

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

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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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The United States Catalog ,1906 *The Lost Elements* Marco Fontani,Mariagrazia Costa,Mary Virginia Orna,2014-10-01 The Periodic Table of Elements hasn't always looked like it does now a well organized chart arranged by atomic number In the mid nineteenth century chemists were of the belief that the elements should be sorted by atomic weight However the weights of many elements were calculated incorrectly and over time it became clear that not only did the elements need rearranging but that the periodic table contained many gaps and omissions there were elements yet to be discovered and the allure of finding one had scientists rushing to fill in the blanks Supposed discoveries flooded laboratories and the debate over what did and did not belong on the periodic table reached a fever pitch With the discovery of radioactivity the discourse only intensified Throughout its formation the Periodic Table of Elements has seen false entries good faith errors retractions and dead ends In fact there have been more falsely proclaimed elemental discoveries throughout history than there are elements on the table as we know it today *The Lost Elements The Periodic Table's Shadow Side* collects the most notable of these instances stretching from the nineteenth century to the present The book tells the story of how scientists have come to understand elements by discussing the failed theories and false discoveries that shaped the path of scientific progress We learn of early chemists stubborn refusal to disregard alchemy as a legitimate practice and of one German's supposed discovery of an elemental metal that breathed As elements began to be created artificially in the twentieth century we watch the discovery climate shift to favor the physicists rather than the chemists Along the way Fontani Costa and Orna introduce us to the key figures in the development of today's periodic table including Lavoisier and Mendeleev Featuring a preface from Nobel Laureate Roald Hoffmann *The Lost Elements* is an expansive history of the wrong side of chemical discovery and reveals how these errors and gaffes have helped shape the table as much as any other form of scientific progress *Hydrography of Virginia* Nathan Clifford Grover,Roy Hale Bolster,1906 *Geological Series* ,1913

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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 **Mining**

Journal, Railway & Commercial Gazette ,1912 Breath Analysis Stefan Weigl,2022-11-14 This volume highlights the potentials as well as the limits and challenges of human breath analysis and describes the current efforts made to advance this promising technology from bench to bed Human breath analysis is a young interdisciplinary and innovative research field aiming to provide a smart and non invasive diagnostic tool which can be used for screening detecting and monitoring of diseases or metabolic disorders This book presents different approaches for breath analysis including real time and offline mass spectrometry as well as optical and semiconductor gas sensing methods Besides the role of smart algorithms to improve the performance of those technologies and the importance of pulmonary function diagnostics for more reliable and meaningful breath analysis are highlighted Finally current application scenarios and future perspectives of breath analysis and pulmonary functioning tests are addressed The volume is useful for researchers who are new in the field to easily get an overview of the current status and the challenges present in human breath analysis Topics from fundamental research over targeted sensor development and application scenarios are described Thus this volume covers all development stages providing support and inspiration for engineers medical doctors and scientists from various fields

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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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