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Using Programmable Sound Waves to Control and Assemble Microscopic Particles

Stanford scientists have developed a versatile platform that uses tunable sound waves to precisely manipulate and concentrate microscopic particles, cells, and biological materials with high throughput and efficiency. This technology can be easily integrated with existing microfluidic systems and standard equipment, offering a transformative method for cell sorting, diagnostic testing, and biomedical sample preparation in applications ranging from cancer diagnostics to drug development.

Precise manipulation of microscopic particles is essential for many biomedical applications, but current methods are limited by their inability to dynamically control particles in real-time. Traditional acoustic systems require expensive equipment and complex modifications to adjust particle positioning, creating a significant barrier to widespread adoption in clinical and industrial settings. Current approaches that use rigid metasurfaces can only trap particles at fixed locations based on the surface geometry and require fabrication of new surfaces to change trapping locations. The lack of dynamic control capabilities in existing systems severely limits their practical applications, suggesting that overcoming this limitation could dramatically expand the utility of particle manipulation technology.

Testing of the DReAM platform demonstrated successful isolation and concentration of various biomarkers, including circulating tumor cells and extracellular vesicles, from flowing biological samples. Importantly, the system achieved this using standard microfluidic equipment and off-the-shelf components, suggesting its immediate practical viability for clinical applications. Consequently, this technology has the potential to transform early disease detection and precision medicine by enabling rapid, efficient isolation of critical biological markers on demand.

Stage of Development

- Proof of concept
- Continued research: testing the system and its utility in isolating and concentrating large extracellular vesicles and oncosomes

Applications

- Isolation of biomarkers for early cancer detection and liquid biopsy
- High-throughput particle sorting and enrichment in microfluidic devices
- Assembly of 3D biomaterials for organoid engineering
- Studies of colloidal crystals and soft matter physics

Advantages

- Dynamic, real-time control of particle manipulation without hardware modifications
- Seamless integration with standard microfluidic systems and commercial components
- Versatile platform compatible with various biological samples and particle types
- Gentle, non-contact method suitable for handling delicate biological materials

Patents

- Published Application: WO2025212658

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