**MatchID**
Metrology beyond colors

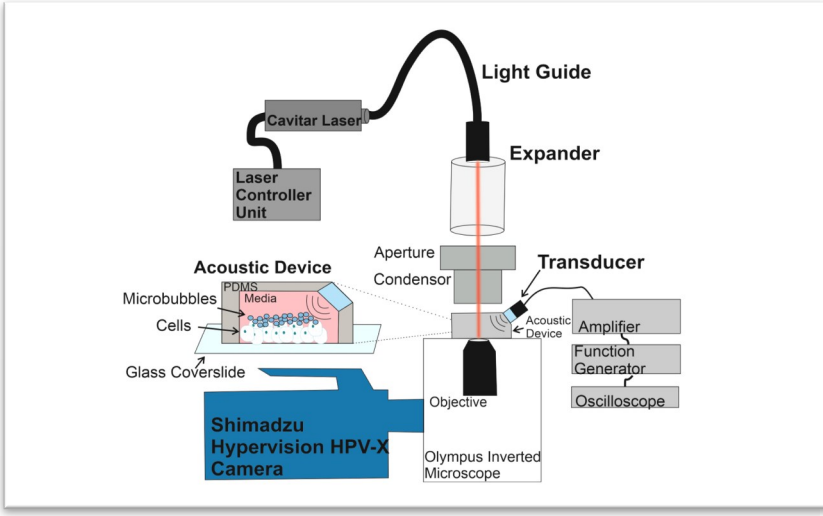
UNIVERSITY OF Southampton

Application Note

# Imaging ultrasonic deformation of biological cells and tissues

## Case Description

**This application note summarizes a corpus of work undertaken to elicit the deformation of biological cells and tissues. Three applications are reported: deformation during ultrasonic cutting of cartilage in the context of surgery, associated deformations of cells representative of the cutting process and finally, sonoporation using microbubbles resonating in a 1 MHz acoustic field. All three applications use high speed or ultra-high speed cameras and high magnification, hereby illustrating the power of MatchID to understand deformations in challenging situations.**




### Study 1

- ✓ **Cameras:** iX 513 high speed
- ✓ **Type:** Stereo DIC
- ✓ **Acquisition Speed:** 69 Hz
- ✓ **Ultrasound Frequency:** 26 kHz
- ✓ **Light Source:** Cavitar pulsed laser
- ✓ **Field of View:** 3 x 2 mm

### Study 2

- ✓ **Camera:** Shimadzu HPV-X
- ✓ **Type:** 2D DIC
- ✓ **Acquisition Speed:** 500 kHz
- ✓ **Ultrasound Frequency:** 20 kHz
- ✓ **Light Source:** Cavitar pulsed laser
- ✓ **Field of View:** 320 x 200 µm

### Study 3

- ✓ **Camera:** Shimadzu HPV-X
- ✓ **Type:** 2D DIC
- ✓ **Acquisition Speed:** 5 MHz
- ✓ **Ultrasound Frequency:** 1 MHz
- ✓ **Light Source:** Cavitar pulsed laser
- ✓ **Field of View:** 160 x 100 µm

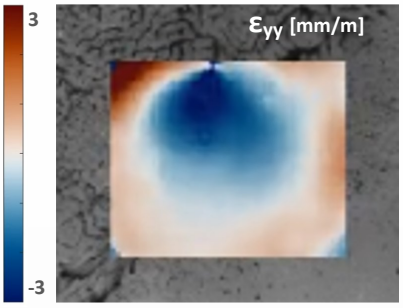
- ✓ Fast bundle-approach including complex lens distortions
- ✓ Powerful **performance analysis module** auto-determines optimized DIC settings
- ✓ **Higher-order shape functions** for more accuracy
- ✓ MatchID scripting interface

