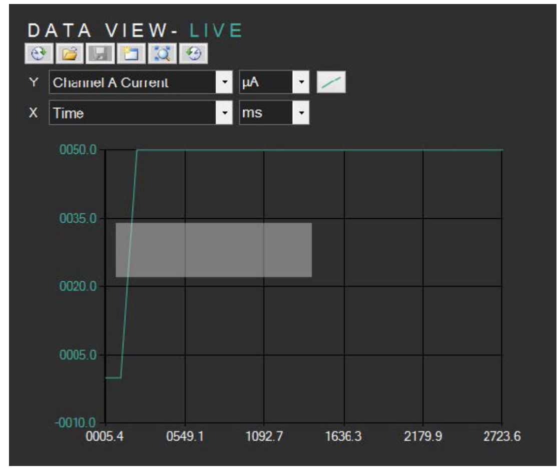
1. In order to use **Channel A** or **B** in the session select **Manual**, if you wish to just use on Channel put the other one on **Off**

2. In Manual mode you are free to set a **Target Stimuli** and a **Change rate**, which will function as a ramp.

3. Once the desired settings are appointed the stimuli can be started by clicking the **Apply button**. The experiment can be **Hold** and **Resumed** at any time. The **Stop button** will end any kind of stimuli. The **All Channels** tab allows you to interact with both channels simultaneously.

4. The **System Status** informs you of the current state of your session.

7.1.1 DATA VIEW



This feature allows you to interact with a graph illustrating the progress of your session. You are free to choose the desired dimension and unit for the **X** and **Y** axis.

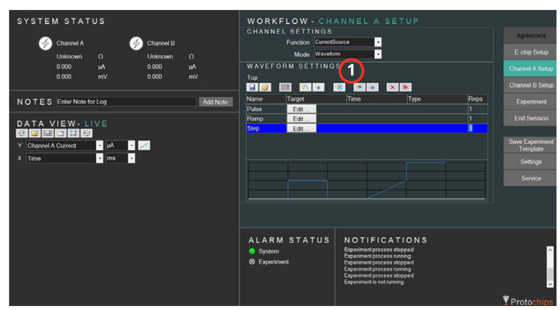
1. **Data View** gives you the option to zoom into the graph by a left click and drag with your cursor. In order to go back to the full graph click the **Zoom Extends** button  located above the graph.

2. In order to compare up to three different sections of the graph, press the **New Window** button 

After every session Fusion software creates a log file marked with the current time and date. When exiting the software you will be asked which files are supposed to be deleted and which to be saved.

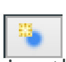
> **NOTE:** *Notes allows you to add entries to your log file. Please keep in mind that notes added after the stimuli has been stopped will be attached to the next experiment.*

7.2 WAVEFORM



This mode allows you to create and execute custom, pre-programmed piecewise temperature changes to the heating membrane on a thermal E-chip. After a program plan is created, you can run the plan without interruption and save it for later use. Program plans can also be saved, loaded, and run repeatedly. After choosing **Waveform** in the dropdown menu, the **Top Level Waveform Settings** are loaded

1. In the **Top Level** the **Add Waveform** button  gives you the option to choose from following forms:
   1. Pulse
   2. Ramp
   3. Step
   4. Custom
   5. Browse....

   Pressing the **Add Point**  button allows you to include those into your session. Pressing the **Add End Point**  allows you to insert either a **Hold** or a **Stop** point to your experiment

   With the **Move Up** and **Down** buttons  you can change the sequence of the forms

   Also you can delete the selected or all forms in the Top Level Setting by pressing 

In order to specify a Waveform click the **Edit button** [Edit ...] next to the waveform.

Customized sequences of Waveforms can be saved locally and be reused in following experiments.

At the **Waveform level** you can adjust certain variables of each form according to a target parameter and timeframe.

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Ramp: This waveform allows you to define a target high and a low target time

1. Begin: Defined Target High
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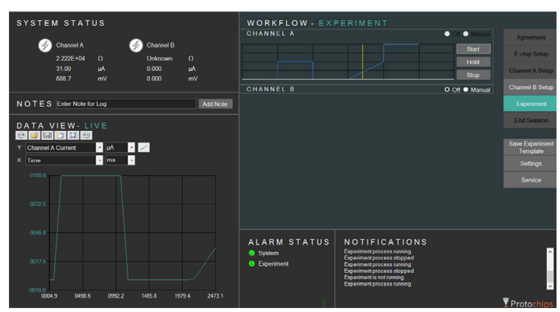
Step: This waveform allows you to define a high target and a high hold time

1. Rise: Defined Target High
2. Run: Defined High Hold Time

> **NOTE:** *Each variable can be set as an absolute value or a relative value, which takes the delta to the last measurement.*

In order to return to the **Top level** click on [Top >] , located under the **Waveform Settings**.

The same **Apply, Hold/ Resume, Stop** and **log file functions**, as in the **Manual Mode** apply when the experiment is started. A thick yellow bar indicates the progress of each session.



8. ELECTRO-THERMAL EXPERIMENTS

In the **Electro-Thermal Setup** you can apply temperature to the sample using **Channel A**, and a voltage or current bias can be applied and measured with **Channel B** independently or simultaneously. The impedance of a sample can be monitored over different temperature ranges.

