Identification of Sr Compound in Radiological Terror Scene by Laser-induced Breakdown Spectroscopy at Long Distance

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1. Introduction

The nuclear incidents is increasing by militant groups such as ISIS and Al-Qaeda. They are eager to obtain hazardous materials. In addition, a lot of terrorism were carried out by these groups like an accidents arise at a concert box in Manchester (May 2017). One of the most common nuclear materials stolen is Sr in radioisotope thermoelectric generators (RTG) [1].

Sr is the only one isotope that emit purely beta in nine suggested potential radiological terror source by Argonne National Laboratory [2]. Such a beta emitter can be hard to detect with conventional instrument such as Guiger-Muller counter. Therefore, the research aim of the present paper was to perform assessment of feasibility for identifying Sr by Laser-Induced Breakdown Spectroscopy (LIBS) at long distance with protecting inspectors.

2. Experimental and results

2.1 Experimental setup

Fig. 1 describes the setup of remote-LIBS detection system. To ablate targets, a compact Q-switched Nd:YAG laser (532 nm, 220 mJ, 5 ns, 20Hz) was used. For measuring spectra of targets, an Echelle spectrograph (f/7, 200 – 975 nm of operating range, 195 mm focal length) combined with intensified-CCD (13 x 13 um^2 pixel size) was established. To collect the light of plasma which has information of atomic spectra, a small Maksutov-Cassegrain Optical telescope (90 mm of aperture, f/14, 1200 mm of focal length) was employed. The distance between this telescope and samples is about 3 m away. The laser lights were transmitted to targets through plane mirrors and plano-convex lens with focal length of 125 mm. The obtained spectra was used with delay time of 500 ns, integration time of 1 ms, and laser power of ca. 22.5 mJ.

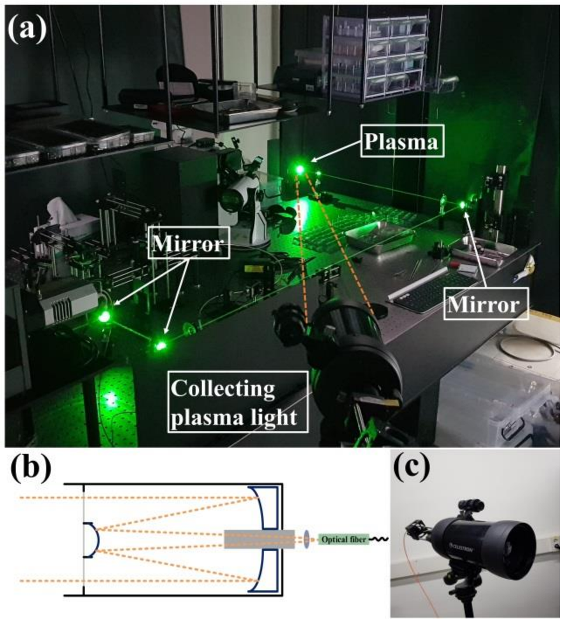

Fig. 1. Photo and schematic view of experimental setup. (a): Photo of measuring the plasma light at long distance, (b): Schematic view of light path in telescope to optical fiber, (c): Photo of cassegrain telescope.

2.2 Samples

The samples are comprised of $SrCO_3$ onto Al, SUS304, mortar and polyester. In fabricating of RTGs, $SrCO_3$ is generated as intermediate products during the process of solvent extraction [3]. These fabrication plant is relatively accessible than reprocessing or interim storage facility for used nuclear fuel. This study proposes the method to identify Sr in radiological terror scene. The proposed method attempts to consider the terror is arise in huge city by using Al, SUS304, mortar and polyester. It is because Al, SUS304, mortar and polyester can be component of radiological dispersal devices outer container, bridge or pipe, pavement or building, and clothes respectively. Finally, $SrCO_3$ was dissolved into highly purified water and sprayed on the surface of matrices homogeneously.

2.3 Results

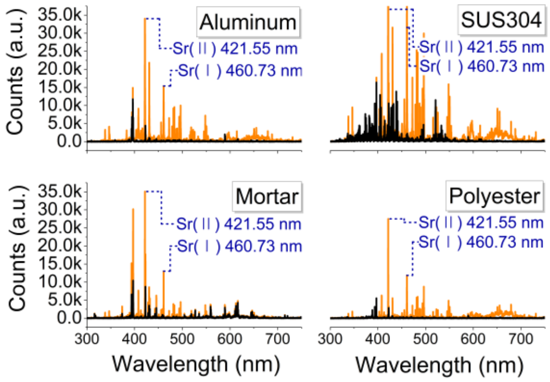

Fig. 2. LIBS spectra at long distance of $SrCO_3$ including Al, SUS304, mortar, and polyester. Orange line: matrix with $SrCO_3$, Black line: only matrix.

Fig. 2 summaries the spectra of $SrCO_3$ on various matrices. All of the peaks were analyzed using National Institute of Standards and Technology (NIST) spectroscopy database [4]. Two wavelength of 421.55 and 460.73 nm were employed to identifying Sr from the samples. It is because these peaks are most powerful intensity. Especially 460.73 nm is a persistent spectrum of Sr. For comparison, the spectra of close contact experiments also summarized as shown in Fig. 3. In case of close contact experiment, the same condition such as delay time, integration time and laser power, but only difference is distance between gathering devices and plasma lights. While searching Sr for ensuring an evidence of radiological terrorism at a long distance to minimize exposure for inspectors, there are not such difference between the spectra at long distant and close contact in terms of identifying Sr from the various matrices. The whole intensity, however, are reduce where detect in a far away.

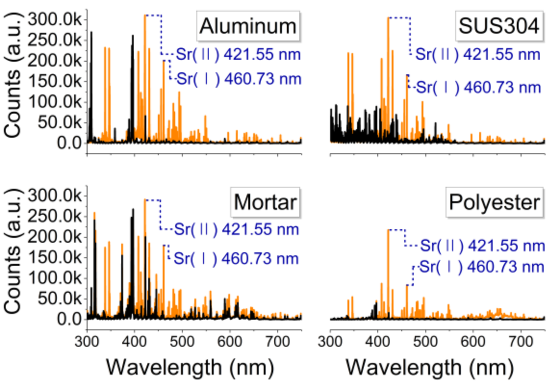

Fig. 3. LIBS spectra at close contact of $SrCO_3$ including Al, SUS304, mortar, and polyester. Orange line: matrix with $SrCO_3$, Black line: only matrix.

3. Conclusion

The present study may suggest that LIBS at long distant can be used to find evidence of Sr radiological terror. For each matrix (Al, SUS304, mortar, polyester) with $SrCO_3$, the feasibility that can be detect radioactive materials in Sr radiological terror scene was demonstrated easily. The advantages of remote detection are identification of targets with minimized exposure rate for inspectors, and rapid collection of information by enhanced area of detection systems covered in one place.

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