Advances in quantitative characterization of thin films with help of AFM-based methods

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Atomic layer deposition (ALD) technique can produce nano-thin films using a variety of materials for numerous applications including these of nano-electronics, photovoltaic, and energy storage devices. Properties of ALD layers may change as a function of film thickness. The flexibility in application demands very precise knowledge of the properties of an ALD film at any given film thickness. In our report, we focus on the challenge of determining the indentation modulus of nano-thin films produced by ALD.

To characterize nano-thin films one needs a technique that has adequate lateral and depth resolution. Atomic force microscopy (AFM) based methods fit the specifications. An AFM tip can be as sharp as single nanometers, and the force resolution is in piconewton range. However, in contrast to accepted and standardized methods such as nanoindentation, AFM based methods are rarely used for quantitative analysis and determination of mechanical properties of materials. Lack of appropriate procedure for calibration of the geometry of an AFM tip is the responsible factor.

At IKTS we have developed a model for nano-scale contact mechanics that describes the geometry of an AFM tip accurately. We have tested it on single crystal silicon and diamond tips and successfully compared the results obtained for the tip radius with the TEM images of the same tips. The calibrated tips were then used to determine indentation modulus values on materials such as single crystal silicon. The values obtained were in a very good agreement with the literature values. The validation of the new model allowed us to develop an experimental procedure for characterization of nano-thin films. Our contribution will report on the new approach in calibration of the AFM tips for mechanical characterization of materials. In addition, we will report our results on characterization of AFD nano-thin films of aluminum oxide and titanium oxide.