Comparison of tip-sample distance dependence of normalized frequency shift in two cantilever oscillation modes

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   Non-contact atomic force microscopy (NC-AFM) technique makes it possible to observe a sample surface with atomic resolution [1]. This technique has two types of mode to oscillate a cantilever. One is the constant amplitude (CA) mode, and another is the constant excitation (CE) mode. Recently, Gotsmann and Fuchs reported the computer calculation of the tip-sample distance dependences of frequency shift and cantilever vibration amplitude in the CE mode operation. And they suggested that different types of tip-sample interaction force produce different types of dependences [2]. We have also reported on the fact that these types of dependences should be observed on GaAs(110) surface[3]. In those experiment we have not employed the CA mode operation to perform NC-AFM observation. On the other hand, Schirmeisen et al. reported the normalized frequency shift [4] curve for CA and CE mode in the case of HOPG surface observation [5] and they showed that these curves are identical within noise level. In this report, we discuss the tip-sample distance dependence of normalized frequency shift on Si(111)-7x7 surface and GaAs(110) surface observation by NC-AFM using CA and CE mode operation.

   Figure 1 shows the normalized frequency shift curve using CA (filled square) and CE (filled circle) mode with fitted line of van der Waals force (dash-dots line) on Si(111)-7x7 surface. The tip-sample distance d = 0 nm was defined by curve fitting with van der Waals force. The distance where tip feels the short-range force is less than 2 nm in CE mode even if it is less than 1.5 nm in CA mode. It is noted that the corner holes were observed at these tip-sample distance in both operational modes. There is a clearly difference of tip-sample distance dependence in two mode operation. We will also discuss the tip-sample distance dependence of normalized frequency shift on GaAs(110) surface where the tip feel the hysteretic conservative force [3].
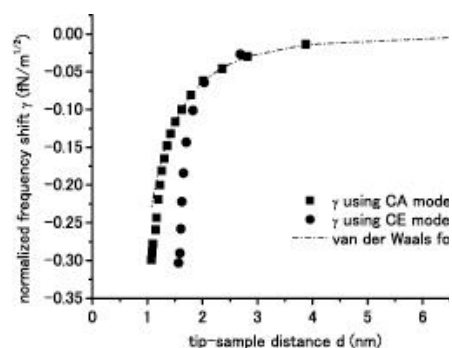

Figure 1: tip-sample distance dependence of normalized frequency shift in CA (filled square) and CE (filled circle) mode on Si(111)-7x7 surface.

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