Channel A has to be set up according to the three steps named in **Chapter 6.1 Manual Mode**

Channel B has to be set up according to **Chapter 7.**

TROUBLESHOOTING

Note: Advanced troubleshooting instructions can be found online at: Success.Protochips.com

Q: Thermal E-chip device check failed.

A: If resistance is too high: A high resistance indicates a possible open circuit in the platform or foreign material impeding performance. Possible solutions to this problem are as follows:

1. Check to make sure that the cable is properly connected to the holder and the power supply as described in the user manual.
2. Check that the membrane is still intact with a stereoscope, microscope or magnifying glass. If the membrane has ruptured, select another E-chip and check the resistance again.
3. Check to make sure that the contact points of the holder are in contact with the contact points of the E-chip. If not, adjust the position of the E-chip or gently bend the contacts to the correct position.

A: If resistance is too low: A low resistance indicates of a short or shunt in the device. This is usually caused by a conductive sample that shorts the electrodes of the E-chip and provides low resistance path. Conductive samples must always be limited to the center of the membrane. Thin film samples should be deposited with a shadow mask. If a conductive sample is to be used with a thermal E-chip, the resistance of the E-chip should be checked before and after the sample has been deposited. If the resistance changes, the E-chip calibration will be less accurate. Other sample preparation methods should then be considered.

Q: The holder does not hold vacuum in the column or in the pre-pump stage.

A: See the “Holder Care” section of the user manual.

Q: The image becomes blurry as I increase the temperature. There is noise in the image and FFT.

A: Noise can be introduced into the platform if the controller or power supply is not connected to the same electrical ground as the microscope. This causes the blurred/noisy images at higher temperatures. The controller or power supply must share a common ground with the microscope to ensure proper performance of the platform. Power cables that are longer than 10 feet are also not recommended.

Q: Image instability appear during the experiment.

A: Image instability can occur if the cables are not properly secured to the same vibration isolation system as the TEM column. This can cause distinct vibrations that show up during imaging, and can significantly degrade the resolution of the instrument. Some instruments have a metal clip where the cable can be clipped in near the goniometer. If your TEM does not have a clip, you can use tape to secure the cable directly to the column of the TEM. Ensure that the cable has sufficient slack so the goniometer can move freely and not strain the connection.

Q: I can’t find the transparent area of the E-chip when I insert the holder into the TEM.

A: On some instruments the transparent area of the E-chip does not fall directly in line with the observable area in the TEM, and you must move around to find the area. First ensure that the objective and selected area apertures are removed. Decrease the magnification as much as possible, and make sure the beam is sufficiently spread. If the transparent area does not appear, slowly move the stage in concentric circles outward and the transparent area should appear.

HOLDER CARE

Cleaning the Fusion holder should be a part of regularly scheduled holder maintenance to ensure the platform is working at its optimal performance.

1. Plasma Cleaning

Plasma cleaning is a common method for cleaning organic materials from the holder tip. Fusion holder is fully compatible with commercial plasma cleaners and should be plasma cleaned on a regular basis. The more the holder is used, the more it should be cleaned. Generally 5 to 15 minutes in argon and/or oxygen plasma should suffice. It is also recommended that the holder be stored under vacuum when not in use.

NOTE: *Plasma cleaning carbon-coated E-chips, depending on the power of the plasma cleaner, should be limited to 10s of seconds. Electrical and electrothermal E-chips can be plasma cleaned for longer durations.*

2. Cleaning The Holder Tip

The probe contacts and E-chip pocket should be cleaned on a regular basis to ensure proper performance. They can be cleaned using the following procedure.

1. Using canned air, spray the tip of the holder to remove any loose particles.
2. Sonicate the tip of the Fusion holder in Ethanol or Isopropyl Alcohol for 3 minutes.
3. Allow the tip of the holder to dry.
4. Inspect the E-chip pocket and the probe contacts under a stereoscope to verify that the tip is clean and free of particles.

In addition to the alcohol cleaning (above), a plasma cleaner may also be used remove contamination from the tip of the holder.

3. O-rings

The external O-rings of a TEM holder provide the vacuum seal while the holder is in the microscope. If the pumping system is taking longer than normal to achieve the proper vacuum level when the holder is in the exchange/pre-pump position or when inserted in the column, it may be an indication that the O-rings need to be cleaned, re-greased or replaced. Use the following procedure to clean and re-grease them.

1. Inspect the O-rings under a stereoscope or with a magnifying

glass to check for debris and fibers that has stuck on the O-ring or in the O-ring pocket.

2. Gently remove debris with carbon tweezers.

3. Using vacuum grease that is specifically designed for TEM O-rings, apply a very thin coating to the O-ring. This application can be done by placing a small dollop of grease on a gloved finger, or directly on the O-ring, and spreading the grease with the gloved finger. Do not apply vacuum grease with metal tweezers, because sharp edges can damage the O-ring. Wipe up excess grease.

NOTE: *If the O-rings need to be replaced, do not use metal tweezers to pry out O-ring from the pocket. A piece of thin bamboo (such as a skewer) or plastic should be used. This will not scratch the metal.*

NOTE: *Do not touch the holder on or passed the O-ring (towards the holder tip) without clean gloves. Touching the holder in this area, and especially at the tip, can cause contamination in the microscope, and reduce the performance of the holder and microscope.*