

Automating Your Asylum Research AFM with the MacroBuilder Interface

Asylum Research

Introduction

Asylum Research provides full-function **MFP-3D™** and **Cypher™** Atomic Force Microscopes (AFMs) with superior capabilities that require no programming to perform advanced imaging and measurements. For more advanced, automated, and custom experiments, Asylum also provides a user-driven programming language called IGOR Pro. The **MacroBuilder™** interface allows you to easily set up and run a sequence of measurements unattended while automatically varying parameters – and without writing any code. The MacroBuilder interface is provided as a standard capability on all MFP-3D and Cypher AFMs.

Do you find yourself doing repetitive measurement tasks with your AFM? Would you like to systematically repeat a sequence of measurements, or run lengthy experiments, while varying parameters like the setpoint, tip bias or other parameters? Would you like to make a series of survey scans, force curves, I-V curves or other measurements? And would you like to perform all of these functions automatically – unattended and without requiring user intervention?

While programming can be a daunting task for the novice, our MacroBuilder interface allows you to easily implement IGOR Pro customization like a pro by simply dragging MacroBuilder “Modules” together to form macros that can automate many measurements and analyses. Automation can range from

simple tasks where you might want to make a sequence of measurements – say a series of images with different setpoints or a series of force curves at different positions on a sample – to more sophisticated procedures where, for example, you want to make a measurement and then, depending on the outcome, change settings for your next measurements. An additional benefit is that automated data acquisition can vastly improve throughput and even increase repeatability by removing arbitrariness from the imaging and measurement process. The options are virtually unlimited. No other AFM system offers this kind of powerful programmability with an easy-to-use interface. MacroBuilder is another example of the power and flexibility of Asylum Research AFMs.



Figure 1: Standard MacroBuilder “Modules” available to users. These Modules can be combined in any number of ways to automate measurements by simply dragging and dropping the Modules into a MacroBuilder Macro sequence. Advanced users can create their own Modules or work with our programmers to develop new Modules.



The Business of Science®

Automating Your Asylum Research AFM with the MacroBuilder Interface

MacroBuilder Modules

Each Module performs a specific operation, such as moving the tip to a position, collecting thermal data, or displaying the next saved force plot. These Modules are functions written by Asylum in IGOR Pro and are represented by the icons on the MacroBuilder panel. There are currently over 50 MacroBuilder Modules included standard in the Asylum Research software (Figure 1). You can also write Module functions yourself, combine your Modules with Modules we supply, and save your Modules for future use. More details can be found in the online “Writing Modules” help file in the Asylum Research software.

Example – Automated Scan Box Creation on a Ferroelectric Sample

A common, “smoking gun” test for ferroelectricity in a Piezoresponse Force Microscopy (PFM) measurement is to scan a region at a positive bias, scan a smaller region inside the first at a negative bias, and then image both regions afterwards to see if the PFM image indicates that either region was reversed – if so, then the sample is therefore ferroelectric. In the following series of images, we will go through setting up this simple Macro step-by-step.

Figure 2 shows the MacroBuilder panel where a simple series of measurements were programmed to first create, and then image, a PFM scan box.

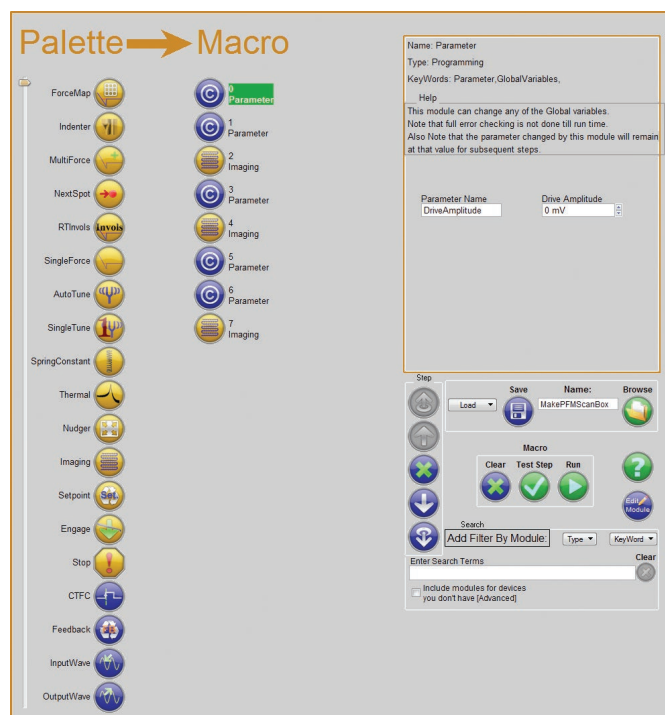


Figure 2: Automated Piezoresponse Force Microscopy (PFM) lithography and testing using MacroBuilder.

