

Electronic Supplementary Information

A fully integrated biomimetic microfluidic device for evaluation of sperm response to thermotaxis and chemotaxis

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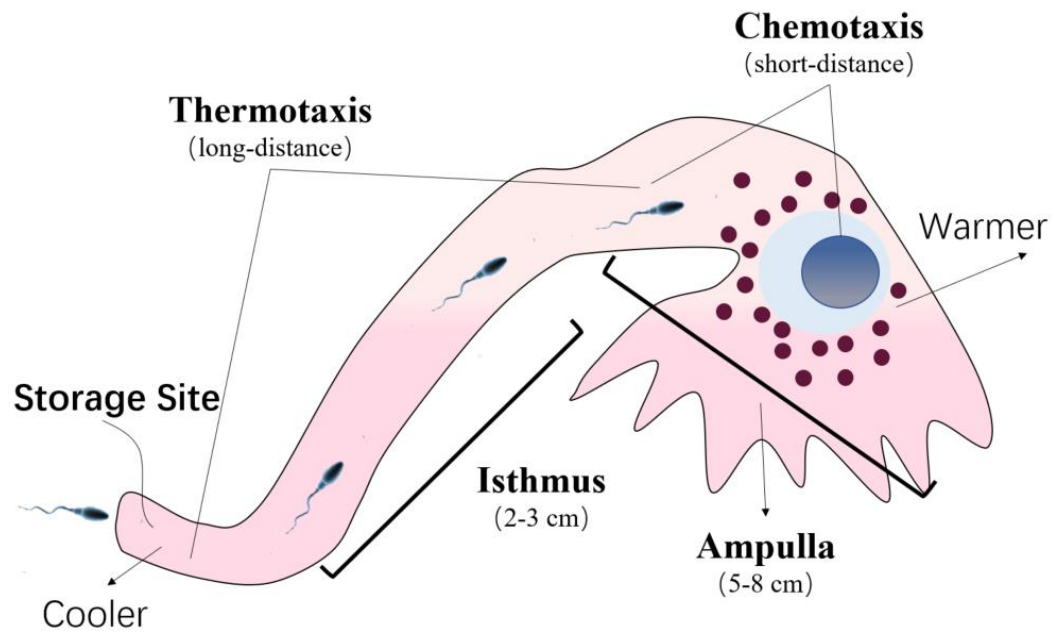


Fig. S1 Sperm guidance mechanisms in the mammalian female genital tract.¹ (The scheme, which is not drawn to scale)

