VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Antonio Maisto**

The public defense will take place on **Wednesday 23rd September 2026 at 5pm** in room **LIC.0.04 Learning Theatre** (Building LIC, VUB Main Campus)

To join the digital defense, please register here

ADVANCING ACOUSTOFLUIDIC PARTICLE HANDLING AND SEPERATION FOR MICRO- AND NANOPARTICLES

BOARD OF EXAMINERS

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Abstract of the PhD research

The thesis aims for improvement and practical implementation of acoustofluidic particle handling, bridging the gap between fundamental physical principles and industrially relevant applications. Acoustofluidics, a transdisciplinary field of microfluidics, utilizes acoustic waves to control fluids and suspended matter on the micron scale. While passive microfluidic methods rely on hydrodynamic phenomena, acoustofluidics provides an externally controllable field for non-contact, bio-compatible manipulation.

The research is structured to transition from a fundamental understanding of mechanical vibration dynamics to the practical challenges of high-throughput separation and nanoscale manipulation. The initial phase of the work focuses on electromechanical coupling between piezoelectric (PZT) actuators and microfluidic devices. By employing Laser Doppler Vibrometry (LDV), the relationship between the vibration dynamics of the system and the resulting acoustofluidic forces is established. A key finding is the impact of signal modulation, such as frequency sweeping, on the stability and strength of the acoustic field. This foundational knowledge allows for the selective enhancement of either acoustic streaming or acoustophoresis, providing a framework for optimizing device performance based on specific target particles. A significant portion of the research is dedicated to overcoming the 'critical diameter' limitation in conventional acoustophoresis. In standard devices, nanoparticles are often dominated by acoustic streaming vortices, making them difficult to focus or separate. This thesis demonstrates that by implementing high aspect ratio channels, the acoustophoretic force can be extended to particles in the nanoscale range with dimensions down to a size of 200 nm, by suppressing streaming in the central region of the device. This development is crucial for applications in nanomedicine and the processing of high value biomolecules, where precise control over sub-micron matter is required. Furthermore, the study addresses the challenges of scaling acoustofluidic technologies for industrial use. Handling high solid loads (up to 10 wt.%) and achieving high throughput (0.2 L/h) leads to significant thermal issues due to the high power actuation required. To solve this, an in-house Peltier-based cooling system was developed. This system enables the continuous separation of highly concentrated suspensions, such as polydisperse glycine crystals, by maintaining temperature stability and preserving the integrity of the acoustic resonance. The integration of these cooling strategies, combined with optimized channel geometries, paves the way for acoustofluidics to become a robust and scalable tool for chemical and pharmaceutical processing. Ultimately, this work provides both the fundamental insights and the practical engineering guidelines necessary for the next generation of acoustofluidic platforms.