The “Palette” lists the currently available Modules – note that the scroll bar on the far left is used to display the additional Modules. The first step is to drag Modules from the Palette list on the left to the Macro list. Here, we have included “Parameter” and “Imaging” Modules. In the Macro list (Figures 2 and 3), the Module which is being programmed is highlighted in green. The right side of the panel contains information about that module and various user-programmable variables. Figures 3a through 3i illustrate the individual steps for setting up the Macro.

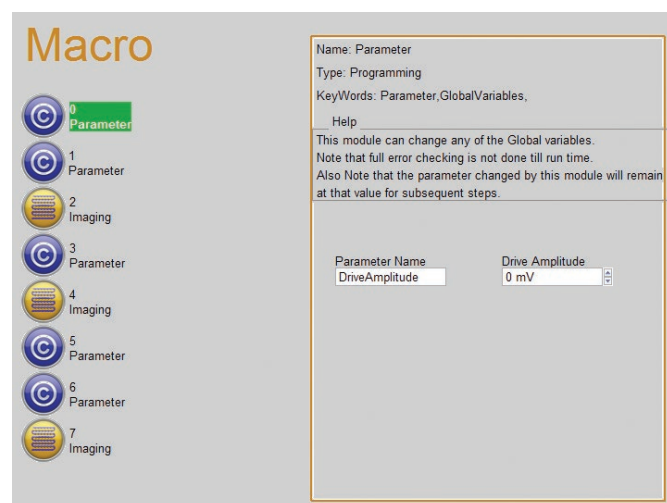


Figure 3a: Step 0, set the drive amplitude to zero. We will apply only a DC voltage during the biasing steps.

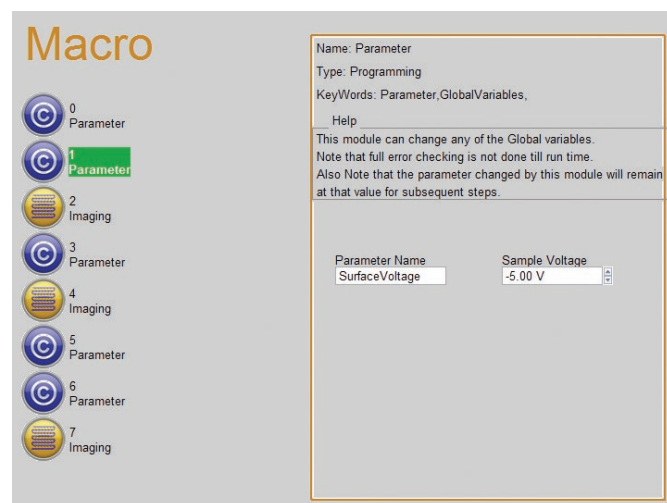


Figure 3b: Step 1, set the bias voltage on the surface to -5 V. This should reverse the polarity of the ferroelectric material in one direction so that we can image at the predefined bias voltage.

Automating Your Asylum Research AFM with the MacroBuilder Interface

Macro

0 Parameter
1 Parameter
2 **Imaging**
3 Parameter
4 Imaging
5 Parameter
6 Parameter
7 Imaging

Name: Imaging
Type: RealTime
Keywords: Scan,Image
Help
This will scan an image. If a "use checkbox" is turned off, the parameter to the right it will not be applied to the scan. So the scan will use whatever value is currently entered in the main interface for that parameter. The last frame is finished with a "last scan", so it will leave it in contact with the surface, or withdraw, based on your settings.

