A sophisticated research instrument for directly measuring static and dynamic forces between surfaces (inorganic, organic, metal, oxide, polymer, glasses, biological, etc.) and for studying interfacial and thin film phenomena at the molecular level. Modular design allows for expansion with numerous attachments and customized upgrades (see page 3).

**APPLICATIONS**

Research areas and types of interactions that can be directly measured *

- Dispersion science – “colloidal” forces between surfaces in liquids and controlled vapors
- Adhesion science – long-range colloidal forces and short-range adhesion forces
- Surface chemistry – surface and electrochemical interactions between dissimilar materials
- Detergency, food research – forces between surfactant and lipid monolayers and bilayers
- Biomaterials and biosurfaces – forces between protein and polymer-coated surfaces
- Biomedical interactions – ligand-receptor, protein and model biomembrane interactions
- Tribology – friction, lubrication and wear of smooth or rough surfaces, thin film rheology
- Powder technology – capillary effects and surface deformations during interactions
- Materials research – mechanical and failure properties of metal and oxide surfaces and films

* This list is not exhaustive; contact us for your specific needs.
GENERAL DESCRIPTION
The SFA measures forces between two surfaces in vapors or liquids with a sensitivity of a few nN and a
distance resolution of 1Å (0.1 nm). It can also measure the refractive index of the medium between the
surfaces, adsorption isotherms, capillary condensation, surface deformations arising from surface forces,
dynamic interactions such as viscoelastic and frictional forces, thin film rheology, and other time-dependent
phenomena in real time at the molecular (nano-) scale. The molecularly smooth surfaces of hard materials
such as mica, silica, sapphire, polymers, serve as suitable substrate surfaces in most measurements; these
can also be coated with thick or thin layers of surfactants, lipids, polymers, metals, metal oxides, proteins and
other biomolecules.

HOW IT WORKS
The figure below is a schematic drawing of the SFA 2000 configured with the Piezoelectric Top Mount
(attached to the exterior of the Main Chamber and hosts the top surface) and the Main Translation Stage
Bottom Mount (resides inside the Main Chamber and hosts the bottom surface) ready for use. For both the
SFA 2000 and μSFA, the shapes of the interacting surfaces, the absolute separation between them, and the
thickness of any adsorbed layer on the surfaces, are measured (to within 0.1 nm) by analyzing the optical
interference fringes (known as FECO fringes) produced when white light passes through the two surfaces.
The distance between the surfaces is controlled by a four-stage mechanism of increasing sensitivity from
millimeters to ångstroms. Using the SFA 2000, dynamic measurements are conducted with surfaces in motion
(vertically, horizontally, or in any direction in 3D space) using one of the attachments described in the following
pages, while for the μSFA dynamic measurements are conducted with the surfaces in vertical motion. The
μSFA retains the same normal force measurement capability as the SFA 2000 but in a compact form factor for
use in typical laboratory microscopes thereby enabling SFA and fluorescence studies, for example.

USES
The SFA technique is routinely used to characterize and quantify various types of interactions between
surfaces in liquids and vapors (see references on page 4). Static interactions include van der Waals and
electrostatic forces, forces due to solvent structure (solvation and hydration forces), capillary forces,
hydrophobic interactions, polymer-mediated steric and depletion forces, surfactant monolayers and lipid
bilayers, adhesion and bio-specific receptor/ligand or other “lock-and-key” type binding interactions. Dynamic
and time-dependent interactions include the viscosity of liquids in ultra-thin films (nano-rheology), slow
relaxations of liquids, and polymers in confined geometries, and surface deformations during the approach,
separation and lateral sliding of two surfaces. More recent applications have included food technology, the
friction of clutches, how geckos run on walls and ceilings, the bioadhesion of mussels, joint biolubrication.
MAIN FEATURES AND ATTACHMENTS

