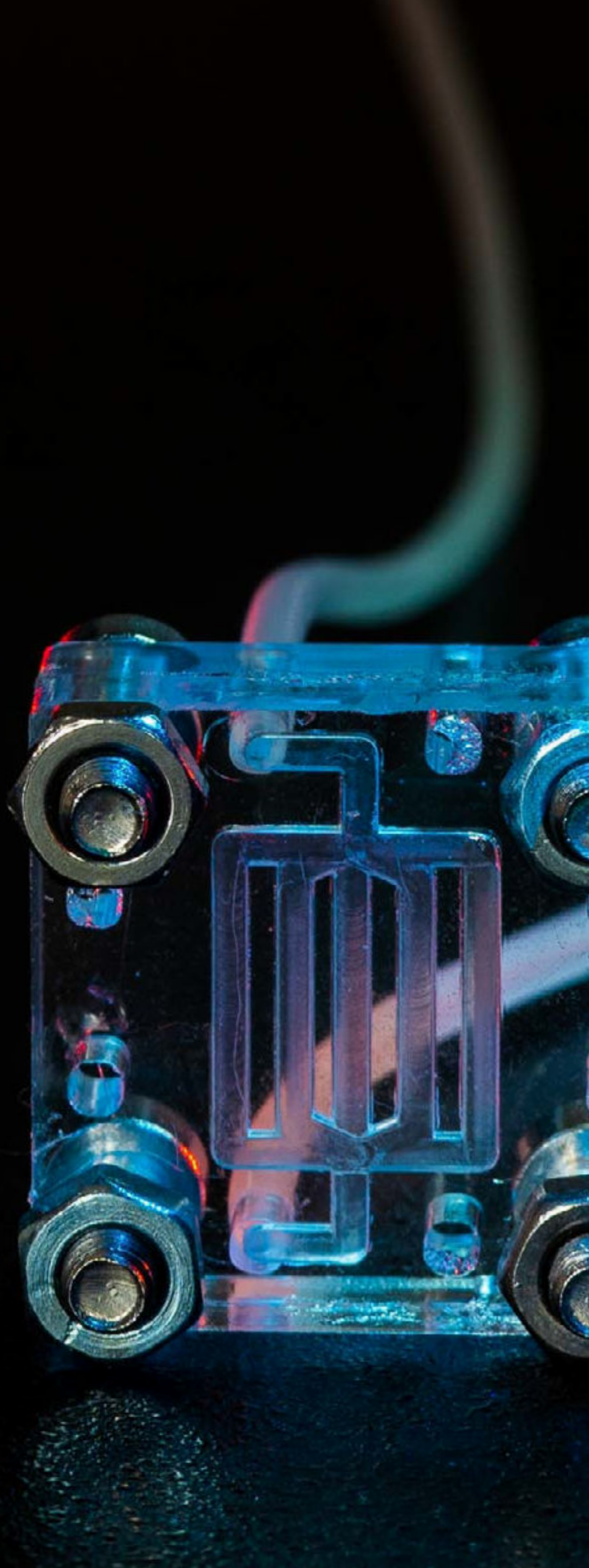
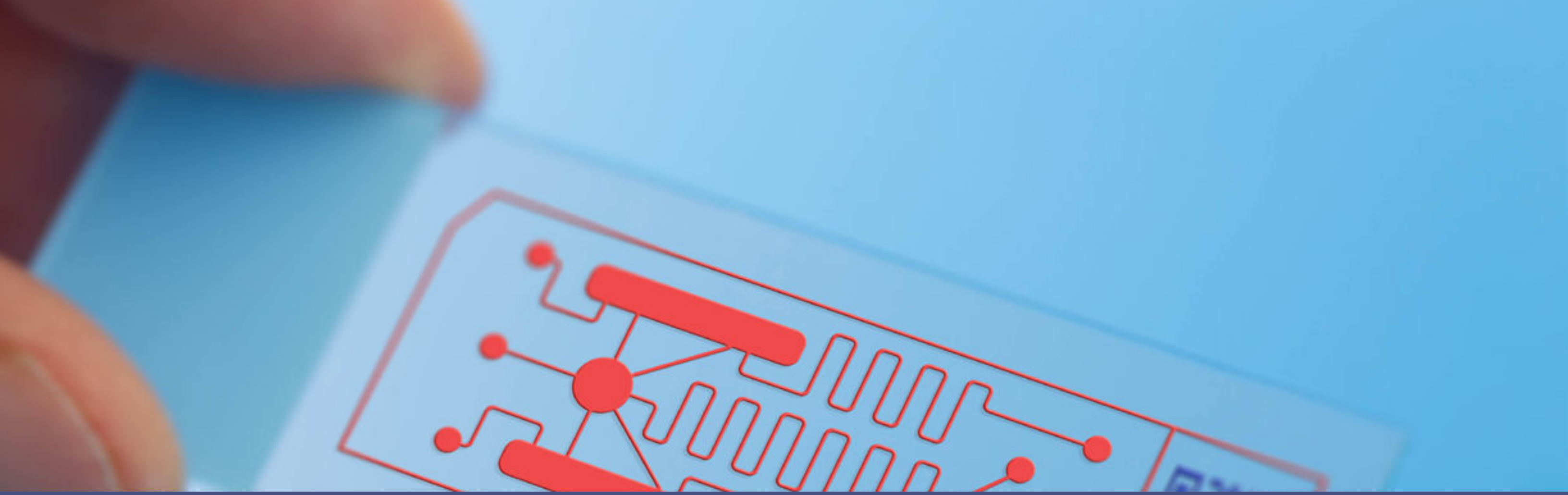


