Scanning parameter adjustment

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Introduction

There are several parameters we should consider during the STM scanning.
This document briefly summarizes the basic idea of determining the parameters.

The parameters may differ depending on the tip conation, sample quality, and STM system.
You may need much experience adjusting the parameters.

The method in this document is just a basic idea, so you may need to establish your way based on your experience.

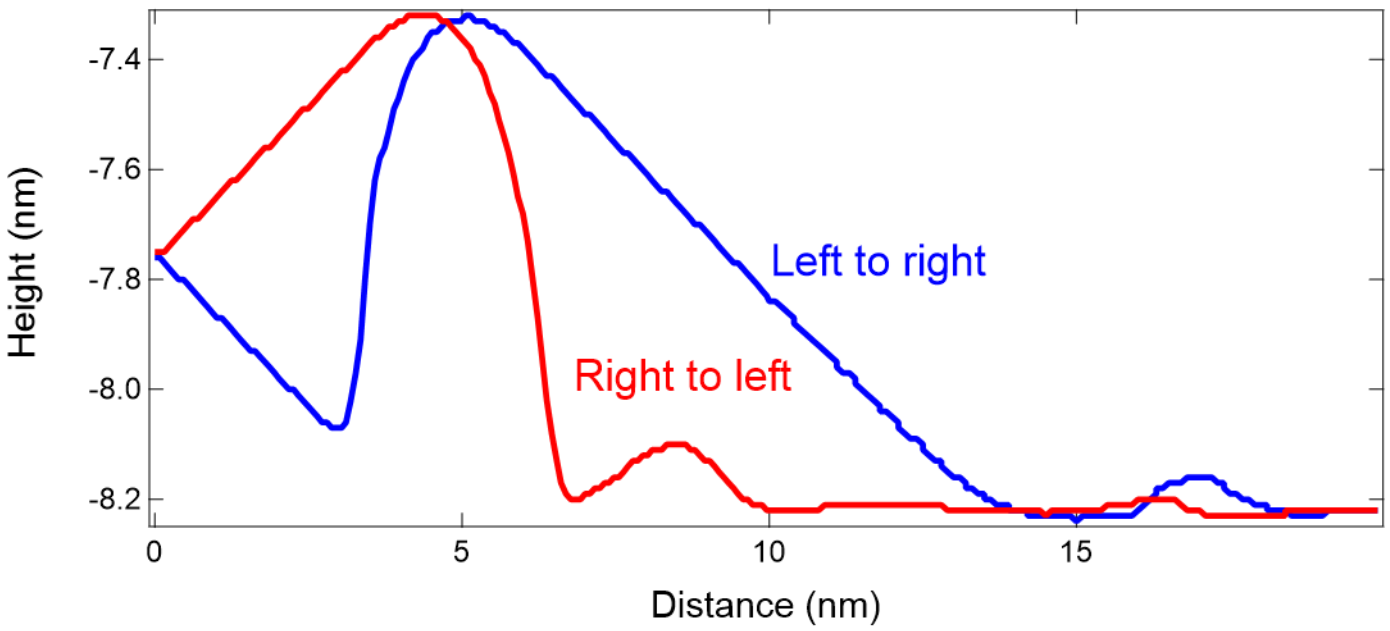
Time constant and gain

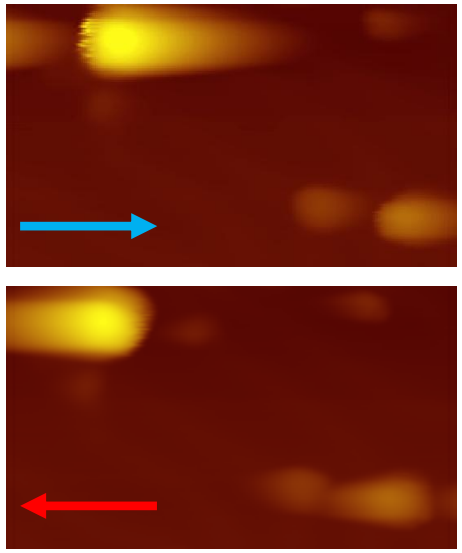
Time constant and gain are the parameters for the feedback loop.
Practically, remember: High gain and low time-constant = **Strong** feedback
Low gain and high time-constant = **Weak** feedback

