Analysis of particles generated by laser processing and development of their nuclide identification methodology (4)
(4) Progress in a Spectroscopic Technique of Laser Based Analysis and Nuclide Identification of Fine Particle Debris

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Laser cutting/processing in nuclear decommissioning is an increasingly useful technique, allowing access to tight spaces, controlled cutting width, among others. Fine particles are produced as cutting waste, presenting a possible hazard to health, but may also be analysed to investigate the cutting material contents. Here, progress on a diode laser system for absorption spectroscopy for fine particle analysis is described.

Keywords: Fine particles, Laser cutting, Material analysis, Plasma spectroscopy

1. Introduction

Analysis of the isotopic species in nuclear decommissioning materials is an important capability, as it enables diagnostic measurements to be carried out, most importantly for radioisotope analysis for waste stream identification. Such elements include gadolinium, typically used in nuclear settings as a reactivity control due to its high thermal neutron cross section. It has a large isotope shift (difference in atomic transition frequencies due to differing nuclear mass) which makes it a good target for isotopic analysis.

2. Methods

To investigate the isotopic constituents of the fine particles, laser absorption spectroscopy is employed, via glow discharge atomisation. Atomic level transitions have resonant frequencies dependent on the isotope shift, therefore allowing isotope identification based on absorption resonances upon laser illumination. In order to atomise the fine particle sample for laser absorption, it will be introduced into a glow discharge plasma [1], and the plasma illuminated by a laser produced by a frequency-tunable external cavity diode laser (ECDL). Frequency tunability is required to set the laser frequency close to the resonance of the isotope, and then to scan to observe the absorption resonance. Due to the extremely low expected signal, a cavity enhanced methodology is expected to be beneficial in the future

3. Discussion and Conclusion

Choosing the isotope of interest to be gadolinium, here we discuss the development of an ECDL system for laser absorption spectroscopy, targeting the relatively strong atomic transition $4f^7(^8S°)5d6s^2\ ^9D^o$ -> $4f^7(^8S°)5d\ (^7D°)\ 6s6p(^3P°)$ at 405.478nm [2]. Glow discharge plasma is used to atomise the sample. This work is expected to be applicable to fine particle debris analysis of nuclear decommissioning, but also has application to any fine sample analysis for isotopic investigation.

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