Unravelling Heterodyne Force Microscopy

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Imaging subsurface structures with nanometer resolution has been a long-standing desire in science and industry. To obtain subsurface information one usually applies ultrasound, like e.g. in echocardiography. Implementing ultrasound in an Atomic Force Microscope, a setup that is capable of imaging surfaces with atomic resolution, gives access to additional information. In particular, it is possible to image subsurface structures with nanometer resolution. However, it is not known why the subsurface structures become visible when applying ultrasound during the imaging with an Atomic Force Microscope. Based on a special excitation scheme, which makes use of two ultrasound excitations (one through the sample and one through the cantilever), Heterodyne Force Microscopy seems to be the most promising candidate for imaging deeply buried objects or structures with nanometer resolution.

This thesis focuses on the poorly understood elements in Heterodyne Force Microscopy. We studied the ultrasound propagation in the sample, the dynamics of an ultrasonically excited cantilever near a sample that is also vibrating at a slightly different frequency, and the generation of the heterodyne signal. The insight we gained in these matters allowed us to determine the contrast mechanism in a very well-defined model sample, which contains gold nanoparticles buried in a soft polymer matrix. We show that the contrast in this system is determined by "friction at shaking nanoparticles".

Casimir PhD series 2013-30

LUP DISSERTATIONS

Leiden University Press

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