

## 7.8 Calibration of A Heads for Atomic-Scale Measurement

The A head is the smallest head, with a total travel of approximately 0.4 micron along each axis. Its compact design lends excellent stability for atomic scans, and requires slightly modified X-Y calibration procedures. These modified calibration procedures are detailed in this section. For atomic-scale measurements, graphite atoms are substituted for the pits seen on silicon calibration standards.

1. Prepare the sample.

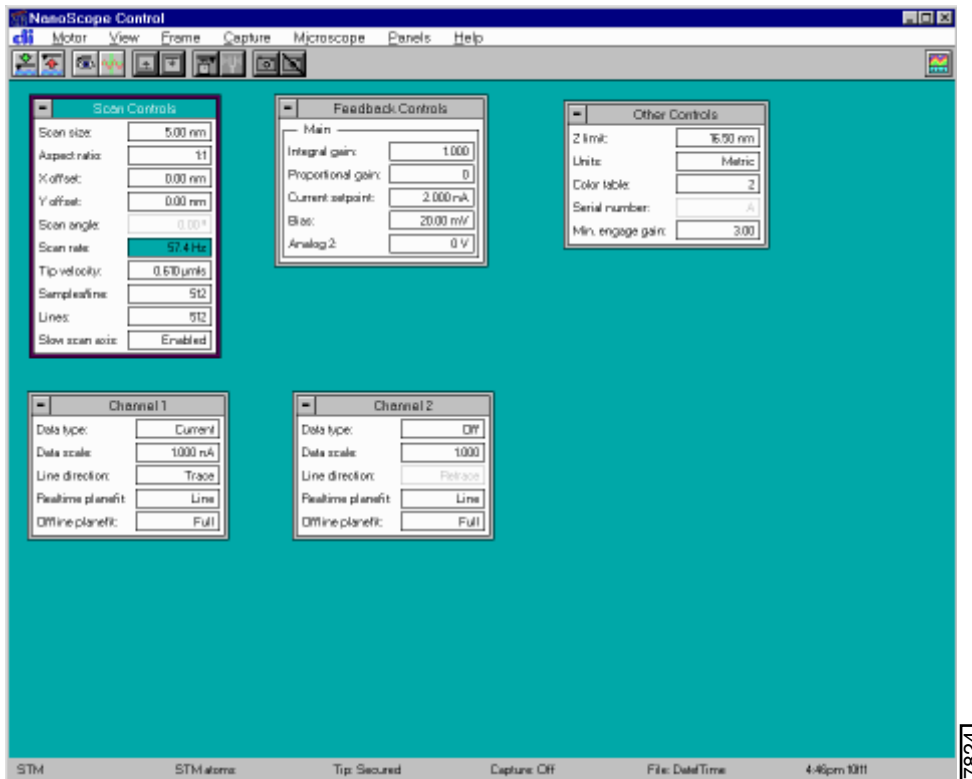
**Note:** Use highly-ordered pyrolytic graphite (HOPG) for STM calibration. See the procedure detailed in Appendix A for cleaving highly-ordered pyrolytic graphite to obtain a good flat surface.

2. Select **Microscope > Profile** to set the microscope to **STM atoms**.
3. Place the sample on one of the bases.

**Note:** A base without X-Y capability will have less drift.

4. Verify the **Real Time** parameter settings for A heads (See [Figure 7.8a](#)).

**Figure 7.8a** Typical A Head Parameter Settings



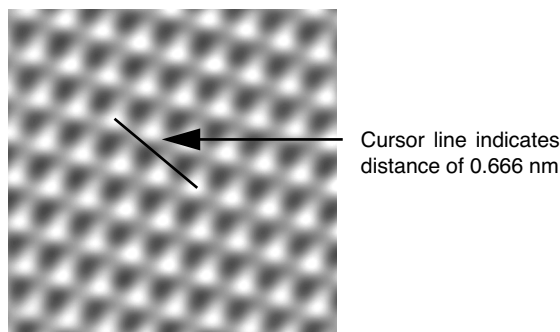
5. Select **Motor > Engage** to engage the surface.
6. Adjust the **Integral gain** and **Setpoint** to obtain a good image in data type current.

**Note:** Keep the **Setpoint** low if possible. Notice that the **Scan rate** is set much higher (up to **61 Hz**) for atomic-scale images to defeat some of the variables due to thermal drift. If you find it difficult obtaining an image, **Withdraw** and try a different site on the surface, then **Engage** again. You may find it easiest to obtain good images and measurements if the sample is rotated until atoms are oriented vertically.

7. **Capture** an image.

**Note:** The image should appear similar to the image of graphite shown in [Figure 7.8b](#). Note the highly regular lattice of the atoms.

