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Two-photon polymerization based microfluidic biochip incorporating a herringbone microchannel and deterministic lateral displacement design for efficient capture of circulating tumor cells

Keywords: Circulating tumor cell (CTC), Cell sorting, Microfluidic chip, Two-photon polymerization, Efficient capture

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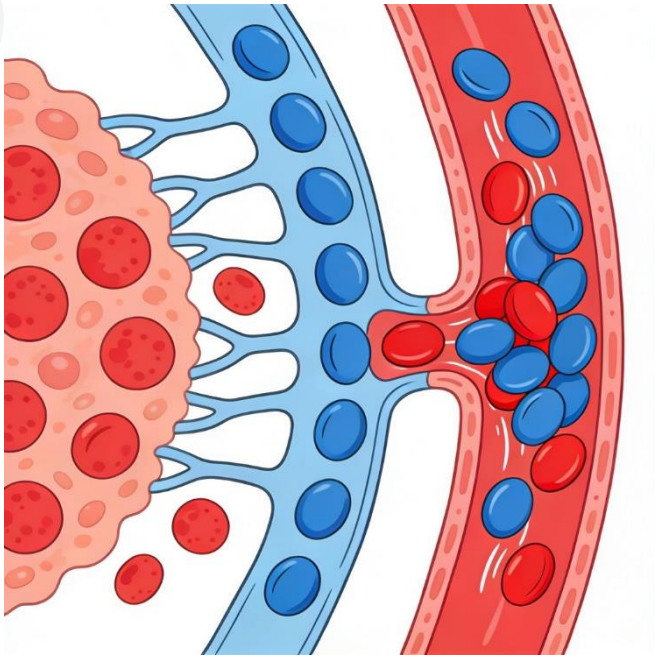
Background and Challenges

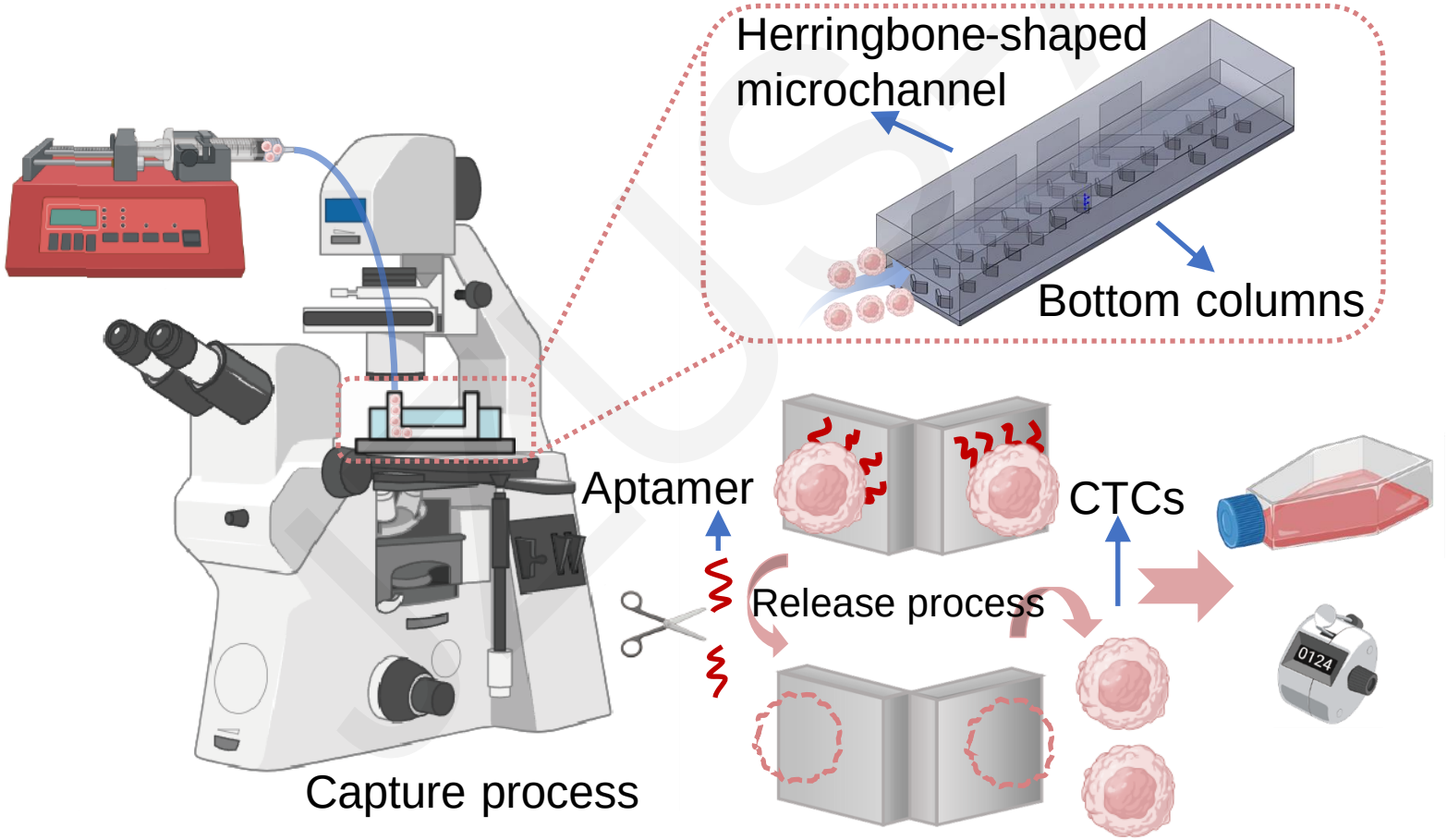
- **Circulating Tumor Cells (CTCs)** are cells shed from primary tumors into the bloodstream.
- Their enrichment and detection are crucial for cancer diagnosis, prognosis, therapy evaluation, and liquid biopsy.