Number Of Frames: 1
Start 1st frame: Scan Down
Scan Size: 4.00 μm
X Offset: 0 nm
Y Offset: 0 nm
Setpoint: 1.000 V
☒ Use this Scan Size
☐ Use this X Offset
☐ Use this Y Offset
☐ Use this Setpoint

Figure 3c: Step 2, make a 4 μm scan.

Macro

0 Parameter
1 Parameter
2 Imaging
3 **Parameter**
4 Imaging
5 Parameter
6 Parameter
7 Imaging

Name: Parameter
Type: Programming
Keywords: Parameter,GlobalVariables,
Help
This module can change any of the Global variables. Note that full error checking is not done till run time. Also Note that the parameter changed by this module will remain at that value for subsequent steps.

Parameter Name: SurfaceVoltage
Sample Voltage: 5.00 V

Figure 3d: Step 3, reverse the bias to +5 V.

Macro

0 Parameter
1 Parameter
2 Imaging
3 Parameter
4 **Imaging**
5 Parameter
6 Parameter
7 Imaging

Name: Imaging
Type: RealTime
Keywords: Scan,Image
Help
This will scan an image. If a "use checkbox" is turned off, the parameter to the right it will not be applied to the scan. So the scan will use whatever value is currently entered in the main interface for that parameter. The last frame is finished with a "last scan", so it will leave it in contact with the surface, or withdraw, based on your settings.

Number Of Frames: 1
Start 1st frame: Scan Down
Scan Size: 2.00 μm
X Offset: 0 nm
Y Offset: 0 nm
Setpoint: 1.000 V
☒ Use this Scan Size
☐ Use this X Offset
☐ Use this Y Offset
☐ Use this Setpoint

Figure 3e: Step 4, make a smaller, 2 μm scan inside the original 4 μm scan box.

Macro

0 Parameter
1 Parameter
2 Imaging
3 Parameter
4 Imaging
5 **Parameter**
6 Parameter
7 Imaging

Name: Parameter
Type: Programming
Keywords: Parameter,GlobalVariables,
Help
This module can change any of the Global variables. Note that full error checking is not done till run time. Also Note that the parameter changed by this module will remain at that value for subsequent steps.

Parameter Name: surfaceVoltage
Sample Voltage: 0 mV

Figure 3f: Step 5, turn off the DC voltage bias.

Macro

0 Parameter
1 Parameter
2 Imaging
3 Parameter
4 Imaging
5 Parameter
6 **Parameter**
7 Imaging

Name: Parameter
Type: Programming
Keywords: Parameter,GlobalVariables,
Help
This module can change any of the Global variables. Note that full error checking is not done till run time. Also Note that the parameter changed by this module will remain at that value for subsequent steps.

Parameter Name: DriveAmplitude
Drive Amplitude: 1.00 V

Figure 3g: Step 6, turn on the drive amplitude for PFM imaging, in this case 1 V.

Macro

0 Parameter
1 Parameter
2 Imaging
3 Parameter
4 Imaging
5 Parameter
6 Parameter
7 **Imaging**

Name: Imaging
Type: RealTime
Keywords: Scan,Image
Help
This will scan an image. If a "use checkbox" is turned off, the parameter to the right it will not be applied to the scan. So the scan will use whatever value is currently entered in the main interface for that parameter. The last frame is finished with a "last scan", so it will leave it in contact with the surface, or withdraw, based on your settings.

Number Of Frames: 2
Start 1st frame: Scan Down
Scan Size: 6.00 μm
X Offset: 0 nm
Y Offset: 0 nm
Setpoint: 1.000 V
☒ Use this Scan Size
☐ Use this X Offset
☐ Use this Y Offset
☐ Use this Setpoint

Figure 3h: Step 7, make a final image at a scan size of 6 μm. In this case, we have chosen to make two final images.

