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Adaptive Q control for Tapping-mode Nano-scanning Using a Piezo-actuated Bimorph Probe

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A new approach, called Adaptive Q-control, for tapping-mode Atomic Force Microscopy (AFM) is introduced and implemented on a home-made AFM set-up utilizing a Laser Doppler Vibrometer (LDV) and a piezo-actuated bimorph probe. In the standard Q-control, the effective Q-factor of the scanning probe is adjusted prior to the scanning depending on the application. However, there is a trade-off in setting the effective Q-factor of an AFM probe. The Q-factor is either increased to reduce the tapping forces or decreased to increase the maximum achievable scan speed. Realizing these two benefits simultaneously using the standard Q-control is not possible. In adaptive Q-control, the Q-factor of the probe is set to an initial value as in standard Q-control, but then modified on the fly during scanning when necessary to achieve this goal. In this paper, we present the basic theory behind the adaptive Q-control, the electronics enabling the on-line modification of the probe's effective Q-factor, and the results of the experiments comparing three different methods: scanning a) without Q-control, b) with the standard Q-control, and c) with the adaptive Q-control. The results show that the performance of the adaptive Q-control is superior to the other two methods.

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