4 - 1 A Moveable Laser-induced Breakdown Spectroscopy Instrument for Application

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As a developing analytical technique, laser-induced breakdown spectroscopy (LIBS) has demonstrated its capabilities for on-line elemental analysis of any material phase without sample preparation or some easy sample preparation. Thus, it has attracted substantial attention nowadays for a wide range of applications. Some LIBS instruments have also appeared in the market over the past few years. However, most prototypes were proposed primarily by research teams mainly in laboratories in connection to potential field applications[1].

This paper presents a moveable LIBS instrument for application developed by ourselves. The picture of the instrument is shown in Fig. 1. A Nd:YAG laseris used for ablation of material and the pulse repetition of laser is 1∼ 20 Hz and its pulse energy can be up to 350 mJ at 1 064 nm with pulse duration of ∼10 ns. The laser beam is focused on the sample using a quartz lens and the plasma emission is collected by a pair of plano-convex quartz lenses to a fible optical spectrometer with a CCD detector. A specially designed location system was used in this instrument which will help users to position the laser focus and the target accurately and to improve the repeatability of measurements. The sample holder is controlled by a 3-D motorized linear stage so that the sample can be refreshed. The spectrometer and the laser are both trigged by a digital delay generator so that the delay time between the laser and the spectra acquisition can be changed easily. A laser guide beam arm is mounted in this instrument and another optical fiber is bundled with it. By switching a mirror for laser propagation, the laser beam can enter the laser guide beam arm and then focused on the target so that the material can be analyzed in site. To enhance user experience, a software based on Labview has been developed which can be used for spectra data acquisition and simple analysis including lines indentification, plasma parameters calculation and so on. We look forward that the instrument can be used for some experimental applications.

Fig. 1 (color online) Picture of the moveable LIBS instrument.

Reference

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4 - 2 Investigation of Uranium Spectra by Laser-induced Breakdown Spectroscopy with Ambient Gas

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With the rapid development of nuclear power and nuclear industry, it is needed to develop a novel inspection technology for nuclear materials, nuclear fuel, and nuclear waste, which should provide reliable and fast measurements in various processes of the nuclear fuel cycle. As a purely optical method, laser-induced breakdown spectroscopy (LIBS) is regarded as a suitable method for remote analysis of any material phase in the environment of high radiation levels.

This paper presents the LIBS spectra of uranium metal and their features in different ambient gas at 1atm. The third harmonic pulse of a Nd:YAG laser was used for ablation of uranium metal and the plasma emission was

measured by a fiber-optic spectrometer. The strong continuum spectrum and several hundreds of emission lines from UI and UII were observed. By changing delay time between spectrometer and laser pulses, it can be found that the continuum spectrum observed in uranium is not only coming from bremsstrahlung emission but owing to the complex spectrum of uranium. The spectral features of U lines in air and ambient gases of argon, neon, oxygen and nitrogen were also studied in this experiment. As shown in Fig. 1, the results indicate that the intensity of uranium lines were enhanced in argon gas and nitrogen while the intensity of uranium lines were decreased when the uranium was ablated in the cases of air and oxygen for the generation of UO by reaction of uranium and oxygen. More intense uranium lines was observed in argon gas than in nitrogen gas and the minimum gas flow rate of 2.5 L/min is enough for experimental measurement in atmosphere pressure.

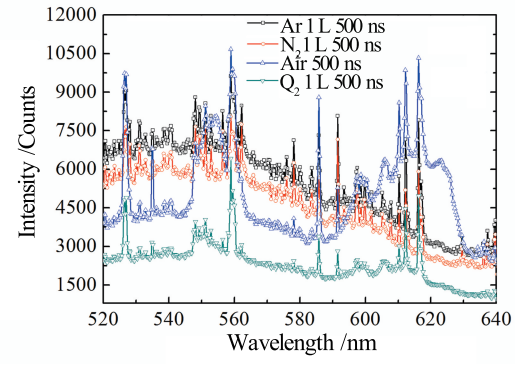

Fig. 1 (color online) Comparison of the spectra of UO in air, argon, nitrogen and oxygen.

A high resolution spectrometer will be equipped in our LIBS system soon and the spectra of uranium and other actinide elements will be analyzed in more detailed. We look forward that the uranium or mixed oxide fuel can be analyzed by the remote and in-situ LIBS detection.

4 - 3 New Insight into Power-law Behavior of Fragment Size Distributions in the C_{60} Multifragmentation Regime*

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Previous experimental work[1] has shown that a Phase Transition (PT) in C_{60} multifragmentation induced by nanosecond laser occurs at almost constant temperature covering a wide range of laser fluency. However, up to now, to the phase transition occurring in C_{60} systems much uncertainty remains regarding its nature. In particular, whether it, like those occurring in other finite systems such as nuclei[2], is also related to a liquid-to-gas phase transition. If so, at the critical temperature, the size distributions of primary intermediate-mass fragments in the multifragmentation regime should obey power law with a particular scaling exponent[3].

In the present work[4], relative yields of ionic fragments (IFs) resulting from the C_{60} multifragmentation were further measured within the PT region and are shown in Fig. 1. By excluding two small IFs and magic IFs due to their abnormal behaviors, the data for residual IFs was used to estimate the size distributions of primary intermediate-mass IFs in the multifragmentation regime. The distributions are found to obey power laws $n^{-\tau}$. Furthermore, the exponent values have sensitive dependence on lower laser fluencies and converge to a constant of about 2.4 ± 0.2 for larger fluencies. These observations are in good agreement with an explanation based on the Fisher droplet model, offering tantalizing possibility of a liquid-to-gas phase transition in C_{60} systems.

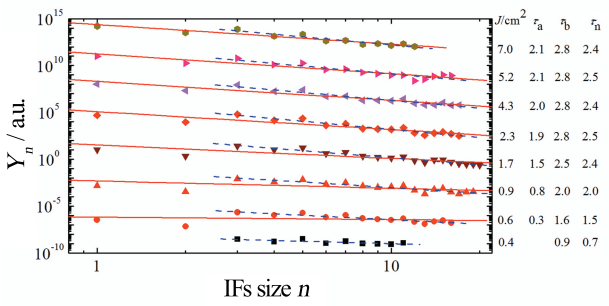

Fig. 1 (color online) Yield distributions of Ionic fragments as a function of the size with different laser fluencies. The relative yield scale of each distribution is given by a multiplication factor.

References

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