SUPPLEMENTARY DATA

Supplementary Figure 1

Computational simulation of formation of electro-thermal vortices inside the PMMA chamber following actuation of electrodes: (A) the cold medium close to the glass substrate is dragged towards the centreline while deflected towards the last microelectrode pair, (B) the medium is driven towards the cold free surface, (C) the displaced medium bounces back along the sidewalls, (D) the medium is deflected towards the centreline to form a vortex, (E) the eye of vortex is evolved, (F) the vortex rapidly grows along its eye and moves parallel to the sidewalls until reaching the middle plane, (G) the eye of the vortex cannot proceed due to symmetry and forms the secondary vortex, and (H) the secondary vortex evolves and interacts with the initial vortex.

Supplementary Figure 2

Computational models of DEP responses during a necrotic cell death assuming cell death-associated cell swelling and thus increase in the diameter from the original 14 µm to 18 µm and 21 µm. The cytoplasm conductivity was reduced from the original 0.5 S/m to 0.35 S/m and 0.25 S/m. Subsequent conditions were modeled:

b1, b2 and b3: $\sigma_{\text{interior}}=0.5$ S/m (untreated cells) and $r_{\text{cell}} = 7, 9$ and 10.5 µm

c1, c2 and c3: $\sigma_{\text{interior}}=0.35$ S/m (middle stage of cell death) and $r_{\text{cell}} = 7, 9$ and 10.5 µm

d1, d2 and d3: $\sigma_{\text{interior}}=0.25$ S/m (late stage of cell death) and $r_{\text{cell}} = 7, 9$ and 10.5 µm

Note that volumetric changes only shifted the crossover frequencies of the cells and did not change the overall variation of the curves.
Supplementary Figure 3

Increasing the conductivity of suspending medium reduces the toxicity of DEP buffer and elongates the survival of cells over longer periods of time. This, however, reduces the positive DEP response of cells and weakens the immobilization of cells between the microelectrodes.

a $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 0.05 \text{ S/m (LEC buffer)}$;

b $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 0.1 \text{ S/m}$;

c $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 0.2 \text{ S/m}$;

d $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 0.35 \text{ S/m}$;

e $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 0.5 \text{ S/m}$;

f $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 1.0 \text{ S/m}$;

g $\sigma_{\text{interior}} = 0.5 \text{ S/m and } \sigma_{\text{medium}} = 2.5 \text{ S/m (RPMI 1640 buffer)}$
Supplementary Figure 1
Supplementary Figure 2

[Graph showing a comparison of different materials' resistivity with frequency.]

Legend:
- b1 0.55 S/m, 7 µm
- b2 0.55 S/m, 9 µm
- b3 0.55 S/m, 10.5 µm
- c1 0.35 S/m, 7 µm
- c2 0.35 S/m, 9 µm
- c3 0.35 S/m, 10.5 µm
- d1 0.25 S/m, 7 µm
- d2 0.25 S/m, 9 µm
- d3 0.25 S/m, 10.5 µm
Supplementary Figure 3

![Graph showing frequency response for different values of conductivity (σ) ranging from 0.05 S/m to 2.5 S/m.](image-url)

- **σ** values:
  - a: 0.05 S/m
  - b: 0.1 S/m
  - c: 0.2 S/m
  - d: 0.35 S/m
  - e: 0.5 S/m
  - f: 1.0 S/m
  - g: 2.5 S/m