Viscosity-sensors
The Institute for Microelectronics and Microsystems at the Johannes Kepler University Linz performs research on sensors for various physical properties. Besides optical, thermal and biochemical sensors also viscosity-sensors are investigated. Viscosity is a measure for the resistance of a fluid against flow and thus affects its flow behavior. Many of the investigated sensors utilize the principle of resonant micro sensors. Here, mechanically oscillating structures are immersed into the viscous fluid to be tested. Due to the interaction with the fluid, the oscillations are damped, where a higher viscosity leads to a stronger damping. Therefore it is possible to calculate the viscosity from the measured damping.

From the idea to the prototype
During the project Process Analytical Chemistry Projekt (PAC), a so called “Levitating Sphere Viscometer” was developed and patented. The system is based on a freely levitating permanent magnet (floater magnet) which is electromagnetically excited to perform mechanical oscillations (see Fig 1). In the current project “K-Projekt imPACts” the idea was refined and a working demonstrator was built. The advantages of this special sensor system are the entirely spatial isolation of the measurement chamber from all actuation or readout systems and the high number of different oscillation or motional modes which can be used for measurements. During the measurement only the floater magnet and the measurement chamber are in contact with the fluid. No mechanical or electrical connections into the measurement chamber are necessary. This makes the system especially interesting for toxic, corrosive or sterile fluids.

Due to the flexible electromagnetic actuation, various different movements of the measurement body can be excited. Linear movements along the vertical axis and also rotational oscillations along the horizontal axis are feasible. Furthermore it is possible to bring the floater magnet into a rotational motion around the vertical axis. Each vibration mode yields certain
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Measurement characteristics that can be utilized to gain more detailed insights.

![Measurement characteristics](image1)

**Fig. 1:** Detailed view of the measurement chamber containing all actuation and readout coils.

The actuated oscillations are damped by the fluid in the measurement chamber, which allows calculating the viscosity. To do so, first the frequency response of the system is measured performing a frequency sweep near the resonance frequency (see Fig 2). In a second step the quality factor of the resonance is calculated. This factor is related to the viscosity of the fluid.

**Cooperations**

For the research on sensors it is essential to have access to the experience and the knowledge of the industry that will potentially apply the investigated device or system. The network of company partners in imPACts covers a large spectrum of different branches in the chemical and biochemical sector. Close collaboration with different company partners allow to consider their requirements already during the ongoing research and in the design phase.

![Frequency response](image2)

**Fig. 2:** Frequency response of the system while performing rotatory oscillations in different viscous fluids.

**Impact and effects**

Due to the improvement of sensors and the integration of inline-viscosity sensors in chemical and biochemical production processes, it becomes possible to improve and optimize process control systems. This leads to increased quality and output combined with reduced production costs.

The results of the sensor development achieved within the imPACts project were published in peer-reviewed international scientific journals.

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**Contact and information**

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