Strong feedback means:
The tip height is sensitive to the feedback signal (tunneling current).
Therefore, the tip height strongly follows the sample topography.
Instead, it is also sensitive to the noise, sometimes making the tip height unstable.
Weak feedback means:
The tip height is less sensitive to the feedback signal.
Therefore, the tip height weakly follows the sample topography.
Instead, it is strong against noise.

The feedback should be strong enough to follow the surface, but it is better to be weak to avoid noise or instability.

How to judge feedback parameters?



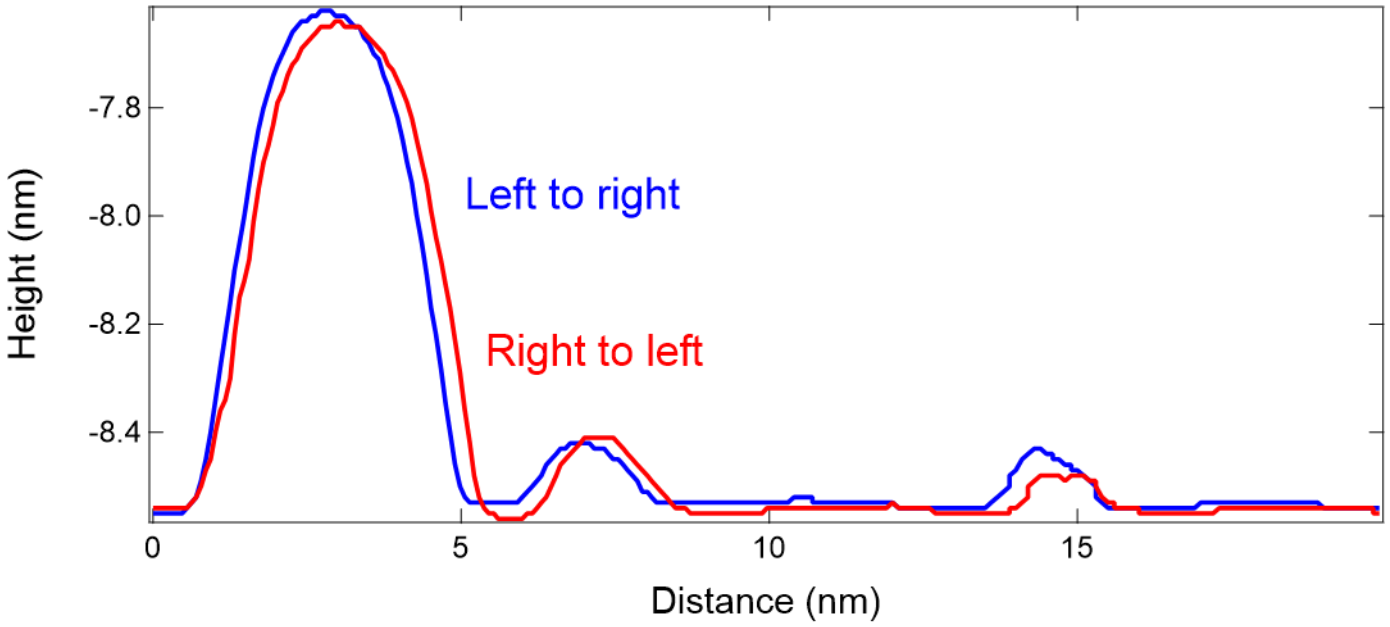


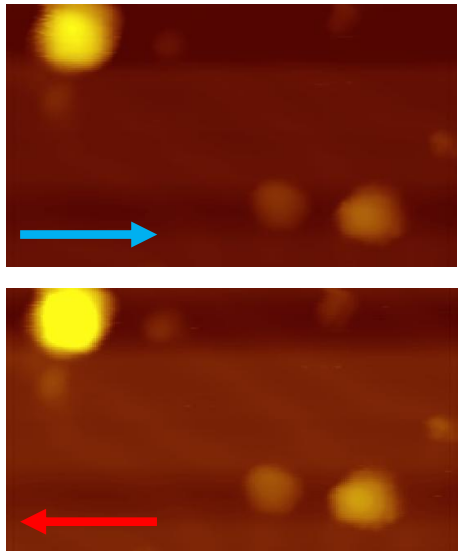
Weak feedback

・Forward and backward scans do not overlap

・The feature in the image extends on one side, depending on the scan direction

→Stronger feedback or a slower scanning speed is needed.





Good feedback