- Existing CTC capture methods, including physical (e.g., size-based filtration, dielectrophoresis) and affinity-based (e.g., immunomagnetic) techniques, often struggle to balance **high capture efficiency, high purity, and preserved cell viability** simultaneously.



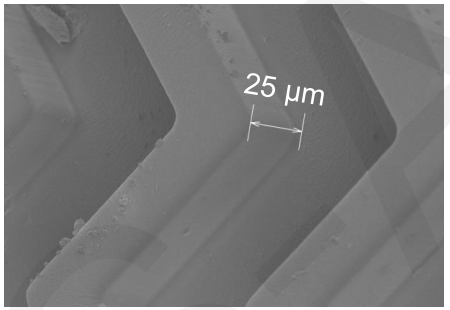
Chip Design and Fabrication

- **Chip Design:** This paper outlines the design, fabrication via two-photon polymerization/soft lithography, and experimental validation of a microfluidic chip for highly efficient and pure capture of circulating tumor cells.

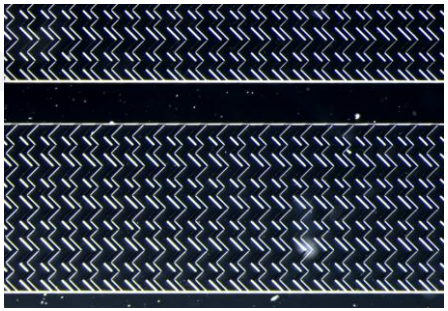


Chip Design and Fabrication

- **Chip Fabrication:** This figure illustrates the top PDMS herringbone microchannel and bottom TPP-printed microstructure, confirming fabrication accuracy and system assembly for CTC capture.



(a)



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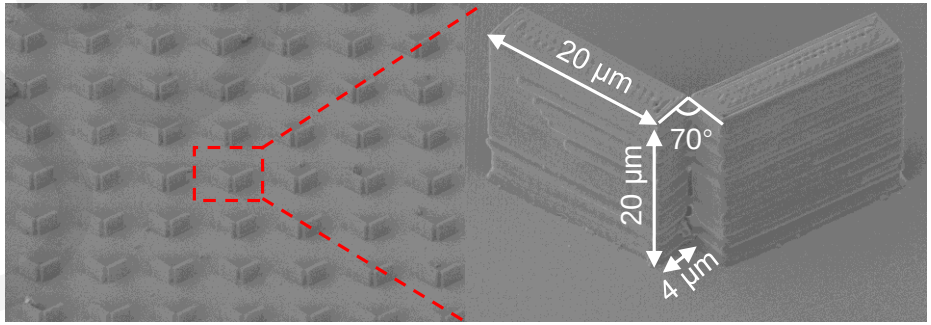

