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## Photonic lab-on-a-chip, a versatile and powerful tool for R&D studies on spent fuel reprocessing

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The study and development of present and future processes for the recycling of spent nuclear fuels require many steps, from design in the laboratory to setting up on an industrial scale. Analysis and instrumentation are crucial in all of these steps. These developments are increasingly carried out on milli/microfluidic devices for scientific reasons (small-scale studies, control of phenomena, etc.) and to minimize costs, risks, and waste. The logic is the same for the chemical analyses associated with their follow-up and interpretation. Due to this, over the last few years, opto/microfluidic analysis devices adapted to the monitoring of different processes (dissolution, liquid/liquid extraction, precipitation, etc.) have been increasingly designed and developed. This communication will review 5 years of photonic lab-on-a-chip (PhLoC) development and show how this technology (cf. Figure 1) can be a suitable and powerful tool to monitor several steps along the PUREX process (Plutonium Uranium Reduction Extraction).

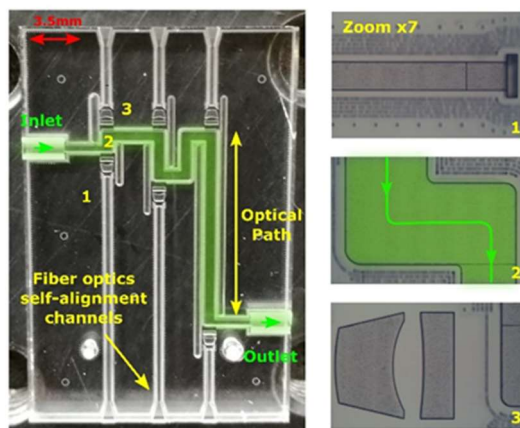


Figure 1: Left, typical picture of a glass made PhLoC with three optical path (1.0, 3.5 and 15mm) – Right, zoom on the main integrated optical elements.

This scientific communication will be organized as follows. First, the PhLoC concept and the integration of optical components at microfluidic scale on lab-on-chips will be reviewed. Second, different manufacturing processes as well as the suitability of the different materials for the harsh environment of nuclear process R&D will be discussed. Finally, based on the design shown in Fig. 1, two typical applications will be presented and discussed in detail:

- One on the use of the PhLoC platform has a tool to tackle actinides analysis in multiple oxidation states even in mixtures over wide concentration ranges and above all with the same degree of simplicity and accuracy of a lab-scale UV-Vis spectrometer, but using minute amounts of sample (Fig. 2 right).

- One on the measurement of optically diluted colloidal suspensions of silica ( $\text{SiO}_2$ ) and polystyrene nanoparticles, with sizes from 30 nm to 0.5  $\mu\text{m}$  and volume concentrations from 1 to 1000 ppm, for both static and dynamic flow conditions (Fig.2 left).

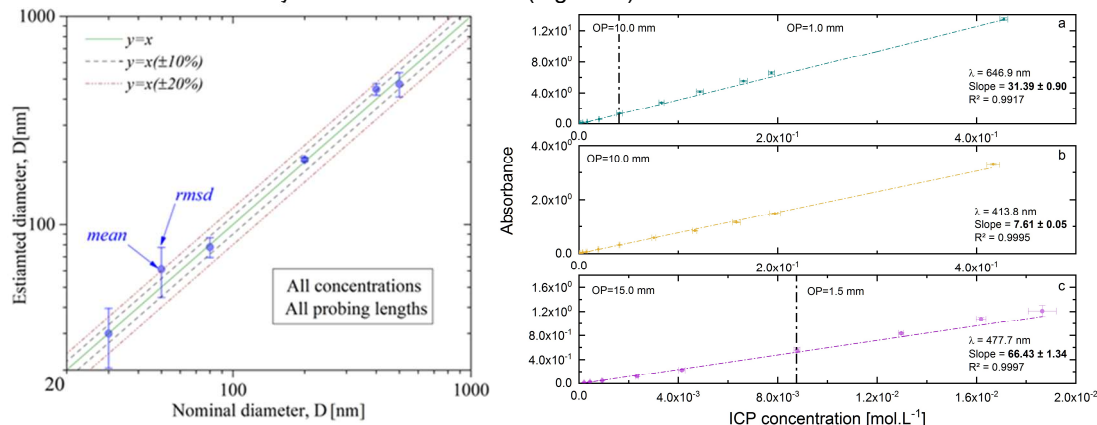


Figure 2: Left, nanoparticles mean diameter measurements for different calibrated suspensions ( $\text{SiO}_2$ , Latex); Right, Concentration measurements for three major actinides of the PUREX process, U(IV), U(VI), and Pu(IV).

As a conclusion, some perspectives and examples of future PhLoC design will be drawn, notably with regard to the characterization of more complex solid suspensions or the coupling of measurement techniques (e.g. UV-Vis and Raman spectroscopy).

## References

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