APPLICATION NOTE

# ENHANCING MICROFLUIDIC MEASUREMENTS WITH SPECTROSCOPY



## INTRO

# BACKGROUND INFORMATION

**Microfluidics has proven invaluable in various scientific and engineering disciplines, encompassing everything from producing polymer microbeads to miniaturized liquid chromatography. Among these disciplines, it is undeniable that the greatest impact of microfluidics has been in the realm of biological and biochemical sensing technology.**

**While there is some debate regarding what exactly constitutes a microfluidic system, the most widely accepted definition is any device in which liquid flows through one or more channels under 1 mm in diameter. Microfluidic channels are traditionally fabricated using patterning, molding, or engraving, but recent advances in high-resolution additive manufacturing technology have enabled 3D printing of microfluidic devices, significantly reducing production costs.**

While the exact dynamics within microfluidic channels are beyond the scope of this application note, it is crucial to note that microfluidic channels produce laminar flows of uniform droplets. This has several advantages when compared to larger flow channels, including smaller sample requirements, decreased reagent consumption, lower limits of detection, lower optical power requirements, and air/oil-gapped droplet formation.

The narrow path length and low overall volume of microfluidic devices have excellent optical properties but typically require active pumping to generate flow. Electro-osmotic pumping is one common approach, where a large voltage is applied across the channel to generate flow, taking advantage of the surface ions within the channel walls. Two other examples are Peristaltic and Venturi pressure pumps which are becoming more commonly used in recent years as the size and cost have decreased.

## LOW-COST WITH HIGH SENSITIVITY

Recently, a research team led by James Grinias at Rowan University demonstrated that 3D-printed peristaltic pumps and low-cost commercial Venturi pumps could "provide stable flow (<2% RSD) over a range of 1 to 7 mL/min and high reproducibility in signal intensity at a droplet generation rate around 0.25 Hz (<3% RSD), which are comparable in performance to similar measurements on standard syringe pumps."[1] In the same article, Grinias and his team went on to verify that both low-cost pumps performed equivalently to more traditional syringe pumps used in laboratory microfluidics measuring a 500 nM resorufin solution with a fluorescent microscope and a xenon lamp (see Fig. 1).

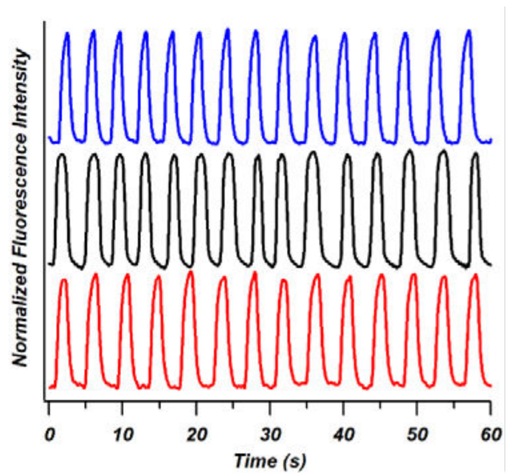



**FIGURE 1:** Comparison of droplet formation rate and signal intensity for three flow generation techniques. Droplet streams for a syringe pump (red trace), a peristaltic pump (black trace), and a Venturi pump (blue trace).[1]

