Abstract Title

Metrology at Nanoscale for Dimensional and Analytical Properties

Symposium Track

Applications to Nanodiagonstics and MEMS

Authors' names

Ludger Koenders

Authors' affiliations

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin, Bundesallee 100, 38116 Braunschweig, Germany

Abstract body

INTRODUCTION

Core of the nano-technology is the linkage of material with dimensions in the nanometre range. To achieve knowledge about its properties it is mandatory to investigate geometrical as well as analytical properties in the nanometre range. A tool to investigate dimensional properties are the class of scanning tunnelling and scanning probe microscopes. The capability of both to investigate surfaces with unprecedented resolution introduced a large variety of techniques using probe that exploit different tip-sample interactions in order to probe sample properties. For thickness measurements as well as for chemical analysis techniques like x-ray reflectometry and surface analytical instruments like XPS, AES are used. By this techniques thickness standards can be calibrated with very low uncertainty. On the other side standards are necessary to test the resolution of surface analytical tools.

SCANNING PROBE MICROSCOPY

SPMs have become important for the measurement of small structures in dimensional metrology [1], like e.g. pitch, step height, particle diameter, line width, roughness, hardness and nano-indentation, as these techniques achieve high spatial resolution. The uncertainties for step height and pitch measurements are now in the sub-nanometre and picometre range, respectively [2]. The main contributions to the uncertainty are still due to some properties of the scanning and positioning apparatus. However, on the atomic scale, effects due to the tip shape or tip wear together with interaction forces between tip and sample, that cause elastic or plastic deformations of tip and sample, have to be taken into account. For scanning probe microscopes the fine tip is crucial to the spatial resolution of structures on the sample, but it must be accepted that this tip is naturally not infinitely fine. Thus the geometry and the physical characteristics of the probe together with the interaction between probe and sample are of substantial importance for the measurement. For dimensional metrology within the range of atomic dimensions, knowledge of tip sample interactions is therefore essential for accurate dimensional metrology.

Fig. 1 shows the profile produced by a tip which feels different interactions forces across its scan over the surface. In contact the Lennard-Jones potential repels the tip, whereas in non-contact mode attractive forces like the short-range van-der-Waals-force and the long-range

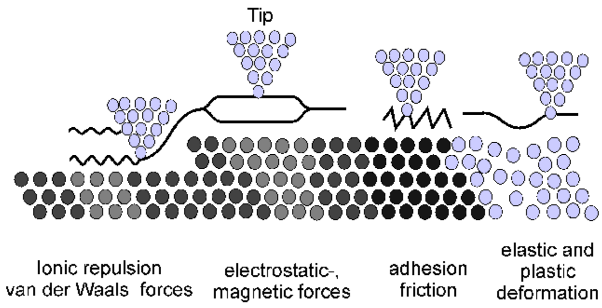

Figure 1 Scanning a fictitious surface: Interaction forces in SFM.

capillary force may act on the tip [3]. Local electrical charges on the surface may lead to attractive or repulsive electrostatic forces on the tip (electrostatic force microscopy). In a similar way, magnetic forces can be imaged if the tip is coated with a magnetic material, e.g. iron, that has been magnetised along the tip axis (magnetic force microscopy). The tip probes the stray field of the sample and allows the magnetic structure of the sample to be determined.

NANOANALYTICS

Whereas SFM provide information about the surface topography they give no information about materials or chemical elements under the tip. For thickness measurements as well as for chemical analysis other methods, like x-ray reflectometry, Auger-electron-spectroscopy, x-ray photoelectron spectroscopy are used. A few aspects of techniques like x-ray reflectometry, ellipsometry as well as x-ray photoemission for thickness measurements will be discussed [4]. To test the resolution of surface analytical instruments 1-dim [5] and 2-dimensional standards [6] with lateral structures in the nanometre range are under development. First results obtained standards will be shown and discussed.

Keywords

dimensional metrology, scanning force microscopy, layer thickness, nanoanalytic, x-ray reflectometry, ellipsometry, x-ray photoemission spectroscopy, standards

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Corresponding author contact information

L. Koenders , e-mail: Ludger.Koenders@ptb.de