

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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