

Rare earth metals detection and recognition based on laser induced breakdown spectroscopy and machine learning

LIPING TIAN,^{1,2,3,4} LINGBIN SHEN,^{1,2,3,4}  DONGPENG TIAN,^{3,4}
YIFAN GE,^{3,4} ZHONGMOU SUN,^{3,4} AND YUZHU LIU^{1,3,4,*} 

¹Key Laboratory of Meteorological Disaster, Ministry of Education (KLME), Joint International Research Laboratory of Climate and Environment Change (ILCEC), Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters (CIC-FEMD), Nanjing University of Information Science and Technology, Nanjing 210044, China

²School of Network and Communication Engineering, Jinding Institute of Technology, Hongjing Road, No. 99, Nanjing 211169, China

³Jiangsu Key Laboratory for Optoelectronic Detection of Atmosphere and Ocean, Nanjing University of Information Science & Technology, Nanjing 210044, China

⁴Jiangsu International Joint Laboratory on Meteorological Photonics and Optoelectronic Detection, Nanjing University of Information Science and Technology, Nanjing 210044, China

*yuzhu.liu@njui.com

Abstract: The rapid detection and identification of the electronic waste (e-waste) containing rare earth (RE) elements is of great significance for the recycling of RE elements. However, the analysis of these materials is extremely challenging due to extreme similarities in appearance or chemical composition. In this research, a new system based on laser induced breakdown spectroscopy (LIBS) and machine learning algorithms is developed for identifying and classifying e-waste of rare-earth phosphors (REPs). Three different kinds of phosphors are selected and the spectra is monitored using this new developed system. The analysis of phosphor spectra shows that there are Gd, Yd, and Y RE element spectra in the phosphor. The results also verify that LIBS could be used to detect RE elements. An unsupervised learning method, principal component analysis (PCA), is used to distinguish the three phosphors and training data set is stored for further identification. Additionally, a supervised learning method, backpropagation artificial neural network (BP-ANN) algorithm is used to establish a neural network model to identify phosphors. The result show that the final phosphor recognition rate reaches 99.9%. The innovative system based on LIBS and machine learning (ML) has the potential to improve rapid in situ detection of RE elements for the classification of e-waste.

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1. Introduction

REPs, due to their noteworthy advantages including the high luminance efficiency, good chemical stability, and strong luminance brightness, etc., has immense marked demand in the application of solid-state lighting, computed tomography tubes, television screens, display panels, biomedicine, and forensics [1–5]. As a consequence of the rapid updating and iteration of electronic products, large quantities of electronic waste (e-waste) containing rare-earth (RE) metals, including REPs, are now among the most important electronic pollutants worldwide. Several studies have shown that long-term exposure to REP e-waste in the environment will cause environmental imbalance and can cause great harm to the human body, largely because it contains large numbers of REPs, oxides of REPs, and toxic metals [6]. Therefore, a method that can detect these phosphors and their RE elements quickly and accurately is urgently required.

At present, the most common techniques used for optical characterization of substance containing RE elements include photoluminescence spectroscopy (PL), Raman spectroscopy, and

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SME Mining Engineering Handbook, Third Edition Peter Darling, Society for Mining, Metallurgy, and Exploration (U.S.), 2011 This third edition of the SME Mining Engineering Handbook reaffirms its international reputation as the handbook of choice for today's practicing mining engineer. It distills the body of knowledge that characterizes mining engineering as a disciplinary field and has subsequently helped to inspire and inform generations of mining professionals. Virtually all of the information is original content representing the latest information from more than 250 internationally recognized mining industry experts. Within the handbook's 115 thought-provoking chapters are current topics relevant to today's mining professional: Analyzing how the mining and minerals industry will develop over the medium and long term; why such changes are inevitable; what this will mean in terms of challenges and how they could be managed; Explaining the mechanics associated with the multifaceted world of mine and mineral economics from the decisions associated with how best to finance a single piece of high-value equipment to the long-term cash flow issues associated with mine planning at a mature operation; Describing the recent and ongoing technical initiatives and engineering developments in relation to robotics, automation, acid rock drainage, block caving, optimization, or process dewatering methods; Examining in detail the methods and equipment available to achieve efficient, predictable, and safe rock breaking, whether employing a tunnel boring machine for development work, mineral extraction using a mobile miner, or cast blasting at a surface coal operation; Identifying the salient points that dictate which is the safest, most efficient, and most versatile extraction method to employ, as well as describing in detail how each alternative is engineered; Discussing the impacts that social and environmental issues have on mining from the pre-exploration phase to end-of-mine issues and beyond, and how to manage these two increasingly important factors to the benefit of both the mining companies and other stakeholders. *Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals* Henry E. Hilliard, B. W. Dunning, Harry V. Makar, 1983

Geological Series, 1913 *Cumulated Index to the Books*, 1965 **Chemische novitäten**, 1907 **Qualitative Chemical Analysis** Albert Benjamin Prescott, Otis Coe Johnson, 1895 *Nuclear Science Abstracts*, 1971-11
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