The preparation and characterization of two- dimensional nanomaterial $YBO_3:Ce^{3+}$

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Abstract

The two- dimensional nanomaterial $YBO_3:Ce^{3+}$ is a new material; the graphene has a lot of characteristics, so we want to study the two- dimensional nanomaterial $YBO_3:Ce^{3+}$. 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 $YBO_3:Ce^{3+}$ 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 $YBO_3:Ce^{3+}$ phosphors indicate that the 320-380 nm light wave is absorbed by Ce^{3+} with a wave peak at 361nm (4f→5d), and a bit of 370-460 nm luminescence is observed with a wave peak at 410nm(Ce^{3+}:5d→2f7/2) .The microstructure of the two-dimensional nanomaterial $YBO_3:Ce^{3+}$ phosphors is charactered by Transmission electron microscope.

Key words: $YBO_3:Ce^{3+}$, 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 $YBO_3:Ce^{3+}$ 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 YBO_3 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 $YBO_3:Ce^{3+}$, and using TEM to observe and analysis its microstructure.

2. Experimental

2.1. Flower-shaped YBO_3: ce^{3+} 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 $(NO_3)_3$) doped cerium nitrate (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 ($NH_3.H_2O$) 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 ℃ and is incubated 12h to give a white precipitate. The white precipitate is washed by centrifugation and dried to give the YBO_3: Ce^{3+} doped luminescent materials its microscopic structure is flower shape.

Raw material	Actual amount	Remark
C_2H_5OH（V_1）	20ml	V_1：V_2=2:1
H_2O（V_2）	10ml	
$NH_3.H_2O$（V_2）		
$C_{12}H_{27}BO_3$	1.36ml	Total:0.005mol
$Y(NO_3)_3.6H_2O$	0.4740g	Total:0.00125mol
$Ce(NO_3)_3.6H_2O$	0.0054g	

Table.1 Actual dosage and the ratio of raw materials

2.2. Preparation of two- dimensional nanomaterial YBO_3: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 (NMP), because the boiling point of dichloromethane is 39.8℃ (Dimethyl sulfoxide(DMSO) 189℃, N-methyl pyrrolidone 203℃), 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 μ m filter membrane polytetrafluoroethylene membrane), drying the white product under conditions of 60℃. After drying and scraping the white product, the two- dimensional nanomaterial YBO_3:Ce^{3+} borate is prepared.

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 YBO_3: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 YBO_3:Ce^{3+} ,