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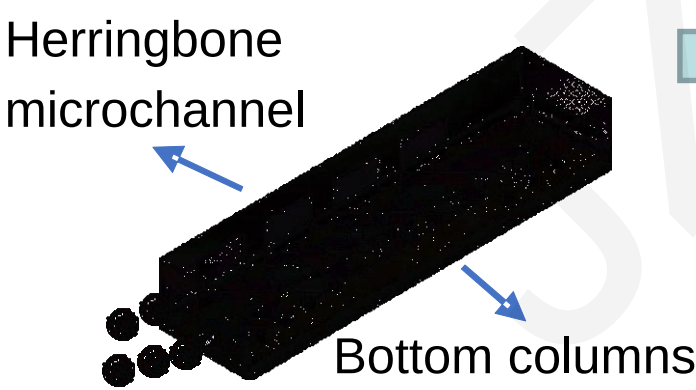
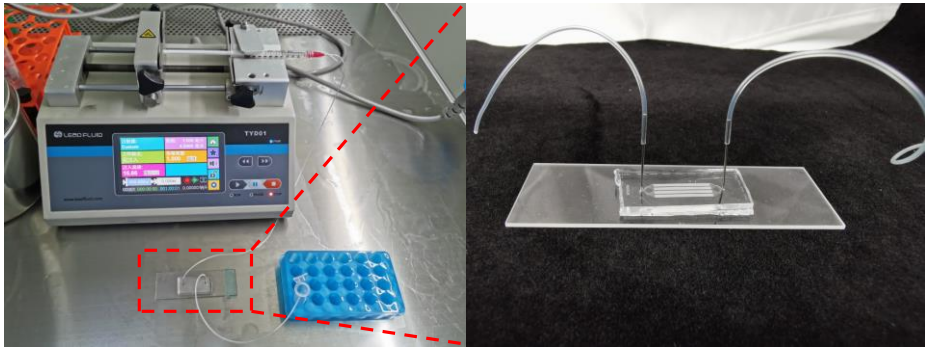
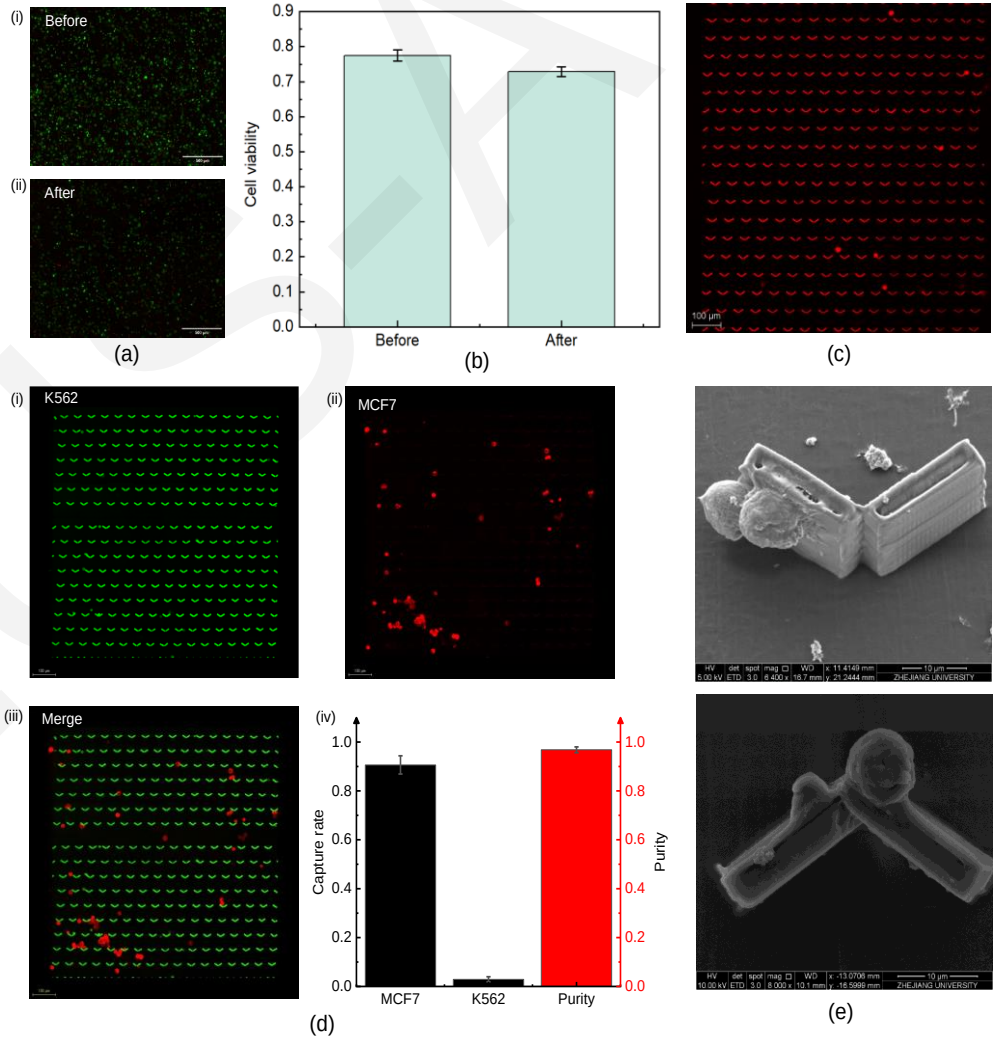




(d)

Chip Performance Characterization

- **High Capture Efficiency:** The chip demonstrates a high capture efficiency of approximately 91.87% for target EpCAM-positive MCF-7 breast cancer cells.
- **Controllable Release with Preserved Viability:** Captured cells can be released with an efficiency of about 77.57%. The released cells maintain high viability (~94.08%).
- **High Capture Purity and Specificity:** The achieves a capture purity of approximately 96.83% for the target MCF-7 cells, with a concurrent capture efficiency of about 90.63%.



Conclusions

- **Key Conclusions:** A microfluidic biochip integrating a herringbone mixer and a DLD array achieves balanced high-performance capture, high-purity enrichment, and viable release of circulating tumor cells (CTCs).

- **Future Research Directions:** Future work will focus on developing a semi- or fully-automated platform to integrate all steps, aiming to improve reproducibility and efficiency for clinical liquid biopsy applications.