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Properties of a planar waveguide with Eu(III)-SWCNTs

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Abstract. A planar waveguide with Eu(III)-singlewalled carbon nanotubes (SWCNTs) was prepared by spinning coating. Its properties have been investigated by fluorescence spectrum, near-field scanning optical microscopy (NSOM) and m-line method. The film thickness is 1.825μm and refractive index is 1.593. The result can provide some basic information for the design of new optoelectronics devices.

Introduction

Carbon nanotubes (CNTs) have attracted much attention because of their unique structures and exceptional electronic and mechanical properties[1]. Singlewalled carbon nanotubes (SWCNTs) have also been shown to absorb infrared light and may have applications in the optics areas [2].Europium complexs have been regarded as attractive for use as luminescent materials because of their high and sharply spiked fluorescence emission efficiency, long lifetime, good stability[3]. Thus, the hybrid materials combining the luminescent features of europium complexs and the unique properties of CNTs have attracted a significant attention recently[4,5] .

In this study, a planar waveguide with Eu(III)-SWCNTs was fabricated by spinning coating. According to fluorescence spectrum, near-field scanning optical microscopy (NSOM) and m-line method, the properties of Eu(III)-SWCNTs planar waveguide has been investigated.

Experimental

Eu(III)-SWCNTs has been prepared according to the procedure reported before [5]. The structure of Eu(III)-SWCNTs is shown in Fig.1

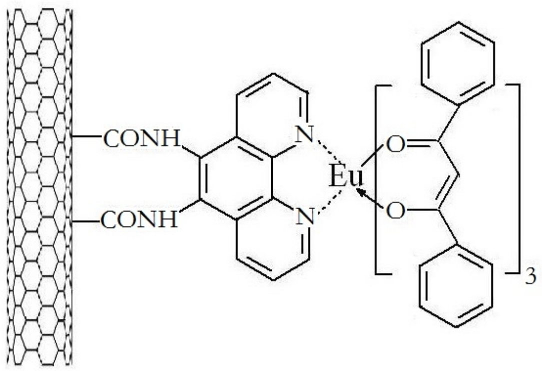

Fig. 1 Structure of Eu(III)-SWCNTs

0.1mol of 4,4'-Oxydianiline (ODA) is added into a solvent of 200g N,N-dimethylacetamide (DMAC) in a three-necked bottle at room temperature. After ODA dissolved completely, 0.1mol of 4,4'-(hexafluoroisopropylidene)diphthalic anhydride(6FDA) is is added into the solution. After 6FDA dissolved completely, the solution is stirred for 12 hours at room temperature and the solution of polyamic acid is formed. To obtain the coating solution, Eu(III)-SWCNTs are added into the polyamic acid solution and dispersed by ultrasonic vibration for 30 minutes. Eu(III)-SWCNTs polyimide film was deposited on a substrate of fused silica (3cm×2cm) using spin coating. The refractive index of the fused silica at 650 nm is 1.459. The sample was prepared at spin speed of 2000 revolution per minutes and dried in a vacuum oven for about 20 hours. After that, Eu(III)-SWCNTs planar waveguide was obtained.

The fluorescence emission spectrum of the planar waveguide was recorded on a Shimadzu RF-5301PC spectrofluorophotometer. A commercial near-field scanning optical microscopy (NSOM) from RHK Technology (USA) is used to detect the surface of the planar waveguide. The light from the Ar+ ion laser (457.9 nm) is coupled into a very small aluminum-coated quartz single-mode glass fiber tip with a 50 nm aperture. The tip illustrates the sample and scans near the sample surface of interest. Typical pixel dwell time in our images was 10ms. Images were acquired and processed by using the software SPM32 5.06 version (RHK, USA). The refractive index n_1 and the thickness h of the planar waveguide were obtained by the m-line method [7].

Results and Discussion

Fluorescence emission spectrum of Eu(III)-SWCNTs planar waveguide

The fluorescence emission spectra of Eu(III)-SWCNTs planar waveguide is shown in Fig.2.

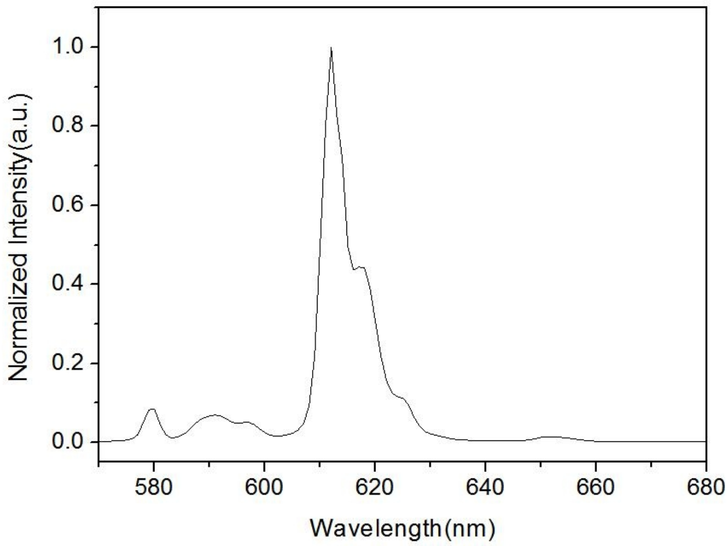

Fig.2 Fluorescence emission spectra of Eu(III)-SWCNTs planar waveguide

The emission spectrum was recorded form 570 nm to 680 nm under the excitation at 360nm. It can be found five emission peaks corresponding to 5D0→7F0,1,2,3,4 can be clearly distinguished for Eu complex in solution. The emission spectrum is similar to those of other Eu complexes, which indicates that the energy levels of the central Eu ions are not affected obviously by the SWCNTs.