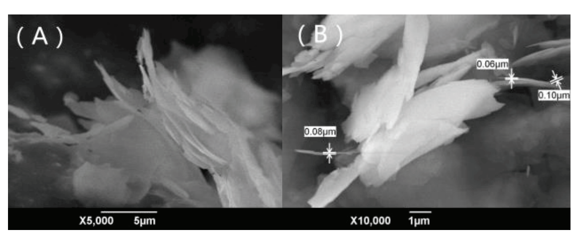

Fig.2 The TEM photos of flower-like YBO_3:Ce^{3+}

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

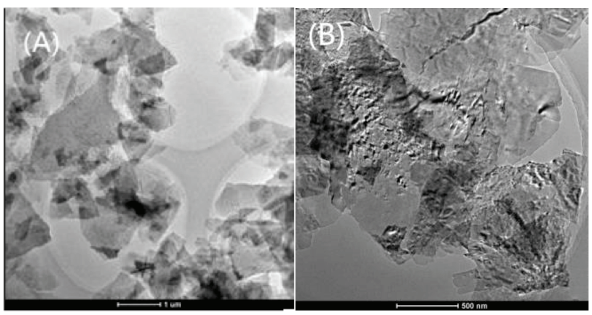

Fig.3 The photos of TEM with wide filed

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

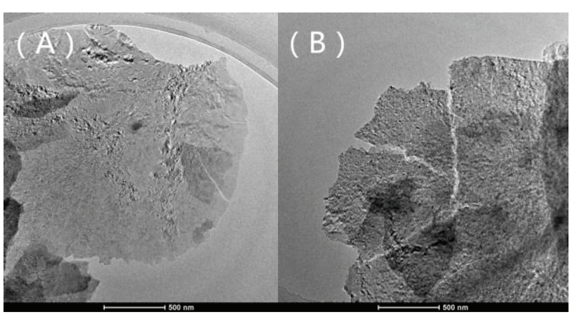

Fig.4 The photos of TEM

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,

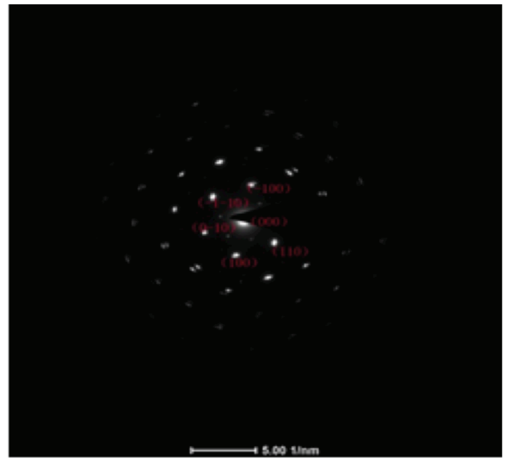

Fig.5 Energy spectrum diagram

$YBO_3:Ce^{3+}$ by electron diffraction that the crystal form is hexagonal close-packed. it also can be seen Fig.6 that the

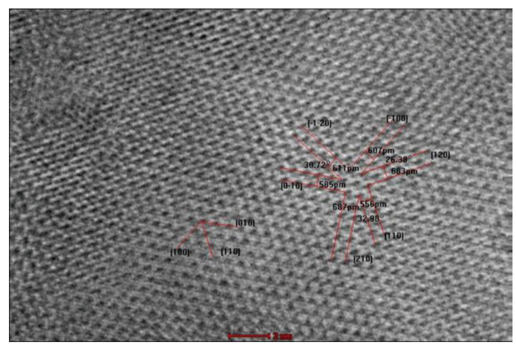

Fig.6 The photos of HRTEM

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 26.38^0, (110) and (210) is 32.98^0, (-1-20) and (0-10) is 30.72^0. 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

[1]Zhengwen.Yang, Dong.Yan, “Color tenability of up conversion emission in YBO_3: Yb, Er inverse opal”, Materials Letters, 1245-1247, 2011

[2] Min Qian, Yun Shen Zhou, Yang Gao, Tao Feng, Zhuo Sun, Lan Jiang, Yong Feng Lu “Production of few-layer graphene through liquid-phase pulsed laser exfoliation of highly ordered pyro lytic graphite” ,Applied Surface Science, 258, 9092– 9095, 258, 2012

[3] Jonathan N. Coleman et al. “Two-Dimensional Nanosheets Produced by Liquid Exfoliation of Layered Materials”, Science 331, 568, 2011

[4] Valeria Nicolosi et al. “Liquid Exfoliation of Layered Materials”, Science 340, 2013

[5] Arlene O’Neill, Umar Khan, and Jonathan N Coleman “Preparation of High Concentration Dispersions of Exfoliated MoS_2 with Increased Flake Size”, chemistry of materials, Chem. Mater, 2414-2421, 24, 2012

[6] Lixin Xu, John-Wesley McGraw, Fan Gao, Mark Grundy, Zhibin Ye, Zhiyong Gu and Jeffrey L. Shepherd “Production of High-Concentration Graphene Dispersions in Low- Boiling-Point Organic Solvents by Liquid-Phase Noncovalent Exfoliation of Graphite with a Hyperbranched Polyethylene and Formation of Graphene/Ethylene Copolymer Composites”, The Journal of physical Chemistry, 10730−10742, 117, 2013

[7] Graeme Cunningham, Mustafa Lotya, Clotilde S. Cucinotta, Stefano Sanvito, Shane D. Bergin, Robert Menzel, Milo S. P. Shaffer, and Jonathan N. Coleman “Solvent Exfoliation of Transition Metal Dichalcogenides: Dispersibility of Exfoliated Nanosheets Varies Only Weakly between Compounds” ,ACS Nano, 3468–3480, 2012

[8]X.Y.Zhang, “The preparation and properties of 2-d boron nitride nanomaterials research” A master's thesis of Shandong University, 2012(In chinese)

[9]Z.Wang, “The research of Graphene-like MoS_2 / graphene nanocomposites synthesis and electrochemical lithium storage properties” , A master’s thesis of Zhejiang university, 2013 (In chinese)

[10]P.Tang, The preparation of Graphene-like Molybdenum Disulfide and Its reaserch in Optoelectornic devices, A master’s thesis of Nanjing university of posts and telecommunications, 2013 (In chinese)