*Transactions of the Korean Nuclear Society Autumn Meeting*
*Jeju, Korea, October 21-22, 2010*

# Cooperation on the Development of Laser-Induced Breakdown Spectroscopy (LIBS) Technology for Curium Ratio Monitoring

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## 1. Introduction

Curium balancing technology is used to measure neutrons that are released from the chemically generated curium within spent nuclear fuels or nuclear materials processed in hot cells, such as the Direct Use of Spent PWR Fuel in CANDU (DUPIC) or the Advanced Spent Fuel Conditioning Process (ACP). The content of plutonium is then calculated using the Pu/Cm ratio. Nuclear material accounting is a crucial process in the application of safeguards in the nuclear fuel cycle.

In an analysis of the characteristics of high-level radioactive nuclear materials under harsh circumstances, such as those in a hot cell or a glove box, conventional chemical analysis requires considerable time and cost. There are also limitations related to sample movement. Against this backdrop, laser-induced breakdown spectroscopy (LIBS) serves as a technology capable of addressing the various constraints.

LIBS technology can be used to analyze all elements in the periodic table at varying sensitivity levels. Requiring virtually no pre-treatment of test samples, it can be applied to a wide variety of samples and enables quick and nearly real-time analysis. For this reason, LIBS-based analysis is a non-destructive assay technique that generates no waste, saves time and cost significantly and enables system modification in various forms in accordance with user settings.

This equipment is installed not simply to analyze the characteristics of high-level radioactive nuclear materials but also to develop algorithms that can be applied by next-generation nuclear material accounting technologies. We are currently building a laboratory and procuring equipment that enables the use of U-samples.

## 2. Methods and Result

Enabling a sophisticated setting, LIBS has been applied to various fields of science and industry over the last 20 years. To analyze high-level radioactive nuclear materials in a hot cell or glove box, we have conducted joint research during this time by examining the basic principles of LIBS and its applicability and by carrying out preliminary tests at the Los Alamos National Laboratory (NANL) and the facilities of the Permanent Coordinating Group (PCG).

In the preliminary experiments for LIBS application, the measurement conditions were optimized and plasma characteristics analyzed in a vacuum based on a performance test of the basic metallic elements; as the preliminary measurement of the actinoids, quantitative analysis was conducted on the lanthanoids.

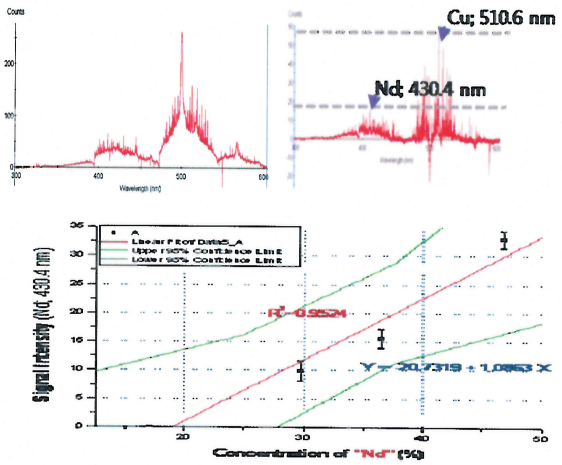


Fig. 1. Background method for Nd samples analysis

To analyze the characteristics of nuclear materials within a hot cell or a glove box, we arranged a laboratory for the use of uranium. We also submitted a Design Information Questionnaire (DIQ), which is currently being reviewed, via the Ministry of Education, Science and Technology (MEST) to the International Atomic Energy Agency (IAEA) to obtain approval of the application for the experiments in this study.

The system is comprised of the following: a high-output pulse laser that activates the to-be-measured test samples; a spectrometer; a detector; and a computer that acquires and analyzes the data. The spectrometer is useful for nuclear material analysis given its high resolution (0.0027 nm at 190 nm). It also has very feasible computer/software compatibility. Its simple accessories also ensure relatively easy quantitative and qualitative analysis. Basic installation will be done around mid-November of this year.

Fig. 2. Echelle Spectrograph with an ICCD camera for use in the wavelength range of 190-420 nm/ ESAWIN software

Therefore, NANL and KAERI will study, experiment and develop LIBS technology for the real-time monitoring of Pu/Cm ratios, as follows:

- Theoretical study of the LIBS technique for measuring spent nuclear fuels.
- Experimental study with material samples for physics verification

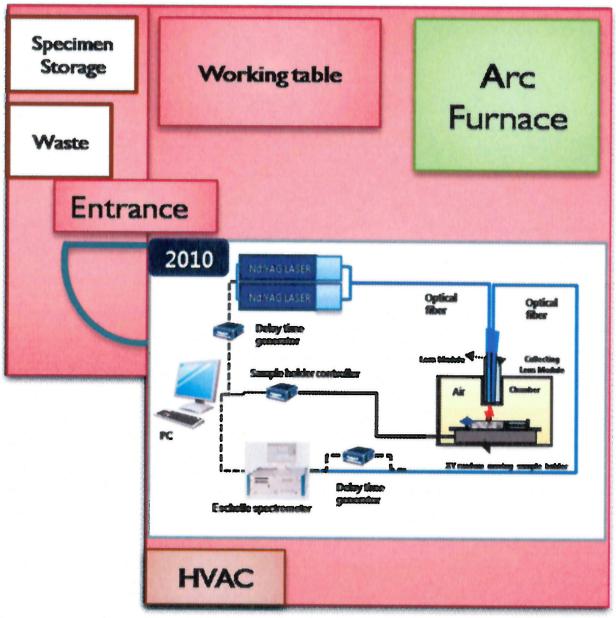


Fig. 3. U sample measurement (NDA Lab. in KAERI)

## 3. Conclusion

The main purpose of this study is to develop LIBS technology with a high level of sensitivity to measure the minimum trace of curium that may be generated in the treatment process of spent nuclear fuels such as DUPIC and ACP. This technology will be vital in nuclear material analyses and accounting in the nuclear fuel cycle.

We are working on the proposed measurement system not only to analyze the characteristics of nuclear materials but also to develop algorithms enabling remote measurement and next-generation nuclear material accounting technologies. A laboratory and equipment enabling the measurement of U-samples are currently being built.

In the future, the development of Fiber Optic Laser Induced Breakdown Spectroscopy (FOLIBS) will be a useful method to measure the Pu/Cm ratio within process materials with spent nuclear fuels in a hot cell or a radioactive environment. To apply safeguards, many experimental factors will be examined and optimized to improve the sensitivity of the LIBS technology.

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