

## Objective

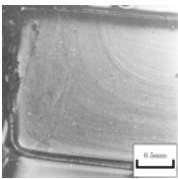
Evaluate the use of nano-indentation as a technique for measuring the mechanical properties of micro-injection mouldings.

## Main elements of the technique

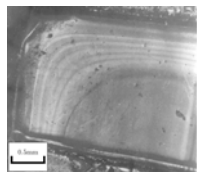
1. Accurately section the moulding to expose the required cross section for testing.
2. Prepare the surface so that its structure is representative of the moulded material.
3. Carry out a programmed series of nano-indentations.
4. Measure the indentations with an atomic force microscope.

## Sample preparation

- Sample embedded in a cold-cure resin.
- Embedded sample trimmed and sectioned with a microtome using a glass knife.
- Cut surface etched using a chemical agent if required.

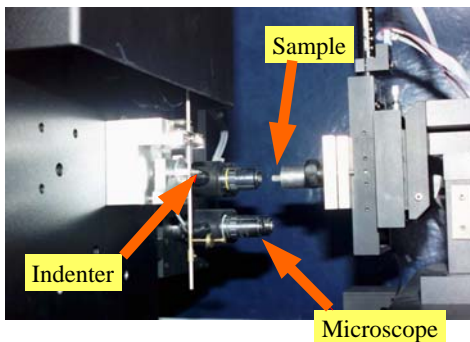


Etched section of a conventional HDPE injection moulding.

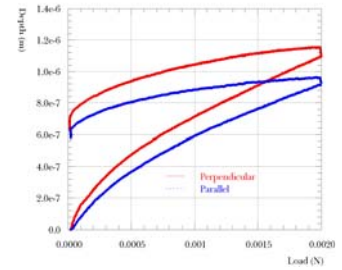
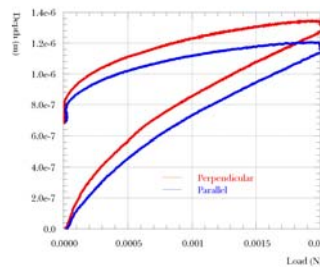


Etched section of an HDPE injection moulding with enhanced molecular orientation.

## Nano-indentation

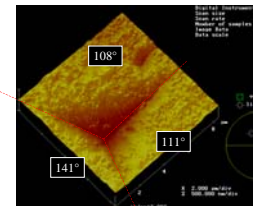
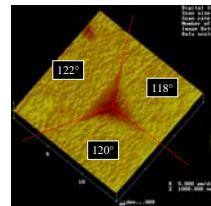


The photograph shows the Micromaterials NanoTest instrument used in the project. The sample is positioned using the microscope attachment. The sample is then switched to the indenter stage and the series of indentations carried out.



Load v depth of penetration for nano-indentation tests on injection moulded samples of HDPE. The lower lines represent the loading stage and the upper section of the traces represent the withdrawing stage of the test. The modulus of the sample is calculated during the retraction of the indenter. The plots on the left are from a conventional moulding the plots on the right are from a moulding with enhanced orientation. The difference between the measurements taken perpendicular (red plots) and parallel (blue plots) to the injection direction indicate the level of anisotropy in the samples.

## AFM and anisotropy



Anisotropy in thermoplastic mouldings can be detected by the shape of the nano-indentation. The left hand image shows an isotropic response to nano-indentation as indicated by the equilateral triangular shape of the impression. The right hand image shows anisotropy as indicated by the isosceles triangular shape of the indentation.

## Summary

- Nano-indentation is an effective technique for the mechanical testing of micro-mouldings
- The micro-samples can be accurately sectioned after being embedded in a cold curing resin.
- Chemical etching of the sectioned surface may be required to remove damage caused by the action of the microtome knife.
- Anisotropy, a common feature of injection moulded thermoplastics, can be easily detected by nano-indentation. The use of atomic force microscopy combined with nano-indentation, offers the potential to accurately measure the level of anisotropy in micro-mouldings.