・Forward and backward scans almost match

・No clear noise or instability.

Scanning speed

Scanning speed is strongly relevant to the feedback condition.
Even when using weak feedback conditions, the tip can follow the surface if scanning is slow.

Instead, slow scanning is time-consuming, and the image is strongly affected by the thermal drift.

Therefore, the fastest scan in good feedback conditions is the best.
When scanning a large area, a slow scan is recommended to avoid an accidental crash.

Bias and current

The simple function of bias and current change is to **adjust the tip-sample distance**.

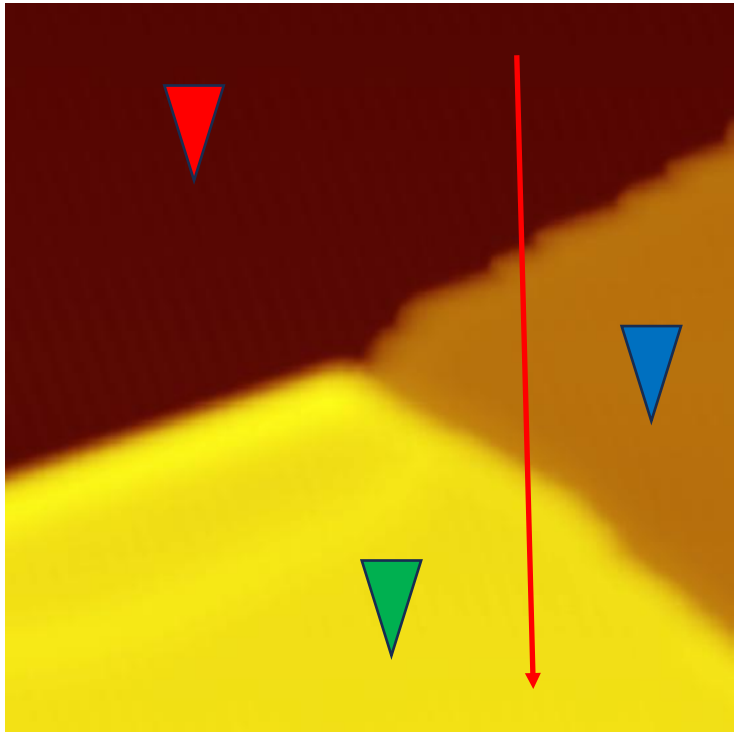
To get an **atomic resolution**, **high current** and **low bias** are recommended, as the closer tip-sample distance results in high resolution.

For a **safety scan**, a **low current** and **high bias** are recommended, where the tip-sample is relatively far.

