# Development of Quick and Remote Analysis for Severe Accident Reactor
# (4) Application of laser-induced breakdown spectroscopy to zirconium in aqueous solution

*Alexandre Ruas[1], Hironori Ohba[1], Katsuaki Akaoka[1] and Ikuo Wakaida[1]
[1]Japan Atomic Energy Agency

Abstract
This work deals with LIBS development, as a rapid, easy and remote analysis technique for monitoring the contaminated aqueous solutions in decommissioning of the Fukushima Daiichi nuclear power station (F1-NPS). A new setup using liquid jet was realized for element determination in aqueous solutions. Preliminary results on zirconium determination are shown. The system permits zirconium semi-quantitative determination down to reasonable concentrations (around 20 mg/L).

**Keywords:** LIBS, solution, zirconium, decommissioning

## 1. Introduction

The laser-induced breakdown spectroscopy (LIBS) is used for the real-time, in situ and remote elemental analysis without any pretreatment. These advantages are very interesting for the post-accident environment analysis inside F1-NPS and for monitoring the contaminated aqueous solutions in decommissioning process. But it is difficult to use LIBS with liquid samples because splashes and ripples that form on the liquid prevent efficient detection of plasma emission in the ablation. However, using liquid jets can cost-effectively counter balance this issue. In this context, the present study focuses on the zirconium determination in aqueous solutions, as a major element of the debris material.

## 2. Experimental setup

The liquid recirculation system consists of a reservoir, a pump, and a slit-type nozzle equipped with XYZ motion and a rotation stage. The liquid jet of the sample solution is formed by a trapezoidal-shaped grooved nozzle tip composed of stainless steel with a nozzle exit of 0.6 mm × 0.3 mm (Metaheuristic JAPAN, Type L), similar to a double-razor-blade nozzle. The pulsed Nd:YAG laser (fundamental) is focused on the thickest region of the liquid-sheet jet.

## 3. Results, discussion and conclusion

The LIBS experimental conditions were optimized, in particular the laser energy and the acquisition delay, to determine the most suited parameters for zirconium analysis in aqueous solution. A energy of 75 mJ/pulse, a gate delay value of 15 μs, a gate width of 20 μs and an acquisition focused on the 475 nm region seems appropriate for observing efficiently ZrI emission high intensity transitions. Despite zirconium very high ionization potential and the difficulties of conducting LIBS analysis on solutions, the liquid sheet system permits its semi-quantitative determination down to reasonable concentrations (around 20 mg/L).

**References**

[1] H. Ohba, M. Saeki, I. Wakaida, R. Tanabe, Y. Ito, “Effect of liquid-sheet thickness on detection sensitivity for laser-induced breakdown spectroscopy of aqueous solution”. Opt. Express. 2014. 22: 24478-24490.