**Electronic Supplementary Information**

# Asymmetric cancer-cell filopodium growth induced by electric-fields in a microfluidic culture chip

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## 1. Calibration of the EF strengths in the culture chamber

The EF strengths inside the cell-culture region is calibrated with the following method: We replaced the top cover glass of the chip by a 1-mm-thick PMMA slip, and opened two small holes on top of the cell culture region separated by 12 mm. Two platinum (Pt) wires of a 150 μm diameter were then placed into the holes. A function generator was connected to the Ag/AgCl electrodes to apply a 1-Hz rectangular wave of voltage on the chip. The current through the cell-culture chamber $I$ was monitored by a current meter, and the voltage differences between the two Pt wires $\Delta V$ were measured by an oscilloscope. The EF strength was calculated as $E = \Delta V/d = I/(\sigma A)$, where $d$ is the distance between the two Pt wires, $I$ is the current, $\sigma$ is the conductivity of the culture medium, and $A$ is the cross section of the culture chamber. The $\sigma$ value of the medium used in this work (DMEM) is 1.38 $\Omega^{-1}m^{-1}$.[1] Figure S1(a) shows the simulated EF strengths calculated by COMSOL Multiphysics, (COMSOL, Burlington, MA), and Fig. S1(b) is the *E-I* curve measured on the cell-culture chambers of 15

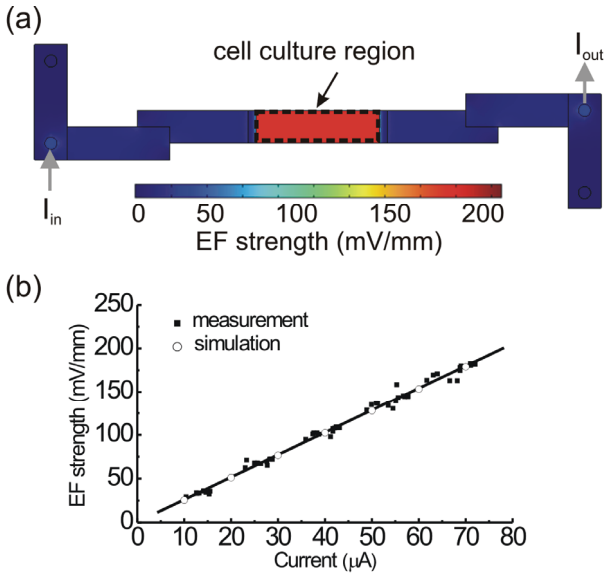


**Fig. S1** (a) Simulated EF strengths inside the MEC chip. (b) Simulated and measured *E-I* curve inside the MEC chip. The measurement data are from 15 chips.

chips. The slope of the measured *E-I* curve is 2.56 ± 0.03 mV/(mm·μA), in agreement with the simulated value 2.557 mV/(mm·μA). The nonlinearity of the EF in the culture region is about 4.4 mV/mm. We used the linear relation in Fig. S1(b) to estimate the EF strengths in the culture chamber during the experiments.

## 2. Setup and operation of the structured illumination nano-profilometry (SINAP) system

The setup of the SINAP system is shown in Fig. S2. We used a standard upright microscope (Eclipse LV150, Nikon, Kanagawa, Japan) as the mainframe of the SINAP system, equipped with a water-immersion objective with a 1.1 numerical aperture (CFI Plan 100×W, Nikon). The illumination wavelength was set as 550 nm with a bandwidth of 50 nm. The illumination patterns were generated by a liquid-crystal spatial light modulator (SLM) (HEO 6001-SC-II, HOLOEYE Photonics, Berlin-Adlershof, Germany). The spatial frequency of the modulating mesh pattern on the sample surface was about 2 $\mu m^{-1}$. Images were captured by a 14-bit electron-multiplying CCD camera (DU-885, Andor, Belfast, Northern Ireland). Axial positioning of the sample was controlled by a PZT-driven vertical stage (P-762.ZL, Physik Instrumente, Karlsruhe, Germany) that has a 10-nm smallest step size and 0.1% linearity.