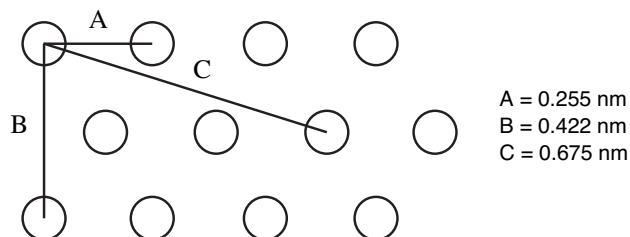
**Figure 7.8b** Atomic-Scale Image of Graphite



8. Select **Offline > View > Top View**.
9. Measure and record the space between a minimum of 10 atoms using the mouse and cursor.

**Note:** The spacings should measure as shown in [Figure 7.8c](#).

**Figure 7.8c** Atomic Spacing for Graphite



10. Record the space between at least ten atoms observed in the captured image.

**Note:** For each axis, measure equal numbers of atoms on consecutive images. For example, on consecutive scans, if the atoms align as in [Figure 7.8c](#), then 10 atoms on the X axis average to 2.55 nm (10 atoms x 0.255 nm) and 6 atoms on the Y axis average to 2.60 nm (6 atoms x 0.433 nm).

Correction of the X- and Y-axis is essentially the same procedure as described in the section on [Fine-tuning for X-Y Measuring Accuracy](#). The only significant difference is that the known distances must be adjusted for the smaller, atomic spacings of the atoms. Furthermore, only the sensitivity parameters are adjusted for atomic-scale imaging.

- X fast sens at 0° Scan angle
- Y slow sens at 90° Scan angle

The derating parameters are not adjusted for atomic-scale imaging, including:

- X fast derate
- X slow derate
- Y fast derate
- Y slow derate
- Retracted offset der
- Extended offset der

Complete the following procedure to adjust the **X Fast Sens** value (See [Figure 7.8d](#)):

1. Divide the theoretical atomic distance by the measured distance and multiply the quotient by the **X Fast Sens** value used when you collected the image.

$$\frac{\text{Known distance between features}}{\text{STM-calculated distance between features}}$$

2. Enter the new **X Fast Sens** value into the **X Slow Sens** field.

Complete the following procedure to adjust the **Y Slow Sens** value (See [Figure 7.8d](#)):

3. Divide the theoretical atomic distance by the measured distance and multiply the quotient by the **Y Slow Sens** value used when you collected the image.

$$\frac{\text{Known distance between features}}{\text{STM-calculated distance between features}}$$

4. Enter the new **Y Slow Sens** value into the **Y Fast Sens** field.

Figure 7.8d Scanner Calibration Panel

Scanner Calibration Panel

Serial number: 0

X fast sens:	33.34 nm/V	Y fast sens:	30.00 nm/V
X fast derate:	0.01987 nm/V <sup>2</sup>	Y fast derate:	0.02000 nm/V <sup>2</sup>
X slow sens:	35.00 nm/V	Y slow sens:	36.20 nm/V
X slow derate:	0.02000 nm/V <sup>2</sup>	Y slow derate:	0.02111 nm/V <sup>2</sup>
Xs-Yf coupling:	0.03000 nm/V <sup>2</sup>	Ys-Yf coupling:	0.03000 nm/V <sup>2</sup>
Xs-Yf coup der:	0.01000 pm/V <sup>3</sup>	Ys-Yf coup der:	0.01000 pm/V <sup>3</sup>
Xs-Yf coupling:	0.005000 nm/V <sup>2</sup>	Ys-Xf coupling:	0.005000 nm/V <sup>2</sup>
Xs-Yf coup der:	0.000 pm/V <sup>3</sup>	Ys-Xf coup der:	0.000 pm/V <sup>3</sup>
X offset sens:	35.00 nm/V	Y offset sens:	30.00 nm/V
Fast mag0:	0.750	Slow mag0:	0.750
Fast mag1:	0.250	Slow mag1:	0.350
Fast arg:	2.50	Slow arg:	2.50
Fast arg derate:	0.00 1/V	Slow arg derate:	0.00 1/V
Fast cal freq:	2.44 Hz	Slow cal freq:	4.77 mHz
Piezo cal:	440 V	Rounding:	0.00
Allow rotation:	Disallow	Orthogonality:	0.00 †
Minimum scan rate:	0.100 Hz		

Annotations:

- ① Calculate the X Fast Sens value (pointing to X fast sens: 33.34 nm/V)
- ② Enter the X Fast Sens value into the X Slow Sens field (pointing to X slow sens: 35.00 nm/V)
- ③ Calculate the Y Slow Sens value (pointing to Y slow sens: 36.20 nm/V)
- ④ Enter the Y Slow Sens value into the Y Fast Sens field (pointing to Y fast sens: 30.00 nm/V)

Buttons: Ok, Print, Cancel