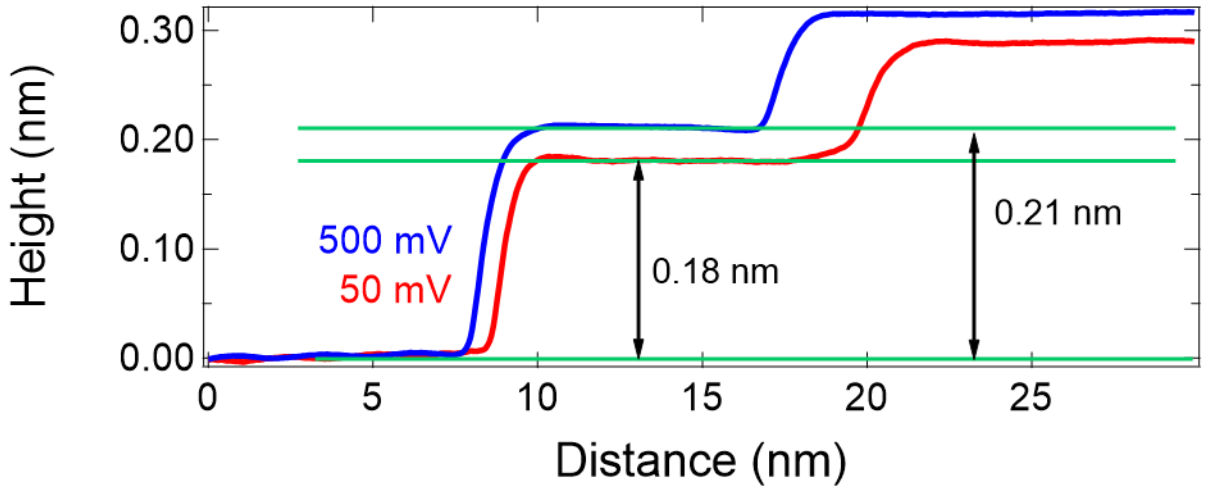
However, when changing these parameters, a detailed inspection is necessary, especially for bias.
Bias not only changes the distance but also affects which electronic state is involved in tunneling.
The appearance and apparent height may change due to the bias change (see next page).
Conversely, the bias-dependent change is sometimes compared with the theoretical calculations.

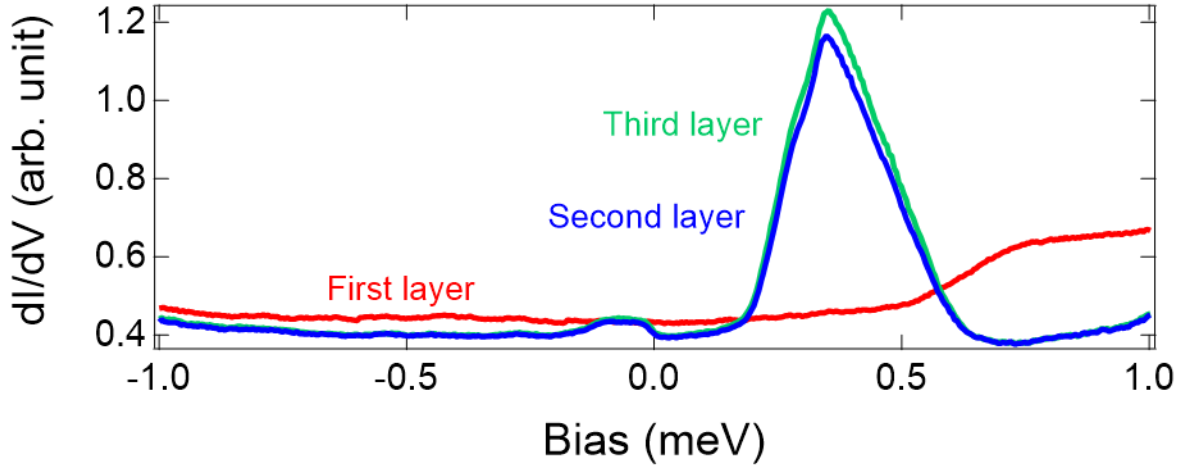
Therefore, it is recommended to get the important image with several different biases to check how the image is affected by the bias.

Bias and current



STM image of Bi/Au(111) (50 mV)





We get the STM image in the same area with two different biases (50 and 500 mV).
The line profile indicates the step height change, due to the large density of states at ~400 mV in the second and third layers.

Note that the step height between different materials in STM can differ depending on bias, so the height difference is not very reliable information in STM.