AFM BASED FORCE-SPECTROSCOPY OF SOFT-MATERIALS: POLYMER GELS AND BIOLOGICAL CELLS

Abstract: The atomic force microscopy (AFM) based force spectroscopy is a nano-mechanical technique used in imaging soft matters, measuring surface forces, manipulating surface features and extracting local mechanical properties at the nano-scale through nanoindentation. The local mechanical properties can be elasticity, adhesion and viscoelastic properties. AFM force spectroscopy needs a contact model to quantify the interaction between the AFM probe and the sample material, and a set of robust protocols for experimental data extraction and analysis.

Present research work is focused on the development of contact models and experimental methods for AFM force spectroscopy technique in soft material characterization, mainly polymer gels and live biological cells. We have addressed two of the most common issues in the analysis of nanoindentation data of soft materials. Firstly, the correction to bottom substrate effect arising during thin sample studies and second, the contact model for simultaneous evaluation of nonspecific adhesion property along with elasticity. The developed contact model has applications in the characterization of soft materials showing adhesive elastic nature. The effectiveness of improvements made in the contact models are experimentally validated by testing transversely isotropic polymer gels of different stiffness and live MCF-7 adenocarcinoma cancer cells. Further, the developed correction factor for finite thickness is incorporated into a dynamic contact model for the study of viscoelastic nature of live cells. The model is applied in the study of micro-rheology of Human Mesenchymal stem cells and HCT-116 Colorectal cancer cells. The main advantage of the proposed model is its closed-form expression, making it easy to use for AFM force spectroscopic data analysis.

AFM-based force spectroscopy technique and incorporated correction to contact models have great significance in the biomechanical approach of studying diseases and drug effects, but their utilization in the evaluation of biomechanical properties needs a thorough understanding of uncertainties influencing the studies. The uncertainties arising from sample preparation, errors from AFM instrument and experimental parameters, the limitations of contact models are discussed along with possible solutions to them. Eventually, it will help in the error-free evaluation of nano-mechanical properties of any unknown soft samples.