Improvement of stability and speed in liquid-environment atomic force microscopy

学 位 論 文 概 要
Dissertation Summary

学位請求論文（Dissertation）
題名（The title）Improvement of stability and speed in liquid-environment atomic force microscopy
（邦題）（Title in Japanese）液中原子間力顕微鏡の安定性および動作速度の改善

専攻（Division）: Electrical Engineering and Computer Science
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Nanoscale imaging of dynamic processes at solid/liquid interfaces requires high-speed operation of atomic force microscopy (AFM). One of the major efforts that have been made for this purpose is development of high-speed scanners. In spite of the previous efforts, there still remains some room for further development. In this study, I develop a high-speed *Z* tip scanner. *Z* tip scanner is one of the most important components of a high-speed AFM. I propose a high-speed *Z* tip scanner with precisely machined cantilever holding mechanism and counterbalance mechanism.

There are several factors to cause distortion in an AFM image such as creeping, hysteresis and non-linearity of a piezoelectric actuator, and drift of mechanical and electrical components. These factors deteriorate accuracy of an AFM measurement. In this study, I aim to solve this problem by developing a highly sensitive displacement sensor for a closed-loop scanner. I investigated the possibility of using a crystal oscillator in a capacitive displacement sensor. I obtained a preliminary result showing the promising aspect of the proposed sensor design.

With a conventional high-resolution AFM in liquid, we often experience sudden change of an atomic-scale contrast pattern during an imaging. Moreover, atomic-resolution contrasts obtained in one experiment is not necessarily reproduced in another experiment. One of the main reasons for such instabilities and poor reproducibility is ill controllability of tip conditions. Tip apex may be covered with some contaminations. It may also be in a chemically or mechanically unstable state. In this study, I aim to improve the stability and reproducibility of AFM by developing a sophisticated tip preparation process. I found that the stability and reproducibility are improved by coating a tip with Si. In addition, I also investigated the mechanism of the improvement and found out that is due to the formation of a local hydration sites under the tip apex.

In conclusion, the proposed *Z* tip scanner significantly improves imaging speed with true atomic resolution. I introduced displacement sensor using a crystal oscillator to advance the accuracy of AFM. Furthermore,