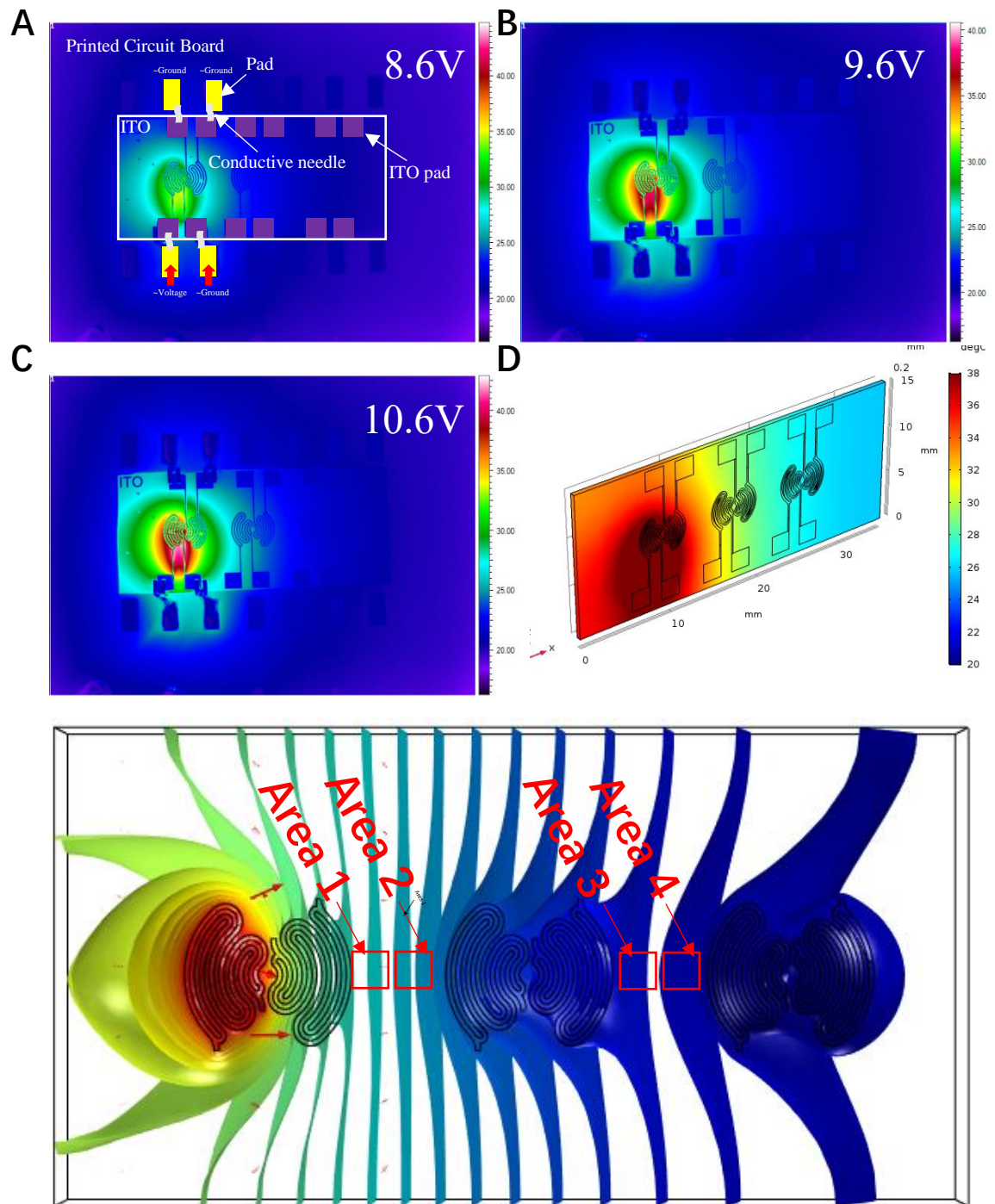


Fig. S2 Thermal imaging and numerical simulation of temperature distribution. (A-C) Results of thermal gradient on the chip by micro-thermal imaging when applied different voltages. (D) Thermal simulation of ITO. (D) Distribution of isothermal plane