Alternatively, microfluidic channels can use capillary actions, removing the need for a pump entirely. This is accomplished by carefully engineering the microchannels with appropriate surface tensions, wetting properties, and internal geometry causing the fluid to flow and stop without external control. This reduction in cost and complexity of microfluidic devices (channels and pumps) makes them ideal for portable sensing applications. Combined with low-cost, miniature UV and visible spectrometers, these devices together can provide powerful analytical tools for any environment.

## LAB-ON-A-CHIP SEPARATION CAPABILITIES

Furthermore, in multichannel microfluidic systems, the channels can be designed to serve as filters separating various component analytes, further improving both specificity and detectability. This can be accomplished by designing the various channel widths to promote size-exclusionary transport or by integrating microfilters. One exciting example of a multichannel microfluidic filter was recently presented by Goncalves et al. in the journal Processes.[2]

Here, the authors demonstrated a 9-channel microfluidic device consisting of internal filters comprised of arrays of pillars. This device, shown schematically in Figure 2 on the next page, was used to separate red blood cells (and synthetic micelles) from plasma in both human and simulated blood.

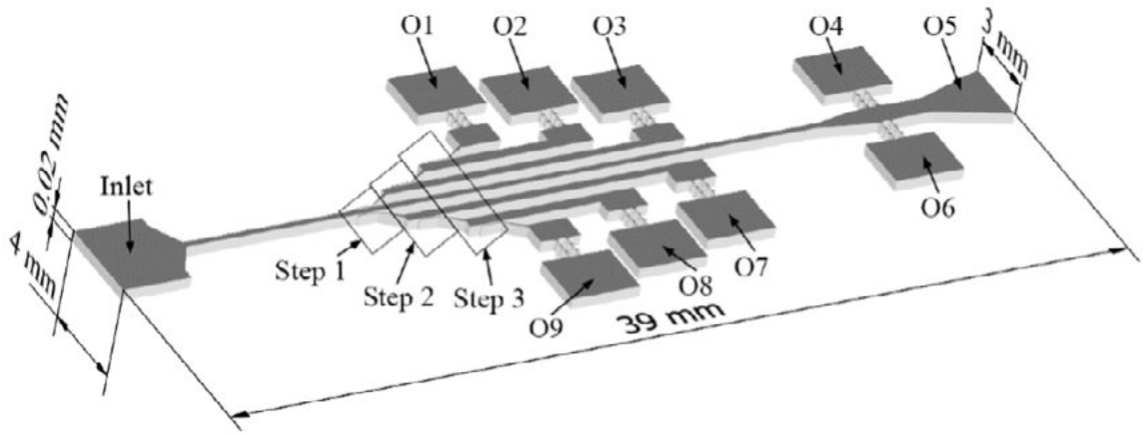



**FIGURE 2:** Schematic representation of microfluidic red blood cell filter designed by Goncalves et al.[2]

The authors used optical absorption spectroscopy to analyze the separation efficiency of the various channel outlets labeled O1 through O9 in Figure 2. To accomplish this, they used a 200 W tungsten halogen light source fiber coupled to an Avantes AvaSpec-ULS2048XL-EVO spectrometer (shown in Figure 3) with a 230 – 720 nm spectral range.

Using the 412 nm hemoglobin absorbance band, they determined the relative concentration of red blood cells in each outlet. These results clearly demonstrated lower red blood cell collection efficiency in the first two outlets, O1 and O9; comparable efficiency in the central outlets O2, O3, O7, and O8; and slightly higher efficiency in the final outlet, O5.

The authors also observed a significantly larger volume from O5 compared to the other outlets. Outlets O4 and O6 collected such low volumes that they could not be analyzed spectrally.