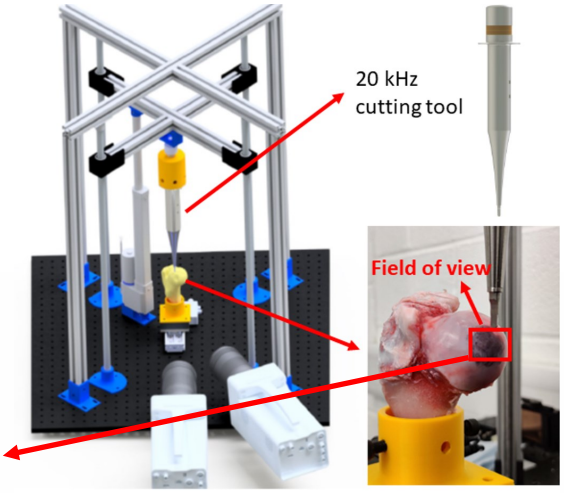
**Why MatchID**

+32 (0) 9 223 64 41 ■ info@matchid.eu ■ www.matchid.eu

## Ultrasonic cutting of cartilage

The development of the next generation of ultrasonic cutting tools is the object of the EPSRC Ultrasurge project in the UK. As part of this effort, MatchID is used to image the deformation of tissues cut by an ultrasonic tool. This application looks at cutting cartilage from a porcine femoral head (see picture). Stereo-DIC was used with a pair of high-speed iX cameras. The strain results are essential to inform the level of tissue deformation that should be considered to simulate what individual cells are subjected to (see application below).

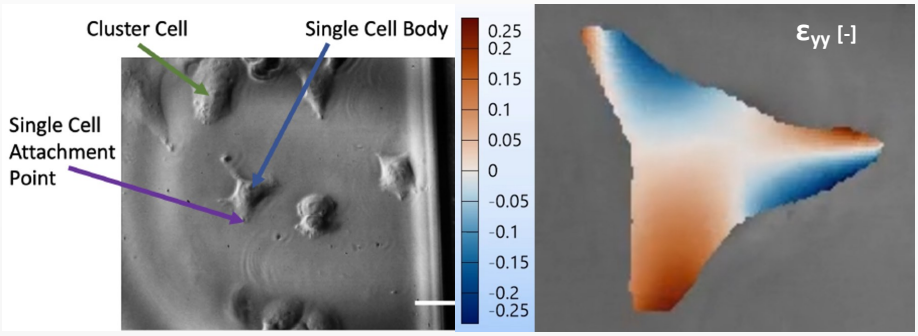



*Work by Dr Alex Marek and Prof. Fabrice Pierron, University of Southampton, UK.*

## Ultrasonic deformation of cells

The influence of ultrasonic deformation on the biological response of cells is still an area requiring more research. From the deformation levels informed by the tissue cutting work (above), representative strain levels are applied at 20 kHZ using a novel procedure called 'Image-Based Ultrasonic Cell Shaking' (IBUCS). A flat PMMA or glass coupon, on which cells are grown and hydrated through a PDMS well, is attached to a 20 kHz sonotrode and vibrated on its first mode of longitudinal vibration, inducing cells to deform. Mechanical strain is obtained by MatchID using the natural features of the cell as speckle.

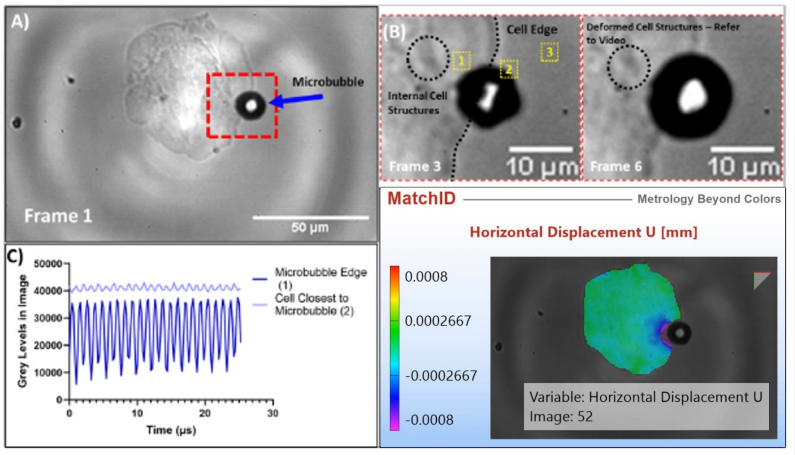



*PhD of Ms Miranda Ballard supervised by Dr Alex Marek and Prof. Fabrice Pierron, University of Southampton, UK.*

## Ultrasonic cell-bubble interaction

Sonoporation consists in using ultrasonically resonating microbubbles to stretch the membranes of cells to enhance their porosity, with a view to facilitate the uptake of drugs.

To understand the relationship between membrane porosity, membrane strain and bubble deformation, ultra-high speed imaging coupled with DIC is a very valuable tool. In this work, it was possible to link up microbubble vibration to cell deformation using the natural pattern of the cells as speckle.




*PhD of Mr Oliver Pattinson supervised by Prof. Nick Evans, Dr Dario Carugo and Prof. Fabrice Pierron, all University of Southampton, UK except Dr Carugo, University of Oxford, UK.*