M-line measurement of Eu(III)-SWCNTs planar waveguide

To investigate the basic parameters of Eu(III)-SWCNTs planar waveguide, its mode structure was measured by the m-line method. The incident polarized light is 650 nm wavelength from a diode laser. Fig.3 is the experiment results of m-line method.

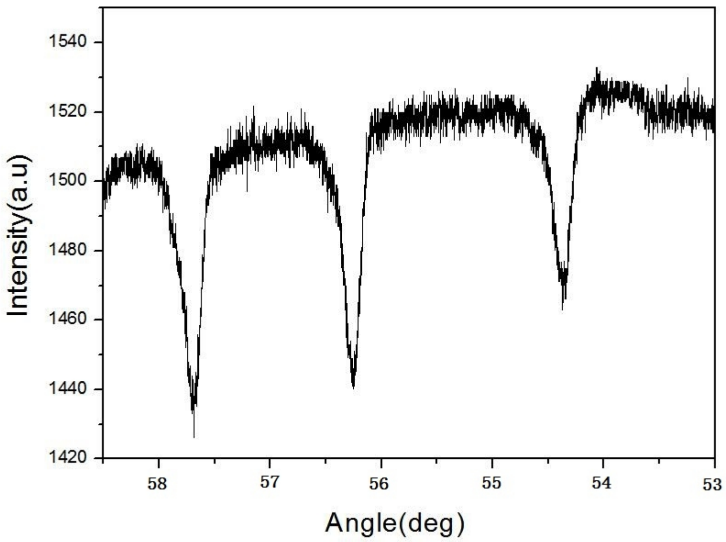

Fig.3 Experiment results of m-line method.

In Fig.3, there are four dropping peaks at θ_1(deg)=54.401, θ_2(deg)=56.262 and θ_3(deg)=57.692, according to reference [8], the film thickness h=1.825μm and refractive index n_1=1.593 can be obtained. The results indicated that the optical signals can be transmitted in Eu(III)-SWCNTs planar waveguide.

Near-field scanning optical microscopy of Eu(III)-SWCNTs planar waveguide

Near-field scanning optical microscopy (NSOM) has the ability to achieve a high spatial resolution and measure the surface topography without any damage to the sample. The experimental setup is the same as reference [9]. Fig.4 is the near-field topography of Eu(III)-SWCNTs planar waveguide in an area of 10μm×10μm.

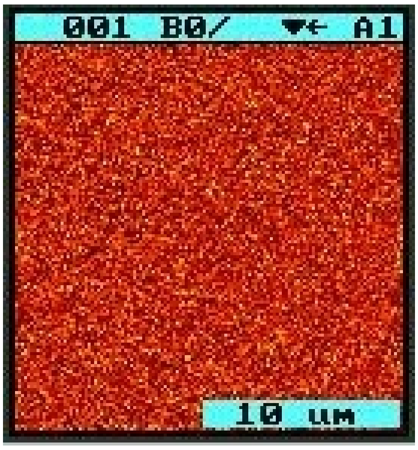

Fig.4 Near-field topography of Eu(III)-SWCNTs planar waveguide.

From Fig.4, it can be found that the film is homogenous under the resolution of 50nm and Eu(III)-SWCNTs dispersed homogeneously in the polyimide matrix.

Conclusions

In conclusion, Eu(III)-SWCNTs planar waveguide was fabricated. The emission spectrum showed that the energy levels of the central Eu ions are not affected obviousily by the SWCNTs. The obtained film thickness of Eu(III)-SWCNTs planar waveguide is 1.748μm and refractive index is 1.571.

Near-field scanning optical microscopy shows Eu(III)-SWCNTs dispersed homogeneously in the polyimide matrix.

Acknowledgements

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References

[1] J. Zhao, X.Chen and J.R.H.Xie: Analytica Chimica Acta Vol. 568 (2006) , p. 161

[2] J.Mohanraj and N.Armaroli: J. Phys. Chem. Lett. Vol. 4(2013) , p. 767

[3] G.E.Khalil, K.Lau, G.D.Phelan, B.Carlson, M.Gouterman, J.B.Callis and L.R.Dalton: Rev.Sci. Instrum. Vol. 75(2004) , p. 192

[4] L.Maggini, J.A.Jensen, G.L.Re, J.M.Raquez,P.Dubois and D.Bonifazi: CARBON Vol.70 (2014) , p. 22

[5] X.Xin, M.Pietraszkiewicz, O.Pietraszkiewicz, O.Chernyayeva, T.Kalwarczyk, E.Gorecka, D.Pociecha, H.Li and R.Hołyst: CARBON Vol. 50 (2012) , p. 436

[7] H.Liang, B.Chen, J.Xu, W.Su, F.Guo, B.Guo, Q.Zhang, Z.Zheng and H.Ming:Materials Letters Vol. 59 (2005) , p. 4030

[8] R.Ulrich and R.Torge: J.Appl.Opt. Vol. 12 (1973), p. 2901

[9] H.Liang, F.Xie, X.Ren and Y.Chen: Adv. Mater. Res. Vol. 750-752(2013) , p. 836