JPK CryoStage - Temperature flexibility for low and high temperature measurements from -120 °C up to 220 °C

Introduction

One of the key features of atomic force microscopy (AFM) is the ability to perform high resolution, label-free measurements under both controlled and adjustable environments. AFM can achieve nanometer resolution in air or liquid, under different gas atmospheres as well as in different temperature ranges. This provides the option of carrying out measurements under native as well as under extreme environmental conditions and makes this technique very attractive in biological, chemical and material research.

The performance of measurements in low temperature and cryo regimes is well-documented and is highly relevant for many application fields. It is established in scanning electron microscopy and AFM vacuum measurements but not under ambient conditions. Until now, cooling during AFM measurements performed under ambient conditions has mostly been achieved by using Peltier elements or freezing mixtures. With these solutions, it is possible to reach temperatures down to -40 °C, but not below.

The JPK CryoStage uses liquid nitrogen cooling. It can therefore reach much lower temperatures down to -120 °C and offers the possibility of performing AFM measurements in both a cryo-regime as well as under ambient environments without compromising the AFM performance and resolution. This opens a completely new field of AFM research and applications.

JPK's CryoStage was developed to enable the use of the highest possible temperature range to provide more flexibility in controlling AFM measurement conditions. AFM imaging and the characterization of nanomechanical, electrical, magnetic or other surface properties can now be performed at low and high temperatures as well as under an ambient and gas atmosphere. In this way, full environmental control can be achieved.

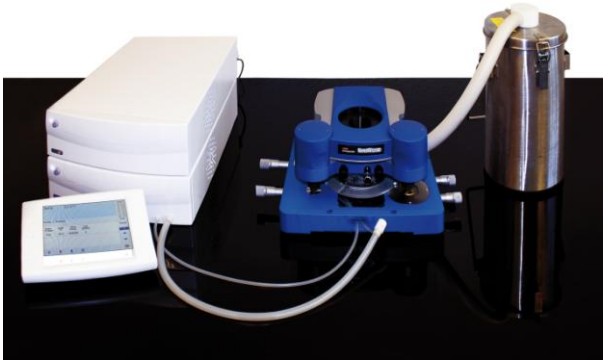

Fig 1: CryoStage with integrated heating and cooling capabilities (-120 °C to 220 °C)

CryoStage design

The CryoStage is a stand-alone stage with integrated heating and cooling capabilities. AFM measurements can be performed in a temperature range from -120 °C up to 220 °C. In particular, the ability to cool down to – 120 °C offers completely new research perspectives. For example, the investigation of cryopreservation of cells and tissue or the study or cold-adaption of microorganisms like bacteria is now possible. The flexibility of temperature control also provides new possibilities in material and polymer research. Crystallization, glass transition temperature and melting studies of polymers can be performed and phase separation on block-copolymers investigated. The study of material properties and structural surface changes at different temperatures, e.g. for materials in aerospace, also represents an important field of application.

The integrated Linkam Scientific Instruments technology allows precise cooling with liquid nitrogen and a temperature stability of +/-0.2 °C can be achieved. To prevent ice formation, the CryoStage is equipped with a rapid cooling rate function (>10 °C / min) and operates in a sealed volume with a gas flow connection for dry or inert gas. For an environmentally-friendly cooling process, the liquid nitrogen is recycled and used to create a sealed nitrogen environment.

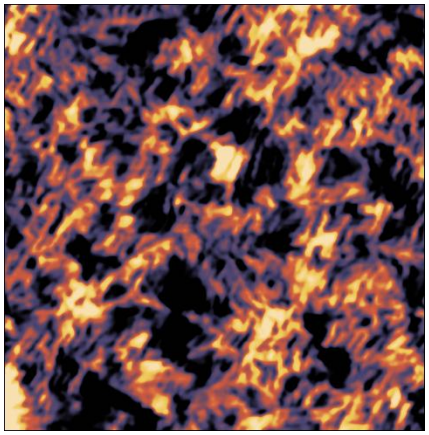

Fig 2: Topography image of crystalline polyethylene (z-range: 15 nm) measured at -120°C, scan size: 2 µm x 2 µm

The cooling process only requires a single Dewar of liquid nitrogen. AFM measurements can be performed within the full temperature range (-120 °C to 220 °C) in any dry or inert gas atmosphere. This is becoming, e.g., increasingly essential for innovative techniques related to the saving, storage and production of electrical energy (e.g. solar cells, lithium ion batteries) or to charge transport investigations.

The temperature can be adjusted and controlled via an ergonomic, LCD touch screen control pad. This offers optimal monitoring of the heating/cooling process. For efficient AFM measurements, the CryoStage offers fine motion control for precise positioning of the AFM tip relative to the sample (10 mm x 5 mm). A sample size up to 22 mm x 22 mm can be used.

Conclusion

Controlling the environmental conditions is essential during experiments. The CryoStage is an innovative option for controlling environmental conditions and offers new flexibility during the performance of high and low temperature measurements. Reliable results can be generated in completely new temperature ranges.

Applications

- Investigation of mechanical properties and structural surface changes of materials for aerospace or construction at different temperatures
- Temperature associated mechanical fatigue
- Adhesive efficiency depending on temperature
- Crystallization, glass transition temperature and melting studies of polymers
- Phase separation studies on block-copolymer or homo polymer mixtures
- Study of cold-adaptation of biological cells, microorganisms and plants
- Influence of cryosurgery or microtome treatment on tissue properties
- Cryopreservation of cells, tissues and gametes
- Cryodesiccation (freeze-drying) of e.g. pharmaceuticals
- Measurements of organic and inorganic surfaces under different gas environments

Specifications

- Temperature range from -120 °C up to 220 °C, temperature stability +/-0.2 °C
- Minimized vibration for high-resolution imaging of samples
- Sealed volume with gas flow connection for dry or inert gas over the complete temperature range
- Rapid cooling rate with liquid nitrogen (>10 °C/min) and nitrogen environment to prevent ice formation while cooling
- Fine motion control for precise positioning of the AFM tip relative to the sample of 10 mm x 5 mm
- Integrated Linkam Scientific Instruments technology
- Ergonomic LCD touch screen control
- Sample size: up to 22 mm x 22 mm
- TopViewOptics™ illumination, no transmission illumination
- Can be combined with electrical, magnetic, nanomechanical measurement modes