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BLUE ELECTROLUMINESCENCE FROM ZnSe/LANGMUIR-BLODGETT FILM MIS DIODES

Yulin HUA

Changchun Institute of Physics, Academia Sinica, Changchun, China

M.C. Petty, G.G. Roberts and M.M. Ahmad

Dept. of Applied Physics and Electronics, Univ. of Durham, Durham, U.K.

H.M. Yates, N. Maung and J.O. Williams

Dept. of Chemistry, UMIST, Manchester, U.K.

We report for the first time, the electrical and electroluminescent properties of Au/substituted silicon phthalocyanine LB film/MOCVD ZnSe MIS diodes. Underforward bias, and at room temperature the devices exhibited blue-white eletroluminescence. Further investigation revealed two peaks in the spectrum. The 460nm peak coincides with the maximum output in the PL spectrum and is attributed to band-to-band recombination.

1. INTRODUCTION

In previous publications we have described the use of Langmuir-Blodgett (LB) films as the insulating layer in MIS EL devices. In recent work we have turned our attention to the exploitation of the more stable phthalocyanine LB film materials and also to the use of II-VI EL semiconductors. Recently high quality ZnSe has been grown by MOCVD at atmospheric pressure and blue photoluminescence(PL) observed at room temperature. In this paper we report, for the first time, blue EL at room temperature from an MIS structure fabricated from MOCVD ZnSe and a substituted silicon phthalocyanine LB film.

2. EXPERIMENTAL

Epitaxial n-type ZnSe films (thickness approximately 3 μm), grown onto single crystal Si-- doped GaAs((100) orientation) substrates were produced by atmospheric pressure MOCVD, according to procedures described elsewhere. Indium metal as Ohmik back contacts was placed on the GaAs substrate which was then heated in an inert atmosphere. The depositipn condition of the substituted siocon phthalocyanine and details of the Au top contact have been given previously. PL was investigated with the ZnSe samples mounted in an optical cryostat (Air Products Displex System) EL measurements were made under pulsed bias conditions. Light emitted through and around the gold top electrode was passed through a Hilger and Watts monochromator and recorded using an a.c. technique with a photomultiplier tube.

3. RESULTS AND DISCUSSION

Figure 1 shows current-voltage data obtained from an MIS device incorporating seven layers (estimated total thickness 10nm of the substituted silicon phthalocyanine). The characteristics exhibit good retification and, for forward voltages less than approximately 1V, show a diode ideality factor of 2.5.

Under a forward bias greater than 2V the MIS devices emitted a blue-white light from beneath the Au top electrode. It should be noted that no such effect was observed for structures which did not include the LB layer (i.e. simple Schottky diodes). The spectrum of the emission (not corrected for the response of the monochromator or photomultiplier tube) is shown in figure 2; for comparison, the photoluminescence

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spectrum obtained at room temperature is also given.

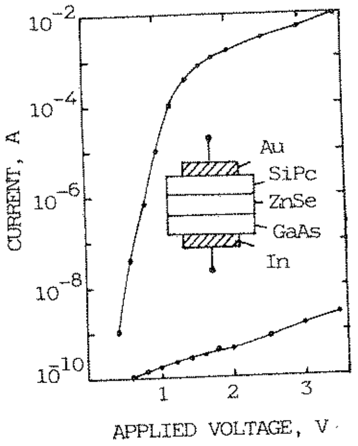

FIGURE 1

Forward and reverse current-voltage characteristics, measured in the dark and at room temperature, for an Au/substituted silicon phthalocyanine (SiPc)/ZnSe MIS diode.

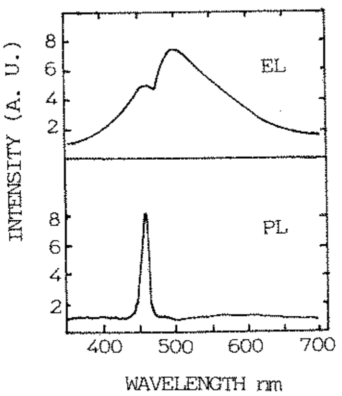

FIGURE 2

Top- EL spectrum obtained for an Au/SiPc/ZnSe MIS diode operated under pulsed condition in forward bias. Bottom- PL spectrum for MOCVD ZnSe substrate material at room temperature.

There are two distinct peaks shown in the EL spectrum; at approximately 460nm and 500nm. The former peak corresponds to the maximum in the PL data, and is almost certainly associated with band to band recombination in ZnSe.

In the MIS structures additional interfaces are present and large electric fields are involved that might lead to impurity ionization.

The enhanced EL for our MIS devices (over the simple Schottky devices) derives from the ability of the Fermi level of the top metal(Au) layer to move with respect to the Fermi level of the semiconductor. When a forward bias is applied, the metal Fermi level will move towards the valence band edge in the ZnSe, thereby aligning filled states in the top of the valence band with empty states in the metal. Provided that the LB layer is sufficiently thin, the minority carrier(hole) current will increase significantly with increasing forward bias, and EL will be observed.

We have already demonstrated that the stability of MIS EL devices incorporating phthalocyanine LB layers is significantry improved over structures containing simple fatty acid multilayers; indeed, under the pulsed conditions reported here, devices are completely stable. However, given the relatively large values of current density that are required in our MIS devices, a full investigation is now clearly desirable.

4. CONCLUSIONS

Blue light emission has been observed from forward biased Au/substituted silicon phthalocyanine LB film/ZnSe MIS devices. It is thought that the presence of the LB layer causes an increase in the minority carrier injection ratio into the II-VI semiconductor.

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