**FIGURE 3:** Avantes AvaSpec-ULS2048XL-EVO

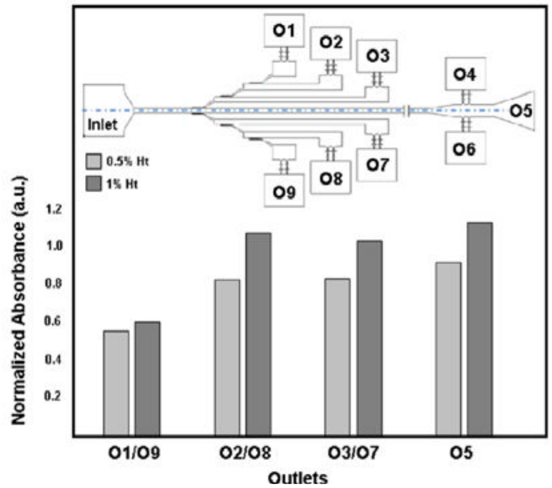



**FIGURE 4:** Normalized absorbance spectrum (a.u.) at 412 nm of the samples in the inlet and collected from the outlets of the microchannel.[2]

While in this study, the authors chose to collect the output from each channel in reservoirs and analyze the samples after the fact; one can easily envision a reader with integrated spectral analysis. This type of microfluidic lab-on-a-chip biosensor can enable low-cost point-of-care blood cell separation and analytics.

# AVANTES SPECTROMETERS & MICROFLUIDICS

In the realm of microfluidics, the integration of spectrometers holds great potential for a wide range of applications. This overview of spectrometers can be used to explore their unique capabilities in the context of microfluidic measurements.

The Avaspec-ULS2048CL-EVO shines in basic measurements within the UV and visible wavelength range. With its broad spectral coverage, it offers researchers the ability to analyze a diverse range of samples in microfluidic systems. Whether it's measuring absorbance, fluorescence, or scattering, the Avaspec-ULS2048CL-EVO proves to be a versatile workhorse.

Equipped with high-resolution optics and sensitive detectors, the Avaspec-ULS2048CL-EVO provides researchers with precise and accurate results. It is a reliable tool for chemical analysis, biomolecular interactions, and environmental monitoring within the microfluidic realm.

When high sensitivity is the game's name, the Avaspec-ULS2048XL-EVO steps into the spotlight. Designed with advanced detection capabilities, it surpasses its counterparts in detecting low concentrations of analytes within microfluidic samples. With a focus on trace analysis and a higher signal-to-noise ratio, the Avaspec-ULS2048XL-EVO enables researchers to push the limits of microfluidic measurements.

In applications where quantities of analytes need to be identified and quantified, the Avaspec-ULS2048XL-EVO takes the stage. Biomolecular studies such as DNA sequencing, protein analysis, and cellular assays benefit from its exceptional sensitivity, unraveling the intricate details of the microfluidic world.

For those instances when low light levels demand extended integration times, the Avaspec-ULS2048x64TEC-EVO emerges as the master of patience. Equipped with optimized electronics, high-efficiency detectors, and cooling, it excels in capturing and measuring the faintest of signals within microfluidic systems. The Avaspec-ULS2048x64TEC-EVO lends itself to environments where sensitivity is paramount, even when faced with challenging conditions.

By accommodating longer integration times, the Avaspec-ULS2048x64TEC-EVO unveils hidden insights in microfluidic samples. It proves invaluable in fields such as environmental monitoring, where minute traces of pollutants or pathogens require meticulous measurement and analysis.

## CONCLUSION

It becomes clear that each spectrometer brings its unique strengths to the world of microfluidics. The Avaspec-ULS2048CL-EVO caters to basic measurements in the UV and visible range, providing a versatile analytical tool. The Avaspec-ULS2048XL-EVO takes center stage when high sensitivity is essential, enabling the detection of trace analytes within microfluidic samples. The Avaspec-ULS2048x64TEC-EVO steps in when low light levels and extended integration times call for patience, unraveling secrets hidden in the microscale world.

Together, these spectrometers empower researchers and scientists to explore the intricacies of microfluidics, advancing our understanding of chemical processes, biomolecular interactions, and environmental dynamics. With their combined capabilities, these spectrometers pave the way for groundbreaking discoveries and practical applications in various fields, heralding a new era of microfluidic exploration.

For more information about the full range of spectrometer options available from Avantes, please feel free to visit the website at www.avantes.com or give us a call at +1 (303)-410-8668 where our knowledgeable applications specialists are standing by to help.

## REFERENCES

1. Analytica Chimica Acta. (2021); doi.org/10.1016/j.aca.2021.338230
2. Processes 2022, 10 (12), 2698; https://doi.org/10.3390/pr10122698

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