

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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Table of Contents Rare Metals Analysis Detection Com 3ed

1. Understanding the eBook Rare Metals Analysis Detection Com 3ed
 - The Rise of Digital Reading Rare Metals Analysis Detection Com 3ed
 - Advantages of eBooks Over Traditional Books
2. Identifying Rare Metals Analysis Detection Com 3ed
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Rare Metals Analysis Detection Com 3ed
 - User-Friendly Interface
4. Exploring eBook Recommendations from Rare Metals Analysis Detection Com 3ed
 - Personalized Recommendations
 - Rare Metals Analysis Detection Com 3ed User Reviews and Ratings
 - Rare Metals Analysis Detection Com 3ed and Bestseller Lists

5. Accessing Rare Metals Analysis Detection Com 3ed Free and Paid eBooks
 - Rare Metals Analysis Detection Com 3ed Public Domain eBooks
 - Rare Metals Analysis Detection Com 3ed eBook Subscription Services
 - Rare Metals Analysis Detection Com 3ed Budget-Friendly Options
6. Navigating Rare Metals Analysis Detection Com 3ed eBook Formats
 - ePub, PDF, MOBI, and More
 - Rare Metals Analysis Detection Com 3ed Compatibility with Devices
 - Rare Metals Analysis Detection Com 3ed Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Rare Metals Analysis Detection Com 3ed
 - Highlighting and Note-Taking Rare Metals Analysis Detection Com 3ed
 - Interactive Elements Rare Metals Analysis Detection Com 3ed
8. Staying Engaged with Rare Metals Analysis Detection Com 3ed
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Rare Metals Analysis Detection Com 3ed
9. Balancing eBooks and Physical Books Rare Metals Analysis Detection Com 3ed
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Rare Metals Analysis Detection Com 3ed
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Rare Metals Analysis Detection Com 3ed
 - Setting Reading Goals Rare Metals Analysis Detection Com 3ed
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Rare Metals Analysis Detection Com 3ed
 - Fact-Checking eBook Content of Rare Metals Analysis Detection Com 3ed
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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