For anyone who wants to accurately measure the forces or any type of “interaction” between two material surfaces at any given separation in air, vapor or liquid, including their local geometry (shape) and deformations, the SFA stands unrivalled as to directness of measurement and visualization, unambiguous (sub-Ångstrom) accuracy, and stability to thermal drift. Unlike some surface force-measuring instruments, such as scanning probe microscopes and pin-on-disk tribometers, the SFA 2000, especially when used with FECO optics, measures forces between surfaces at precisely known surface separations, providing the local surface geometry (shape), directly at the point of interaction. A number of capabilities that appeared as accessories in earlier models (such as the SFA 3) are now part of the SFA 2000, and new attachments allow for various dynamic measurements to be made, for example, of friction, lubrication and viscoelastic forces over a large range of speeds or shear rates. Some of these capabilities are illustrated below:

FRICTION SENSOR/ACTUATOR ASSEMBLIES
For friction and lubrication studies

PIEZOELECTRIC BIMORPH SLIDER (1D & 2D)
For high-speed shearing of thin films

1D Sense & Actuation

2D/3D Sensing

BIMORPH VIBRATOR
For measuring thin-film viscosity

VARIABLE MAIN STAGE SPRING
For multiple in-situ selectable spring stiffnesses

CUSTOM ATTACHMENTS
Designed for your specific research

OTHER ATTACHMENTS INCLUDE:

(1) Variable Stiffness Force-Measuring stage, (2) Constant Force-Measuring Balance, (3) Attachments for moving and detecting forces in 3D, (4) High-Speed Friction attachment (pin-on-disk type), (5) Attachments for applying electric or magnetic fields, (6) Short Working Distance for in-situ fluorescence & FRAP measurements (FL-SFA), (7) Attachment for electrochemical studies (EC-SFA), (8) Under-Water Mounts for biological surfaces
The microscope-ready SFA, or μSFA, is intended to be used in common upright or inverted laboratory microscopes. Instead of an external white-light source, the microscope itself provides the broad-band white-light (tungsten source, 75W minimum) as well as the light collection and redirection to a side exit port for external guiding to a spectrometer to generate the FECO (Fringes of Equal Chromatic Order) measure of the inter-surface separation and contact geometry. This allows common modern microscopy, such as fluorescence imaging, to be done with the SFA. The μSFA supports large diameter, short focal-length objectives (< 36MM diameter and working distance > 11MM). The μSFA, like the SFA 2000, especially when used with FECO optics, measures forces between surfaces at precisely known surface separations, providing the local surface geometry (shape), directly at the point of interaction. The μSFA uses the same SFA disks and surfaces as the SFA2000 and can be used in an SFA2000 optical setup without modification.

FUTURE ATTACHMENTS TO INCLUDE:

(1) 1D Bimorph Slider, (2) 1D Friction Device, (3) Attachment for electrochemical studies (EC-μSFA), and (4) Under-Water Mounts for biological surfaces.
THE SFA AND FECO OPTICAL TECHNIQUE AND INTERFACING WITH OTHER TECHNIQUES


Topographic information from multiple beam interferometry (MBI) in the SFA. M. Heuberger et al., Langmuir (1997) 13 3839-3848.


The intersection of interfacial forces and electrochemical reactions. Israelachvili et al., JPCB (2013) 177 (51) 16369–16387.


COLLOIDAL, POLYMER AND ADHESION INTERACTIONS


Evaporation and instabilities of microscopic capillary bridges. Maeda et al., PNAS (2003) 100 (3) 803-808.

Transient Interfacial Patterns and Instabilities Associated with Liquid Film Adhesion and Spreading. H. Zeng et al., Langmuir (2007) 23 6126-6135.


Tuning underwater adhesion with cation-π interactions. Gebbie et al., Nature Chemistry (published online 13 Feb 2017).

BIOLOGICAL AND BIOMEDICAL INTERACTIONS


DYNAMIC, RHEOLOGICAL AND TRIBOLOGICAL INTERACTIONS


