Appendix A

Surface Forces Apparatus (SFA)

The experimental device

In its standard form the Surface Forces Apparatus (SFA) can measure the force of interaction between two surfaces as a function of their mutual distance. The distance between the surfaces is measured by an interferometric technique (fringes of equal chromatic order) to an accuracy of about 3 Å. The force is determined simultaneously from the deflection of the horizontal leaf spring that supports the lower surface (figure A.1). The smallest force detectable is on the order of $10^{-7}$ N.

Since surface forces act at very small distances (typically tens or hundreds of Å) the surfaces need to be atomically smooth for a well defined contact area to exist. For this reason thin foils of mica are used as surfaces since they can provide atomically smooth surfaces with macroscopic dimensions. On the back side of the thin mica foils very thin (semitransparent) films of silver are evaporated in order to be utilized as mirrors to create the interferometer cavity. When white light is shined through the silver-mica-medium-mica-silver sandwich only discrete wavelengths are transmitted, depending on the distance between the silver layers and the refractive indices. The transmitted light is subsequently focused onto the entrance of a spectrometer where a grating disperses the light into its component wavelengths. This decomposition provides a series of sharp fringes known as fringes of equal chromatic order from which the surface separation and the mica surface geometry can be determined.

In the polymer chemistry department of Groningen university the SFA has been modified by mounting the lower moving part on a piezoframe, in such a way that the lower surface can also be moved parallel to the upper surface. The lateral force that develops on the upper surface is then determined by detecting the deflection of two vertical leaf springs supporting it, again by an interferometric technique. Moreover a capacitance

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2. The crystal structure of muscovite mica is phylomorphic with a cleavage plane, thus crystals with extended (cm$^2$) atomically flat surfaces and with μm width can be easily obtained when deaved carefully.
6. Through the interference of two reflected beams: the beam reflected from the edge of the optical fiber and the one reflected by leaf spring surface (figure A.1)
force sensor has been added both to measure the distance between the mica plates and can also be utilized, as part of a feedback system, to keep them at a given distance while shearing. Finally, a liquid cell is used in the modified apparatus. In Israelachvilli’s apparatus the whole device was filled in by solvent before the injection of polymers between the two mica plates. In the device of figure A.1 only the liquid cell is filled up with solvent thus reducing dramatically the chances of contamination.

More information

A historical review on the evolution of the SFA has been compiled by T. Lodge\(^8\) whereas more info about the applications of SFA to polymer systems can be found in a review article by S. Patel\(^9\) and in the references: [5, 18, 19, 20, 23, 56, 95, 108] and for nanorheological studies in: [47, 48, 50, 51, 52, 54, 55, 56, 57, 76] For more details about the SFA used in the Groningen University one should refer to the Ph.D. thesis of S. Hirz (Stanford Univ., 1990) and G. F. Belder (Groningen Univ., 1995).

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\(^7\) the differential capacitance between the middle moving plate and the other two gives the deflection of the lower surface from a fixed reference point and subsequently a feedback loop can apply a suitable voltage on the capacitor plates, which drives the lower mica surface to the presetsed position by means of the electrostatic forces acting on the middle plate (figure A.1)


Acknowledgements

Looking back in time, it is difficult to believe how much have happened the last four years that I’ve spent in Groningen. Having reached the point of concluding this thesis, now putting on paper the final words, I can’t help thinking of all the people who made this possible and (sometimes) enjoyable. Unavoidably, much is lost from the feelings when one is trying to transform them in words, but engraved on the pages of a book, can and do, outline the author and resist the march of time: from this standpoint I would like to express my sincere thanks to:

Professor Georges Hadzioannou for making this work possible through his unfailing support and constant guidance and advice, through the encouragement and motivation but also the freedom and the security one could feel in the lab. Moreover, for providing the opportunity to work in a multi-disciplinary scientific environment, which could give a unique perspective although sometimes one could be overwhelmed by trying to keep up with the storm of his new ideas. For all these I owe him a immeasurable dept of gratitude.

Professor Gerrit ten Brinke for his expert guidance and all the scientific instructions and education, for trying to make me reach my potential and for all the inspiring help and supervision he always offered.

Professor Yiannis Bitsanis for introducing me to the world of computer simulations and for the many enlightening discussions we so often had; I could only consider him as a third thesis advisor. Professors Herman Berendsen, Albert Pennings and especially Doros Theodorou for reading my dissertation and providing their insight and judgment.

All my colleagues in our group and the those who visited us—one way or another. Andrei Sabbotia for all those long and sometimes thunderous debates, V. Koutso, G.F. Belder and K. Andrikopoulos for the enjoyable exchange of ideas. G. Malliaras, V. Papantonou and F. Syntouka for being there every time I needed somebody, for their friendship and support. A. Oikonomou for the balance and the different viewpoint in difficult moments.

Last but not least, my parents Maria and Dimitris for their continuous love, encouragement and devoted support all these years that I go through one school or another; for believing in me and inspiring me to set and achieve goals in my life, for the affectionate safety that I feel knowing that they are always there for me.

Evangelos D. Manias
Groningen, September 1995
Published work:

Some of the work presented inside this dissertation was actually published:

Stick and slip behaviour of confined oligomer melts under shear. A MD study.
E. Manias, G. Hadzioannou, I. Bitsanis, G. ten Brinke

§ 5.1 in:
Effect of shear on the desorption of oligomers in nanoscopically confined films.
E. Manias, G. Hadzioannou, G. ten Brinke

§ 5.2 in:
Adsorption-desorption kinetics in nanoscopically confined oligomer films under shear.
E. Manias, A. Subbotin, G. Hadzioannou, G. ten Brinke

§ 3.3 in:
On the nature of shear thinning in nanoscopically confined films.

§ 3.2 in:
Inhomogeneities in sheared ultra-thin lubricating films.


Other related work not presented in this thesis:

Atomic Force Microscopy and real atomic resolution. Simple computer simulations.
V. Koutsos, E. Manias, G. ten Brinke, G. Hadzioannou

Crystallization at solid-liquid interfaces.
R.K. Ballamudi, D.C. Koopman, E. Manias and I.A. Bitsanis

Rheology of confined polymer melts under shear flow: strong adsorption limit.
A. Subbotin, A.N. Semenov, E. Manias, G. Hadzioannou, G. ten Brinke

Nonlinear rheology of melts under shear flow.
A. Subbotin, A.N. Semenov, E. Manias, G. Hadzioannou, G. ten Brinke