The preparation and characterization of two-dimensional nanomaterials

YBO₃:Ce³⁺

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Abstract

The two-dimensional nanomaterial YBO₃:Ce³⁺ is a new material; the graphene has a lot of characteristics, so we want to study the two-dimensional nanomaterial YBO₃:Ce³⁺. The preparation methods which commonly used is high temperature solid phase method, sol-gel method, precipitation method, burning method, thermal decomposition method and hydrothermal method. Because of the rare earth borate luminescence materials which particle size and particle size distribution and surface topography has greater influence on the luminous performance; ultimately affect the effect of practical application, so people according to the use of different environment to take different preparation methods to avoid disadvantages. The two-dimensional nanomaterial YBO₃:Ce³⁺ phosphors was synthesized by solvothermal method and layered by liquid exfoliation treatment, and it is the material with layered structure. SEM image shows that the thickness of each layer is about 50nm before layered. The PLE spectra and the PL spectra of the two-dimensional nanomaterial YBO₃:Ce³⁺ indicate that the 320-380 nm light wave is absorbed by Ce³⁺ with a wave peak at 361nm (4f→5d), and a bit of 370-460 nm luminescence is observed with a wave peak at 410nm(Ce³⁺:5d→2f7/2). The microstructure of the two-dimensional nanomaterial YBO₃:Ce³⁺ phosphors is characterized by Transmission electron microscope.

Key words: YBO₃:Ce³⁺, hydrothermal method, Two-dimensional nanomaterial, liquid exfoliation, Microstructure

1. Introduction

Because of borate stability, relatively low synthesis temperature, this luminescent material of it is an excellent substrate in a plasma display, a projection television and HDTV flat panel displays, mercury-free fluorescent lamps, application in silicon solar cell performance [1]. The practical application of the material has a lot of relevance with its micro and nanostructure, morphology, size and purity. The preparation of borate phosphors are hydrothermal method. The YBO₃:Ce³⁺ is prepared in our laboratory which is sheet substrate material. Graphene material is a hot topic in the past two years. Graphene has many special properties [2-4], so we have to consider whether this can YBO₃ prepared stratified, making it the class structure of graphene to see what will have special properties. Reference method for preparing the two-dimensional nanomaterial molybdenum disulfide, molybdenum disulfide two-dimensional nanomaterial general method, the methods include micromechanical exfoliation, lithium-based intercalation and liquid exfoliation [2-10]. In this paper we use the method is liquid exfoliation to prepare two-dimensional nanomaterial YBO₃:Ce³⁺, and using TEM to observe and analysis its microstructure.

2. Experimental

2.1. Flower-shaped YBO₃: Ce³⁺ preparation

The nitrate dissolved in a mixed solution of deionized water and ethanol (volume ratio of deionized water and ethanol 1:2), it stirred to a clear solution, a solution of yttrium nitrate \( (Y(\text{NO}_3)_3) \) doped cerium nitrate \( (\text{Ce(NO}_3)_3) \). Tributyl borate was added to the colorless, clear solution and it stirred to completely dissolve. In this case the amount of substance of tributyl borate is the total amount of four times with the nitrate substance. Aqueous ammonia \( (\text{NH}_3\cdot\text{H}_2\text{O}) \) was added to the solution and it stirred to have a white precipitate. So the solution have weakly alkaline. In this case the volume ratio of aqueous ammonia solution and the total volume of water and ethanol is 1:2. Actual dosage and the ratio of raw materials in Table.1. The solution is stirred for 1-2 hours, and the solution is moved in 100ml the thermal water kettle at 200 °C and is incubated 12h to give a white precipitate. The white precipitate is washed by centrifugation and dried to give the \( \text{YBO}_3: \text{Ce}^{3+} \) doped luminescent materials its microscopic structure is flower shape.

2.2. Preparation of two-dimensional nanomaterial \( \text{YBO}_3: \text{Ce}^{3+} \)  

0.1g of the sample were dispersed in a solvent it has 100ml, the solvent is selected that has dimethyl sulfoxide(DMSO), methylene chloride and n-methyl pyrrolidone, because the boiling point of dichloromethane is 39.8°C (Dimethyl sulfoxide(DMSO) 189°C, N-methyl pyrrolidone 203°C), it is not continuous ultrasound (when ultrasound, the temperature will rise at the same time), so the ultrasound two hours, change the water every 20min (you can also consider using ultrasonic flow water environment) as ultrasound is end, then standing it the same time with 24h. At time is over, we found in N-methyl pyrrolidone all sample submerged in the bottom, and the dimethyl sulfoxide (DMSO) and dichloromethane have the upper suspension. N-methyl pyrrolidone removed as a dispersant solution, keeping the methylene chloride and dimethyl solution. Filtering the upper of methylene chloride and dimethyl sulfoxide solution (using 0.45 μm filter membrane polytetrafluoroethylene membrane), drying the white product under conditions of 60°C. After drying and scraping the white product, the two-dimensional nanomaterial \( \text{YBO}_3: \text{Ce}^{3+} \) borate is prepared.