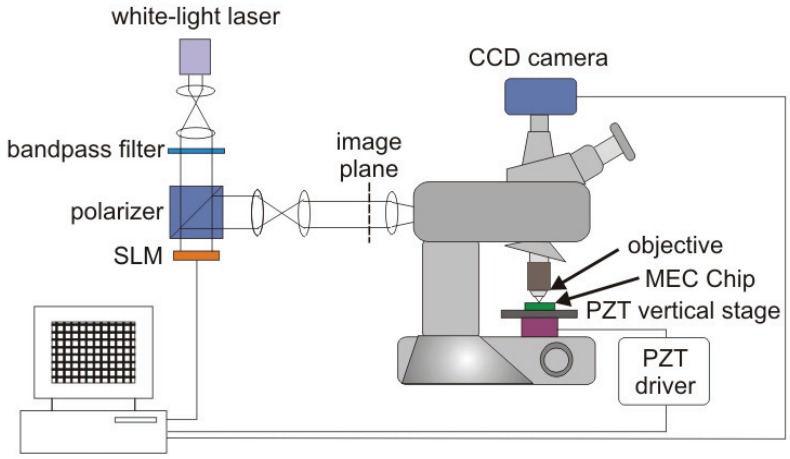


**Fig. S2** Setup of the SINAP system. SLM, spatial light modulator. PZT, piezoelectric transducer.

The operation and calibration procedures of the SINAP technique was reported in our previous publication.[2] In brief, we captured 5 frames with the patterned illumination on the specimen and composed them into a new frame with a simple superimposing calculation in the Fourier domain of the images. The composed image is axially sectioned and has lateral resolution about 0.3 wavelengths. We placed the surface of the specimen into the linear region of the axial response curves of the system to obtain nanometer depth sensitivity. Because the highest frame-refreshing rate of the SLM is 60 Hz, the maximum profiling speed of SINAP can be as high as 12 frames/sec.

## 3, Images of A549, BEAS-2B and CL1-0 cells

In addition to the CL1-0 cells, we also used the other human lung cancer cell line A549 and the human bronchial epithelial cell BEAS-2B to test the filopodial responses. Figure S3 shows the images of these three cell types without the electrical stimulation. On A549 and BEAS-2B cells we see very few long (>1 μm) and clear filopodia around the cell edges. In comparison, the CL1-0 cells exhibit more filopodia with lengths of several micrometers. Therefore, quantitative studies on the filopodial growth of A549 and BEAS-2B cells may not have significant biological meanings. Hence we only compared the filopodial growth of CL1-0 cells under dcEFs with that of CL1-5 cells in this work.

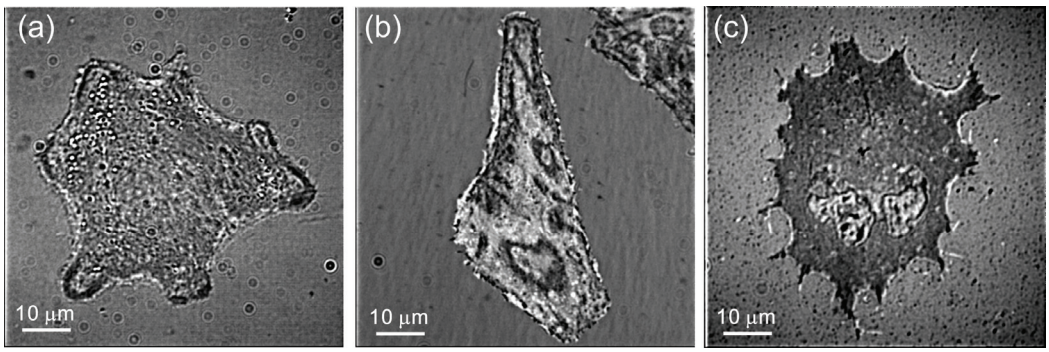


**Fig. S3** Images of an (a) A549 cell. (b) BEAS-2B cell. (c) CL1-0 cell. No electrical field is applied. The CL1-0 cell shows more filopodia with lengths of several micrometers.

## References

1. T. Schnelle, R. Hagedorn, G. Fuhr, S. Fiedler and T. Miiller, *Biochim. Biophys. Acta*, 1993, **1157**, 127-140.
2. C.-C. Wang, K.-L. Lee and C.-H. Lee, *Opt. Lett.*, 2009, **34**, 3538-3540.