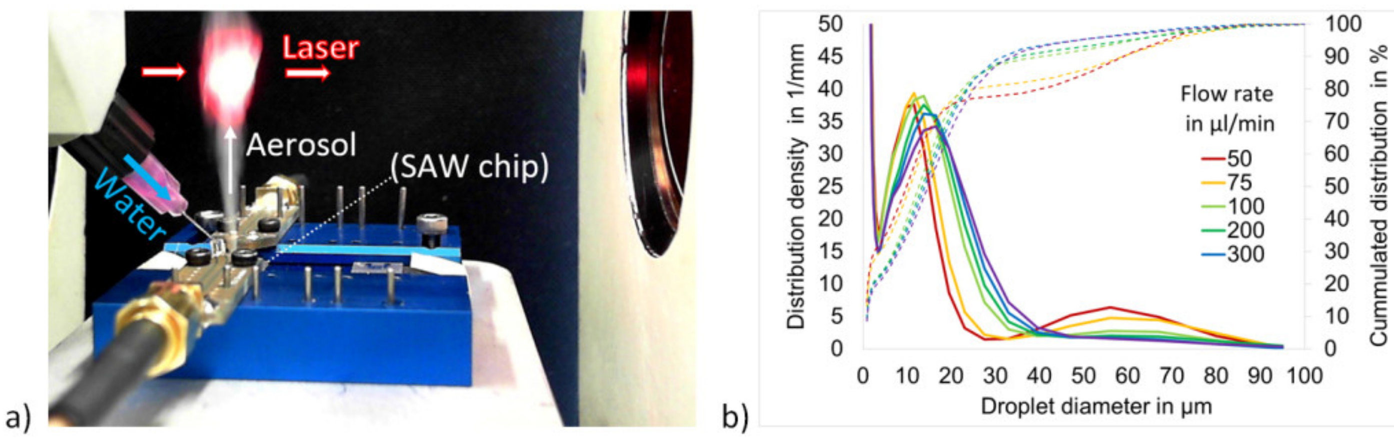
# Chip-based microacoustic aerosols generators

Aerosols consist of a large quantity of either liquid droplets (fog, mist) or solid particles (dust, smoke) dispersed in a surrounding gas (e.g. air). They occur naturally and they can as well be generated artificially, e.g. by pressing fluids through tiny nozzles or by electrospray techniques. Artificially generated aerosols already have widespread application in our today's world. They are used to create colourful or functional coatings, for cosmetic purposes like in perfumes, for medical treatment of respiratory diseases, in fuel injection systems and for various other applications. Unfortunately, there are still limitations of conventional aerosols sources such as a low control over the droplet size, the clotting of nozzles, a lack of applicability to a variety of liquids and the bulky size of most generators combined with high power needs. Miniaturized aerosol sources could overcome some of these limitations and enable completely new fields of application, including hand-held inhalators, olfactory sources integrated in virtual reality devices for an increased degree of immersion, and small aerosol-based printers for electronics.




a) SAW generated aerosol with a microchannel fluid supply in a setup for laser diffractometry droplet size measurement; b) Measured droplet size distribution for different fluid flow rates (Reproduced from Winkler et al., 2015, with permission from the Royal Society of Chemistry)

In the SAWLab Saxony, we investigate microacoustic devices including chip devices based on surface acoustic waves (SAWs). Such mechanical waves propagating along the surface of solids are well known from earthquakes, but can also be excited in a controllable manner on the small scale on piezoelectric crystals like quartz or the artificial lithium niobate ($LiNbO_3$). The devices needed for the wave excitation can be produced mass-produced cheaply by lithography techniques on circular wafers, similar to the fabrication of semiconductors. An interaction of a SAW with a fluid on the chip surface can lead to the production of an aerosol, without the need for nozzles, pumps or macroscopically moving parts. These aerosols are characterized by a small droplet size (few microns diameter), a droplet speed of up to some m/s and a production rate of up to 0.5 ml/min. SAW-based fluid atomizers have shown great potential for miniaturization and can lead to an economic device production. However, their potential was limited in the past by inadequate fluid supply methods, i.e. the technological means of delivering the fluid to the chip surface. Existing methods incorporating wetted tissues or fluid-filled capillaries thereby lack the suitability for mass production and have a low accuracy and reliability.

Our contribution to this field is the development of a new fluid supply method, based on fluidic microchannels with the height and width of about the diameter of a hair incorporated in epoxy resin structures on the chip surface. The realization of these channel structures with an innovative lithographic technique is fully compatible to wafer-scale manufacturing and, therefore, can be done on the mass scale. By taking into account the special properties of the acoustic wavefield for the channel outlet placing, a precise and stable aerosol production with a small aerosol plume-opening angle can be achieved with several centimetres of coverage. Additionally, we also demonstrate the possibility of *in-situ* altering the droplet size distribution by controlling the rate of fluid flow through the microchannels.

Summarized, we demonstrate a very promising approach for economic mass-scale production of SAW fluid atomizer chips with the ability to produce tailored aerosols for hand-held and even disposable devices.

## Publication

[SAW-based fluid atomization using mass-producible chip devices.]
Winkler A, Harazim SM, Menzel SB, Schmidt H
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