# PIUMA NANOINDENTER

Optics11 B.V.
De Boelelaan 1081
1081 HV Amsterdam
The Netherlands

For more information,
please visit our website:
www.optics11.com

or contact us at:
info@optics11.com

Office telephone:
+31 (0)20 598 79 17

## Piuma Nanoindenter Application note:

# Measuring the mechanical properties of cartilage immersed in PBS

The Piuma Nanoindenter is specifically developed to non-destructively characterize the mechanical properties of soft materials, such as tissues, biomaterials, hydrogels and cells. Using a novel proprietary optical fiber-top technology, the Piuma provides great force sensitiviy, accuracy and precision while remaining very easy to use.

Application note AN-1503, written by Ernst Breel, Optics11 BV
Published on 3 November 2015 on www.optics11.com

**Cartilage is a widely studied material, as defects due to trauma or disease can severely impact quality of life. At the basis of developing new therapies lies a thorough understanding of both biological and mechanical properties of cartilage. This note describes the mechanical characterization of rat cartilage using the Piuma Nanoindenter.**

## Introduction

To characterize the mechanical properties of rat cartilage, two experiments are performed: varying the probe displacement from 7 to 20 micrometer, resulting in an increasing depth of indentation, and mapping of a section of the cartilage to explore local variations in stiffness.

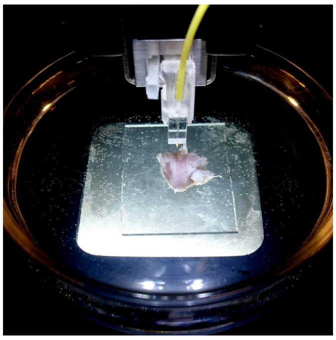
## Methods and materials

The Piuma Nanoindenter is fitted with a 7 N/m probe with a 88 µm radius extended spherical tip for the first experiment and a 7.95N/m probe with a 24.5 µm radius extended sperical tip for the second experiment. The displace-ment profile is varied from 7 to 20 µm from the surface, with 2 µm/s loading and un-loading displace-ment rates and 6 s holding time.

Applying the Hertzian model describing the indentation of elastic bodies, the data in the loading section of the load-displacement curve is used to determine the Youngs Modulus, using a fit of all datapoints from the contact point to 60% of the maximum load point [1].

For these experiments, the Piuma Nanoindenter is placed on top of a regular lab bench; no special stabilization or dampening is used during the experiments.

## Sample preparation

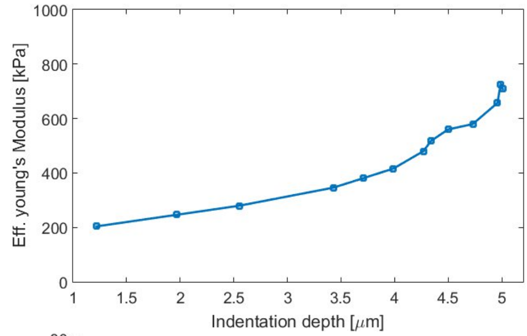


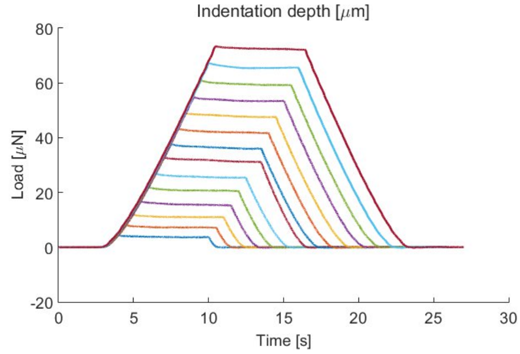
*Immersed cartilage sample mounted on Piuma X-Y stage.*

Bone samples from adult rat are harves-ted, cut below the metaphyseal com-partment, parallel to the cartilace surface, and frozen at -80$^{o}$C for one week. The sample is thawed at room temperature and the epiphyseal section is attached to a glass substrate using a thin cyanoacrylate film (see picture above). The sample is fully immersed in PBS (pH 7.4) during the measurement.

## Results

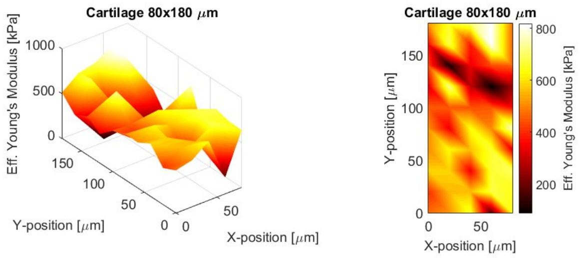
To investigate the E-modulus response to varying indentation depth, one series of indentations using 7 to 20 µm displacement profiles are set. The displacement rate and hold time are kept contstant.

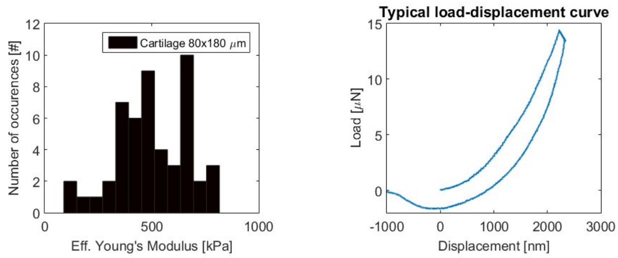



As the data shows, the resulting indentation depths vary between 1.2 to 5.0 µm. The E-modulus increases with increasing indentation depth and load.

Additionally the spatial E-distribution of a site on the cartilage is examined, using a 12 µm displacement profile.




The scan reveals that the cartilage surface has regions with softer and stiffer properties, when using a 20 µm pitch in X and Y direction.

[1] Hertz, H. R., 1882, Ueber die Beruehrung elastischer Koerper , in Gesammelte Werke (Collected Works), Vol. 1, Leipzig, Germany, (1895)