

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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**Peter Darling, Society for Mining,
Metallurgy, and Exploration (U.S.)**

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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

The United States Catalog, 1906 **Geological Series**, 1913 Geology of the Titanium and Apatite Deposits of Virginia Thomas Leonard Watson, Stephen Taber, 1913 *Bulletin* Virginia. Division of Mineral Resources, 1913 *General Catalogue of the Public Library of Detroit, Mich. First-third Supplement. 1889-1903: 1899-1903* Detroit Public Library, 1904 ASM Metals Reference Book, 3rd Edition Michael Baucio, 1993-01-01 This reference book makes it easy for anyone involved in materials selection or in the design and manufacture of metallic structural components to quickly screen materials for a particular application Information on practically all ferrous and nonferrous metals including powder metals is presented in tabular form for easy review and comparison between different materials Included are chemical compositions physical and mechanical properties manufacturing processes applications pertinent specifications and standards and test methods Contents Overview Glossary of metallurgical terms Selection of structural materials specifications and standards life cycle and failure modes materials properties and design and properties and applications Physical data on the elements and alloys Testing and inspection Chemical composition and processing characteristics **Bulletin - Virginia Geological Survey** Virginia

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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

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