特集 17
研究速報

Two Dimensional Positioning Control using a Crystal as the Reference

結晶を基準に用いた2次元位置決め制御

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1. Introduction

A scanning tunneling microscope (STM) 1) was used to monitor the movement of a crystal attached on an XY sample stage and used for its positioning control in the lateral direction2). The note explains recent results obtained for a two degree of freedom positioning.

2. Experimental

Graphite was used as the reference crystal. A home built STM was put to operation is air. Figure 1 depicts the schematic of the lateral position controller. After confirming a relatively good atomic resolution image, the lateral position of the XY sample stage was modulated in the X and Y directions consecutively with an amplitude of 70pm (p-p) at 3.3 kHz. A lock-in amplifier was used to obtain the gradient of the tunneling current. The gradient signal of the tunneling current is integrated and applied to the X or Y piezo in order to maintain zero gradient of the tunneling current. Since positions that give zero tunneling current gradient correspond to features that give the array structure in the image, the control enables positioning of the tip over periodic structures for a long duration of time. We have confirmed tip to atom positioning for more than 15 minutes before lateral drift saturated one of the piezo drive amplifiers.

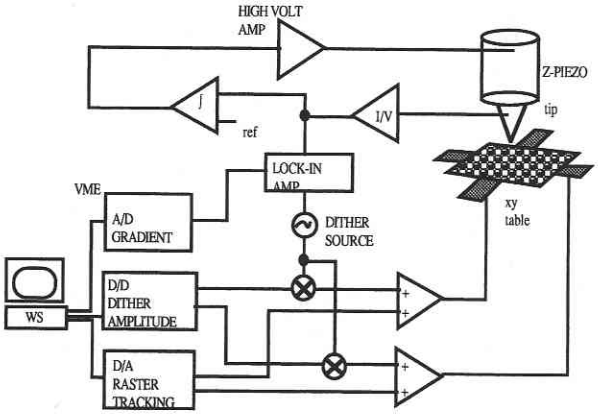

Figure 1　Control circuit for lateral positioning control. The circuit consists of a conventional tunneling current controller and a circuit for lateral position modulation of the sample by a few 10 pm. The measured differential of the tunneling current is used for the lateral control.

For implementing servo tracking of the atomic arrays, imaging of the crystalline lattice was carried out to observe the orientation of the crystal with respect to the XY axis of the XY sample stage. Then, the voltages applied to the X and Y piezos were increased in a step form so that the tip makes a step movement roughly corresponding to the pitch and orientation of the array of atoms that was chosen in the image. The lateral position controller aligns the tip and the atom after every step movement of the sample stage, enabling continued servo tracking of the atomic arrays without accumulative error. Figure 2 shows an example of positioning along an array of atoms. It can be seen

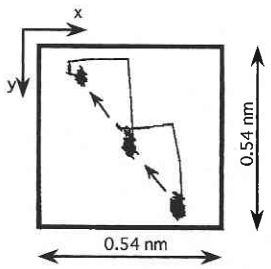

Figure 2　Example of step motion with the tip registered to the lattice.

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in the figure that over shoot of the sample stage is compensated by the lateral position controller. After the tip and an atom is well aligned, the sample stage makes the next stepping action.

3. Conclusions

Using an ordinary STM operating in air, we have demonstrated that lateral position control of the XY sample stage can be implemented using a graphite crystal as the scale reference. We are working on enlargening the excursion of the XY stage to tens of microns. Effects of grain boundaries and atomic steps will be measured and considered in the future.

4. Acknowledgements

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Reference

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