DMA DYNAMIC CHARACTERIZATION OF VISCOELASTIC SOLIDS BY AFM : THE NANO DMA MODE

Michel Fajfrowski, Bruker Nano Surface 7 rue de la croix Martre 91120 Palaiseau
michel.fajfrowski@bruker.com
Bede Pittenger, Bruker Nano Surface 112 Robin Hill Road Santa Barbara, USA

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Quantitative measurement at nano scale of complex modulus of materials submitted to dynamic sollicitation through a surface tip interaction is a challenge. Experimental difficulties come from the relevance of measurement on the full frequency domain. Other phenomenoms must be also be taken in account like the adhesion during approach and unloading, non linear effects during measurement and multidimentional cantilever solicitation which happens during a conventional AFM approach.

These experimental difficulties must be taken into account in order to link the material properties traditionaly obtained in dynamical mechanical analysis, meaning the storage and loss moduli, to the data generated by the nano scale instruments. In order to achieve these requirements, the AFM nanoDMA approach use different algorithms : dual channel demodulation, phase drift correction, reference frequency tracking, enabling a small strain measurement in the rheologically relevant 0,1 Hz to 20 kHz at a spatial resolution only an AFM can provide.

This technique complements the peak force QNM mode (quantitative nanomechanical characterization) which extract the necessary informations coming from systematic analysis of the approach retreat curves during each tip surface interaction during measurements.

It's then possible to create viscoelastic properties mapping (loss, storage moduli, tan delta) on a large material range in frequency and temperature with the unattainable resolution of the AFM technique.
This viscoelastic analysis technique allows also to plot time temperature master curves and to measure activation energy using the arhenius law.

Comparative measurements between bulk DMA and nanoDMA obtained in nanoindentation and in AFM are proposed on different materials as PDMS (Polydimethylsiloxane), FEP (fluorinated ethylene propylene) or peek (PolyEtherEtherKetone) which is a semi crystalline thermoplastic. It allows for example to analyse the material evolution on both sides of the Tg and to quantify the volume of material which has been submitted to an irreversible recrystallization process.

We will also present the experimental procedure associate to these results.