P8 – Nanoelectromechanics of Yeast Cells

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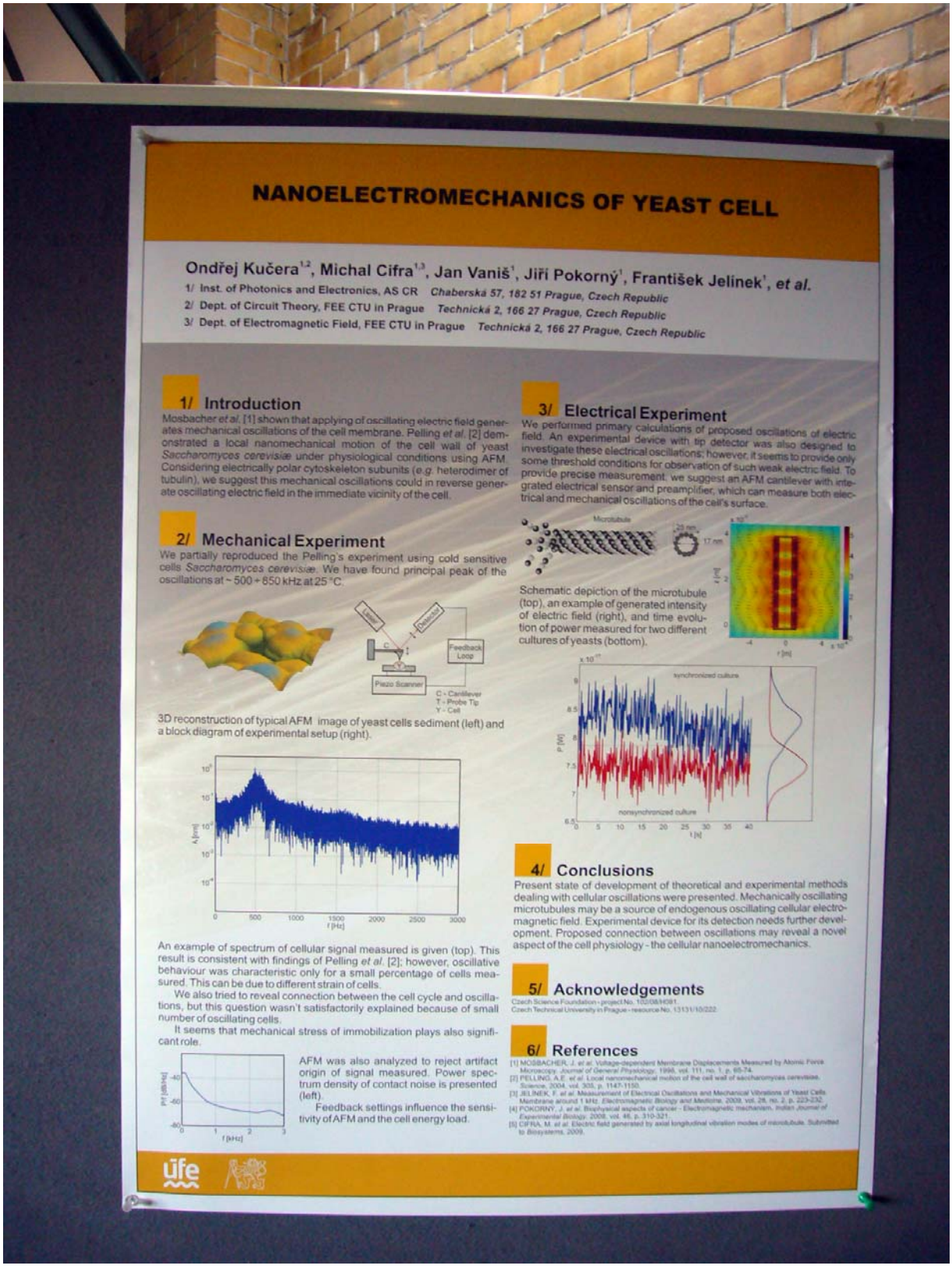
Mosbacher *et al*. [1] shown that applying of oscillating electric field generates mechanical oscillations of the cell membrane. Pelling *et al*. [2] demonstrated a local nanomechanical motion of the cell wall of yeast *Saccharomyces cerevisiæ* under physiological conditions using AFM. Considering electrically polar cytoskeleton subunits (e.g. heterodimer of tubulin), we suggest this mechanical oscillations could in reverse generate oscillating electric field in the immediate vicinity of the cell.