Table.1 Actual dosage and the ratio of raw materials

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Actual amount</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{C}_2\text{H}_5\text{OH} ) ( (V_1) )</td>
<td>( 20\text{ml} )</td>
<td>( V_1: V_2=2:1 )</td>
</tr>
<tr>
<td>( \text{H}_2\text{O} ) ( (V_2) )</td>
<td>( 10\text{ml} )</td>
<td></td>
</tr>
<tr>
<td>( \text{NH}_3\cdot\text{H}_2\text{O} ) ( (V_2) )</td>
<td>( 1.36\text{ml} )</td>
<td>Total:0.005mol</td>
</tr>
<tr>
<td>( \text{C}<em>{12}\text{H}</em>{27}\text{BO}_3 )</td>
<td>Total:0.0054g</td>
<td></td>
</tr>
<tr>
<td>( \text{Y(NO}_3)_3\cdot6\text{H}_2\text{O} )</td>
<td>Total:0.00125mol</td>
<td></td>
</tr>
<tr>
<td>( \text{Ce(NO}_3)_3\cdot6\text{H}_2\text{O} )</td>
<td>Total:0.0054g</td>
<td></td>
</tr>
</tbody>
</table>

3. Results and Discussion

3.1. The analysis of the phenomenon of different solvents

As a solution in dichloromethane solvent at have 24h standing the upper suspension obvious clear than dimethyl sulfoxide upper suspension. This phenomenon may have two cases, one is the dimethyl sulfoxide greater than the viscosity of dichloromethane, so the sample in dichloromethane settling velocity sedimentation rate faster than in dimethyl sulfoxide (DMSO), resulting in upper suspension of dichloromethane clear than in dimethyl sulfoxide(DMSO) solution after 24h of the upper suspension clear. The other reason is the sample in dimethyl sulfoxide(DMSO) solution has small surface area. So we do dispersant with methylene chloride to prepare the sample, and all of the photos in this article are this sample.

3.2. The analysis of SEM photos

Both A and B in Fig2 is under SEM photos, all is before the layered of \( \text{YBO}_3: \text{Ce}^{3+} \), A is a photo of magnified 5000 times, B is a photo of magnified 10000 times. From the Fig.2, before the layered of \( \text{YBO}_3: \text{Ce}^{3+} \),

Fig.2 The TEM photos of flower-like \( \text{YBO}_3: \text{Ce}^{3+} \)
we can have a collusion is every piece of layer has 60nm -100nm, and on the edge which the distance between layers is very big. It is this condition; it created a good condition by using the ultrasonic method to layer.

3.3 The analysis of TEM and HRTEM photos

Fig3 and Fig4 is four photos which under the condition of different field to see with TEM, and Fig6 is a HRTEM photo. Fig5 is electron diffraction spectrum diagram. After the analysis transmission electron microscope (TEM) and high-resolution transmission electron microscope (HRTEM) photos can be seen in the vision (Fig.3, Fig.4) have lamellar YBO$_3$:Ce$^{3+}$, sheets have different shading, the thickness of the sheet is not unifying to judge with the degree of light. In Fig.3, this is

![Fig3 The photos of TEM with wide filed](image1)

a photo of the sample in dimethyl sulfoxide solution with TEM, the piece is thick, but you can see in the Fig.4 out

![Fig.4 The photos of TEM](image2)

of ultrasonic has collusion that ultrasonic break lamella structures, but it effect on layer, some layer loose to edge. However, there is still a relatively thin nanosheet, after the samples again adhesive on the big lamella. In Fig.5, YBO$_3$:Ce$^{3+}$ by electron diffraction that the crystal form is hexagonal close-packed. it also can be seen Fig.6 that the

![Fig.5 Energy spectrum diagram](image3)

then get the angle between (-1-20) and (-100), (1-20) and (110), (0-10) and (210) is right angle. The angle between (-100) and (1-20) is 26.38°, (110) and (210) is 32.98°, (-1-20) and (0-10) is 30.72°. The crystal distance between two parallel lines of (-1-20) is 611pm, (-100) is 607pm, (1-20) is 683pm, (110) is 556pm, (210) is 687pm, (0-10) is 585pm.

4. Conclusions

In summary, liquid exfoliation in this paper to prepare two- dimensional nanomaterial YBO$_3$:Ce$^{3+}$. We used two kinds of dispersants, methylene chloride and dimethyl sulfoxide(DMSO),and have a conclusion that methylene chloride as dispersant to prepare sample is good than dimethyl sulfoxide as a dispersant. We
prepared two-dimensional nanomaterial YBO$_3$:Ce$^{3+}$ and observing the microstructure and grid data.

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References