ELECTRIC ALIGNMENT OF MICROTUBULES ON A MICROFABRICATED SURFACE: MICRON-LEVEL CONTROL

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Microtubules are hollow tubes 25 nm in diameter (for 13-protofilament microtubules) whose walls are assembled from parallel α-β-tubulin dimers, making them polar. This structure is capable of providing mechanical support to a cell, while being dynamic enough for quick remodeling (as when forming the mitotic spindle during cell division). In addition, microtubules function as tracks for motor proteins (e.g. dyneins and kinesins), which usually have a preferential sense of movement according to the microtubule's polarity.

We propose to use localized electric fields to induce the alignment (due to their electric dipole) of microtubules on a surface with high precision. This would enable the use of microtubules as interfaces of nanoengineered devices with biomolecules or whole cellular organelles. It would at the very least allow close control of motor protein movements.

We have already demonstrated the viability of this approach with the alignment of a bulk sample of surface-adsorbed microtubules by a high electric field. For that purpose, microtubules were allowed to adsorb to a poly-l-lysine coated glass coverslip while being exposed to a 400 $kV.m^{-1}$ electric field. When dried and imaged with AFM in air, the resulting samples showed preferential alignment of the microtubules parallel to the applied electric field [1].

To expand on these results, we resorted to standard microfabrication technology to manufacture a chip with integrated capacitor arrays. This is designed to obtain much finer control of the alignment, while still applying to a large (8x8 mm^2) area. Specifically, the chip includes structures for bulk parallel alignment and also for alignment along a curved pattern in a non-uniform field.

In preliminary experiments, microtubules were adsorbed to the chip's surface, silicon dioxide coated with poly-l-lysine, under a maximum electric field of 900 $kV.m^{-1}$ (5V over the minimum distance of 5 µm) and imaged in air by AFM. A clear alignment of microtubule bundles was observed along curved field lines in the non-uniform field experiment.

We are presently optimizing the sample preparation method and the device itself.

References:

[1] Ramalho RR, Soares H, Melo LV, Mat. Sci. Eng. 27 (2007): 1207-1210