We partially reproduced the Pelling's experiment using cold sensitive cells Saccharomyces cerevisiæ tub2 – 401 401(strain CUY67 Mata tub2-401 ura3-52 ade2-101 (20)). We have found principal peak of the oscillations at ~ 850 kHz at 25 °C.

We performed primary calculations of proposed oscillations of electric field. An experimental device was also designed to investigate these electrical oscillations; however, it seems to provide only some threshold conditions for observation of such weak electric field. To provide precise measurement, we suggest an AFM cantilever with integrated electrical sensor and preamplifier, which can measure both electrical and mechanical oscillations of the cell's surface.

Proposed connection between oscillations may reveal a novel aspect of the cell physiology – the cellular nanoelectromechanics.

[1] MOSBACHER, J. *et al*. Voltage-dependent Membrane Displacements Measured by Atomic Force Microscopy. *Journal of General Physiology*, 1998, vol. 111, no. 1, p. 65 – 74.
[2] PELLING, A.E. *et al*. Local Nanomechanical Motion of the Cell Wall of Saccharomyces cerevisiae. *Science*, 2004, vol. 305, p. 1147 – 1150.



NANOELECTROMECHANICS OF YEAST CELL

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1/ Introduction

Mosbacher *et al.* [1] shown that applying of oscillating electric field generates mechanical oscillations of the cell membrane. Pelling *et al.* [2] demonstrated a local nanomechanical motion of the cell wall of yeast *Saccharomyces cerevisiae* under physiological conditions using AFM. Considering electrically polar cytoskeleton subunits (*e.g.* heterodimer of tubulin), we suggest this mechanical oscillations could in reverse generate oscillating electric field in the immediate vicinity of the cell.

2/ Mechanical Experiment

We partially reproduced the Pelling's experiment using cold sensitive cells *Saccharomyces cerevisiae*. We have found principal peak of the oscillations at ~ 500 ÷ 650 kHz at 25 °C.

3D reconstruction of typical AFM image of yeast cells sediment (left) and a block diagram of experimental setup (right).

An example of spectrum of cellular signal measured is given (top). This result is consistent with findings of Pelling *et al.* [2]; however, oscillative behaviour was characteristic only for a small percentage of cells measured. This can be due to different strain of cells.

We also tried to reveal connection between the cell cycle and oscillations, but this question wasn't satisfactorily explained because of small number of oscillating cells.

It seems that mechanical stress of immobilization plays also significant role.

AFM was also analyzed to reject artifact origin of signal measured. Power spectrum density of contact noise is presented (left).

Feedback settings influence the sensitivity of AFM and the cell energy load.

3/ Electrical Experiment

We performed primary calculations of proposed oscillations of electric field. An experimental device with tip detector was also designed to investigate these electrical oscillations; however, it seems to provide only some threshold conditions for observation of such weak electric field. To provide precise measurement, we suggest an AFM cantilever with integrated electrical sensor and preamplifier, which can measure both electrical and mechanical oscillations of the cell's surface.

Schematic depiction of the microtubule (top), an example of generated intensity of electric field (right), and time evolution of power measured for two different cultures of yeasts (bottom).

4/ Conclusions

Present state of development of theoretical and experimental methods dealing with cellular oscillations were presented. Mechanically oscillating microtubules may be a source of endogenous oscillating cellular electromagnetic field. Experimental device for its detection needs further development. Proposed connection between oscillations may reveal a novel aspect of the cell physiology - the cellular nanoelectromechanics.

5/ Acknowledgements

Czech Science Foundation - project No. 102/08/H081.
Czech Technical University in Prague - resource No. 1313/10/222.

6/ References

[1] MOSBACHER, J. *et al.* Voltage-dependent Membrane Displacements Measured by Atomic Force Microscopy. *Journal of General Physiology*, 1998, vol. 111, no. 1, p. 65-74.
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[5] CIFRA, M. *et al.* Electric field generated by axial longitudinal vibration modes of microtubule. Submitted to *Biosystems*, 2009.