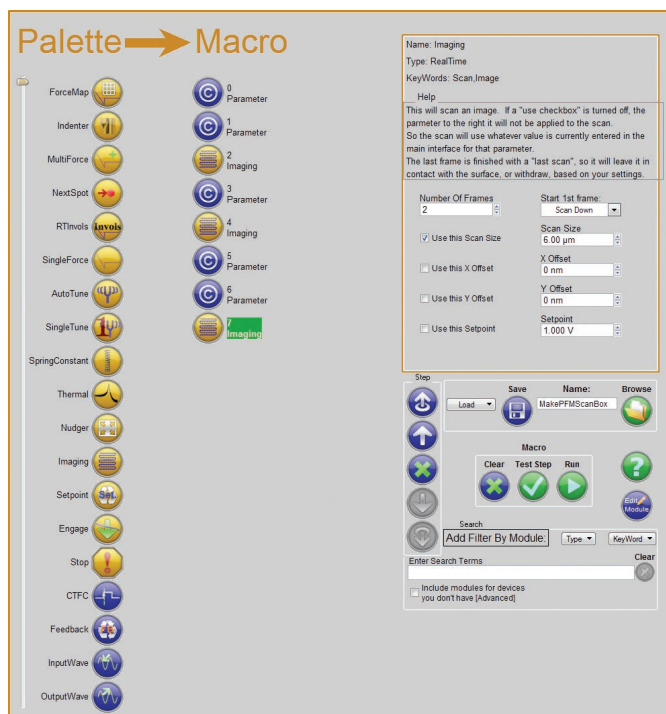


Figure 3i: Step 8, click on the "Run" button to start the Macro. Go grab a snack or take a coffee break...

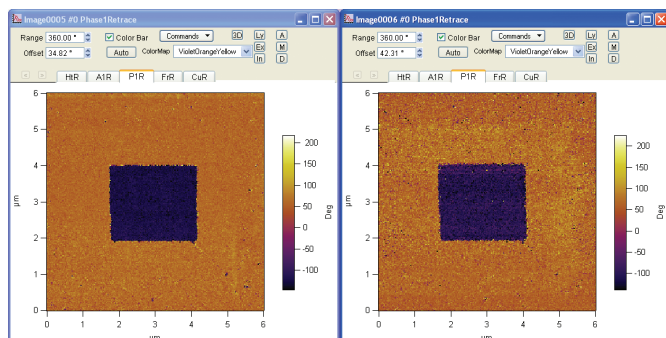


Figure 4: Final result of the PFM scan boxes produced by the Macro illustrated in Figures 3. The results clearly indicate that the material is ferroelectric.

As shown in Figure 4, the results of our MacroBuilder example show that the test material is indeed ferroelectric.

The flexibility of IGOR Pro with Asylum's MacroBuilder capability offers virtually unlimited flexibility for customization. For repetitive measurements with your AFM or for standardizing common tasks, MacroBuilder allows you to quickly and easily setup and perform automated instrument control, data acquisition and analysis.

Limitless Possibilities with MacroBuilder Automation

There are many other examples of automated measurements that can be accomplished with MacroBuilder:

- Variable temperature measurements – step the sample temperature while acquiring sequential images or making other measurements with drift compensation to ensure imaging in the same location.
- Measure hysteresis loops in ferroelectric samples by stepping the voltage and acquiring successive images, or in magnetic samples by stepping the applied magnetic field using one of Asylum's Variable Field Module (VFM2™).
- Stepping from point to point (point locations and sequence defined by the user) while measuring force-distance curves or acquiring I-V (current vs. voltage) curves.

Minimum System Requirements

- Screen resolution 1600 x 1200 minimum
- IGOR Pro v6.12a or later
- Asylum Software v090909+0801 or later

Visit www.AsylumResearch.com to learn more

The foregoing datasheet is copyrighted by Oxford Instruments Asylum Research, Inc. Oxford Instruments Asylum Research, Inc. does not intend the datasheet or any part thereof to form part of any order or contract or regarded as a representation relating to the products or service concerned, but it may, with acknowledgement to Oxford Instruments Asylum Research, Inc., be used, applied or reproduced for any purpose. Oxford Instruments Asylum Research, Inc. reserves the right to alter, without notice the specification, design or conditions of supply of any product or service. Data Sheet 40 – 6/2014.

6310 Hollister Avenue
Santa Barbara, CA 93117
Voice +1 (805) 696-6466
Toll free +1 (888) 472-2795
Fax +1 (805) 696-6444

www.AsylumResearch.com
info@AsylumResearch.com
sales@AsylumResearch.com



The Business of Science®