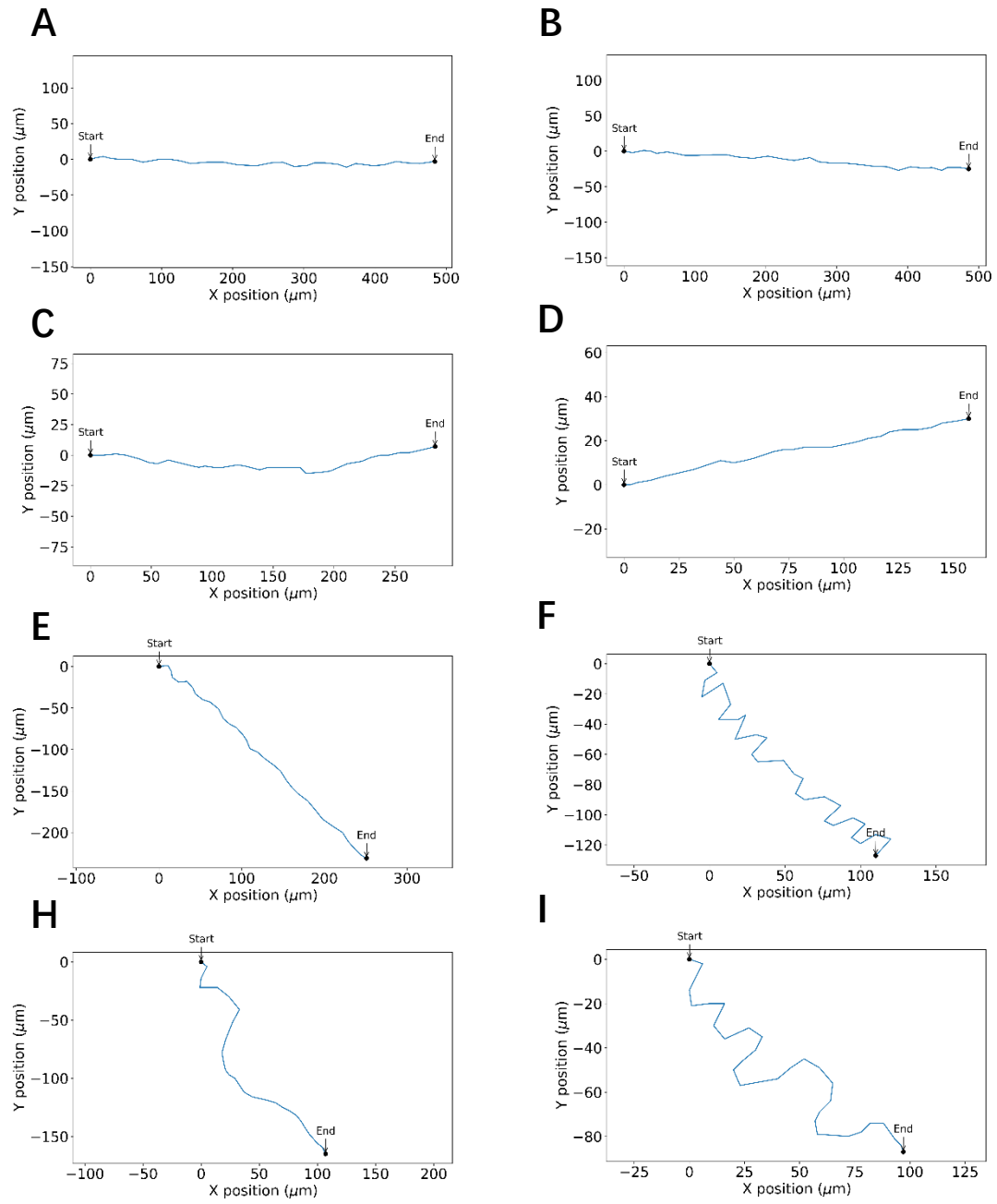


Fig. S3 Trajectories of functional sperm in Area 1~4, Area 5,5a, Area 6,6a.

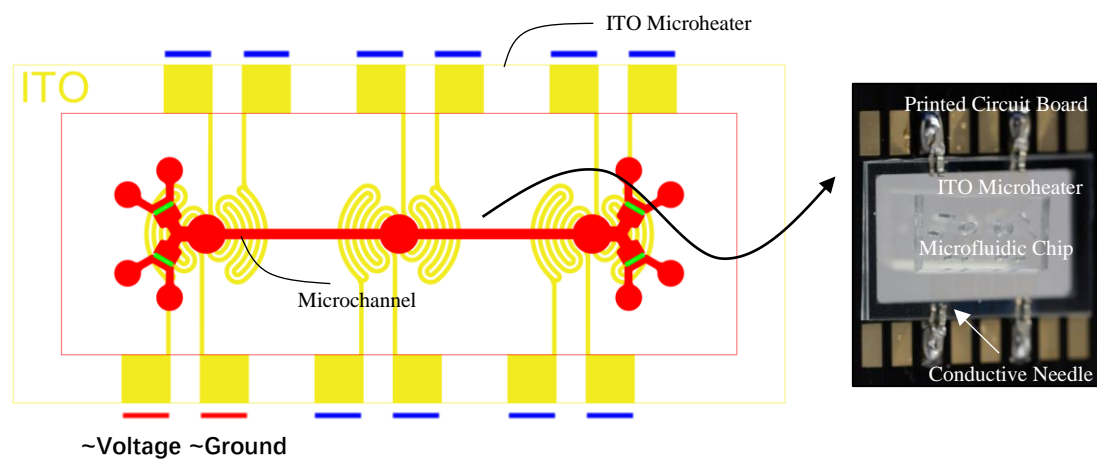


Fig. S4 Schematic demonstrating ITO microheater assembling.

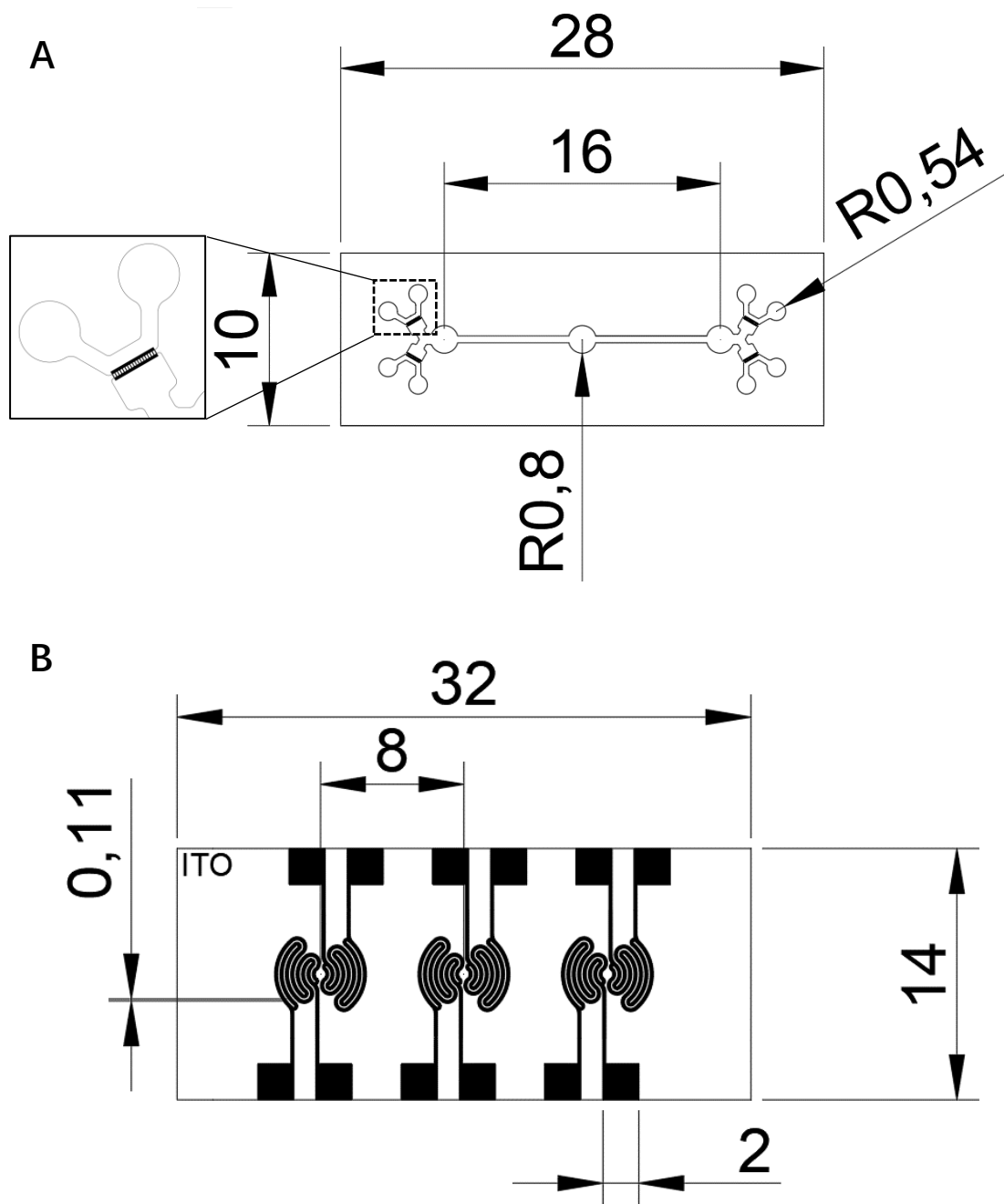


Fig. S5 (A) The design and dimensions of microfluidic chip. (B) The design and dimensions of ITO. (in mm)

Table S1. Sperm concentration and sperm motility grading rates of anonymized patient semen samples used in this study

Patient#	1	2	3	4
Serpm concentration ($10^6 \times \text{mL}^{-1}$)	140.56	290.51	94.38	107.71
Grade a (Rapidly progressive > 20 $\mu\text{m}/\text{second}$)	31.52%	34.68%	38.39%	40.88%
Grade b (slowly progressive 5-20 $\mu\text{m}/\text{second}$)	15.36%	21.33%	41.84%	16.41%
Grade b (Rapidly progressive < 5 $\mu\text{m}/\text{second}$)	5.80%	8.67%	3.14%	2.48%
Grade d (Immotile)	47.32%	35.34%	16.63%	40.4%

Table S2. Material properties for the heat transfer analysis.²

Material	Density (kg/m ³)	Specific heat (J/kg·K)	Thermal conductivity (W/m·K)
ITO	7000	369.4	3.2
Glass wafer	2230	753.789	1.13

Table S3. Meaning of the motility parameters.³

Parameter	Meaning
Straight-line velocity (VSL)	VSL is determined by finding the straight-line distance between the first and last points of the trajectory and correcting for time.
Curvilinear velocity (VCL)	VCL is the distance travelled by the sperm along its curvilinear path/s and is calculated by finding the sum of the distances along the trajectory then correcting for time.
Average-path velocity (VAP)	VAP is the distance the sperm has traveled in the average direction of movement in the observation period.
Linearity (LIN)	LIN is a comparison of the straight-line and curvilinear paths.
Wobble (WOB)	WOB is the expression of the relationship between the average and curvilinear paths
Straightness (STR)	STR is a comparison of the straight-line and average paths

Table S4. Description of directionality-based parameters⁴

Parameter	Description
ΔX	the net distance parallel to the gradient. X > 0 :the number of sperm with a net distance parallel to gradient higher than zero.
ΔY	the net distance perpendicular to the gradient
$\Delta X/ \Delta Y $	$\Delta X/ \Delta Y > 1$: the number of cells with the quotient between the net distance in X over the absolute value of the net distance in Y higher than the unit. That means sperm travel a longer distance in the direction of the temperature (chemical) gradient than in a gradient-less direction, perpendicular to the former

Movie S1. Thermotaxis sperm selection process. Sperm employ free swimming and thermotactic mode swimming through the temperature gradient region.

References

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4. M.E. Teves, F. Barbano, H.A. Guidobaldi, R. Sanchez, W. Miska, L.C. Giojalas. *Fertil Steril*, 2006, **86**, 745-749.