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Optical Properties of Highly Fluorescent Conducting Polymers and Lasing in Micro-cavity and in Opal Matrix as Photonic Crystal

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Luminescent conducting polymer has attracted much interest from both scientific and practical view points, because high quality of electroluminescence (EL) devices have been demonstrated utilizing luminescent conducting polymers [1-3]. The low threshold lasing upon optical excitation of micro-cavity structure of conducting polymer films and also the polymers infiltrated in a synthetic opal as photonic crystal have also been reported [4,5]. Luminescent characteristics of conducting polymers are strongly dependent on their molecular structure. In this paper, we discuss various highly luminescent conducting polymers and EL and Lasing characteristics.

Figure 1 indicates molecular structures of highly luminescent polymers used in this study.

From the view point for applications, the conducting polymer is desirable not only to be highly luminescent but also to be soluble in common solvents, because thin films can be easily prepared by spin coating or casting methods.

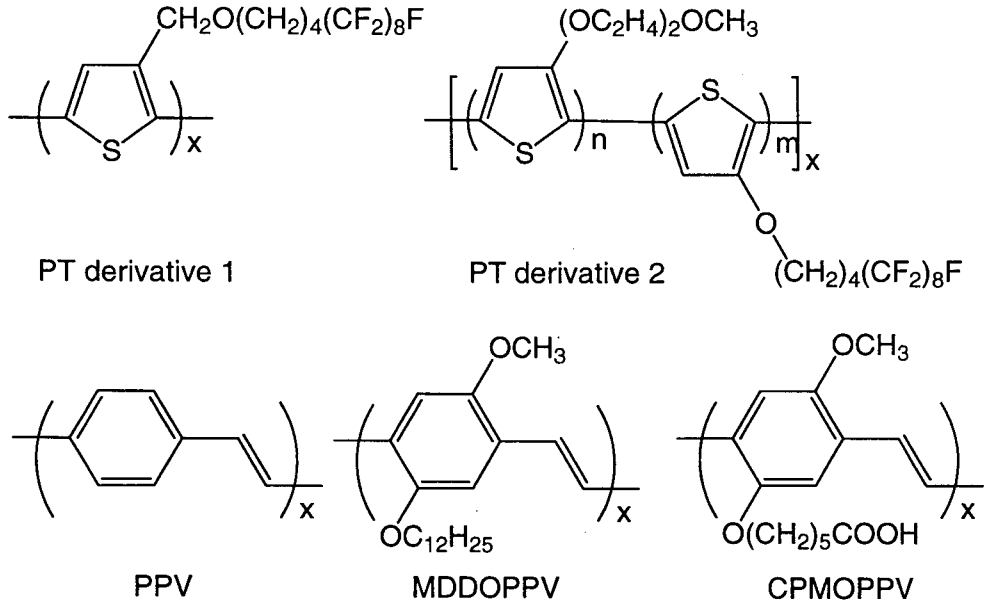

Fig.1 Molecular structures of polythiophene derivatives and poly(*p*-phenylenevinylene) derivatives.

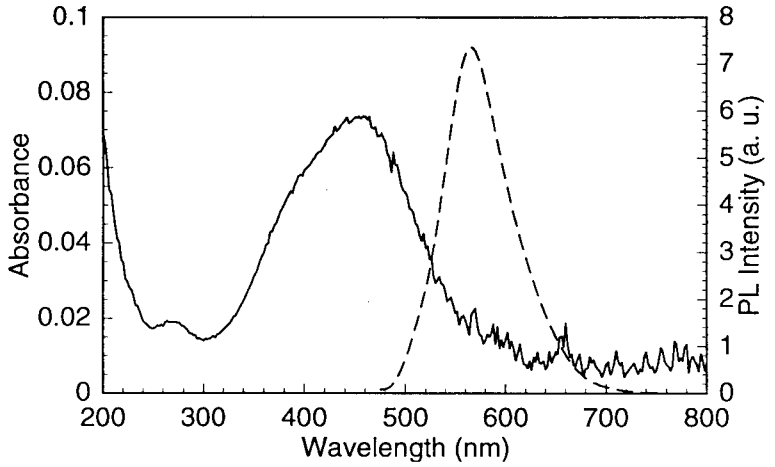

Fig. 2 Absorption and PL spectra of the film of PT derivative 1.

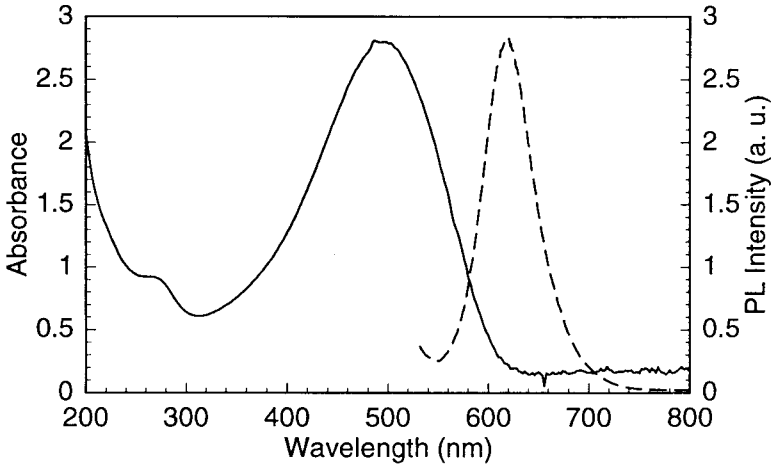

Fig. 3 Absorption and PL spectra of the film of PT derivative 2.

All conducting polymers shown in Fig.1 are highly luminescent. It should also be mentioned that polythiophene derivatives with fluorine groups in the side chain, poly{3-(5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heptadecafluoro-dodecyloxymethyl)thiophene} (PT derivative 1), and their copolymers with alkoxy derivatives of polythiophene, poly[3-{2-(2-methoxy-ethoxy)-ethoxy}thiophene-*co*-3-(5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heptadecafluoro-dodecyloxy)thiophene] (PT derivative 2),are highly soluble in common solvents and their thin films can be prepared by the spin coating.

Figures 2 and 3 show the absorption and fluorescence spectra of these polythiophene derivatives. It should be noted in these figures that they exhibit yellow-green and red luminescence both in film and solution. The luminescence quantum yield was as high as poly(3-alkylthiophene).

The diodes with the structure of ITO/polythiophene derivative/Al also exhibited strong EL , yellow-green EL in the former and red EL in the latter.

Figure 4 shows the luminescence spectra of poly(p-phenylenevinylene) (PPV)) derivatives such as non-substituted PPV, poly(2-methoxy-5-dodecyloxy-p-phenylenevinylene) (MDDOPPV), poly(1,4-

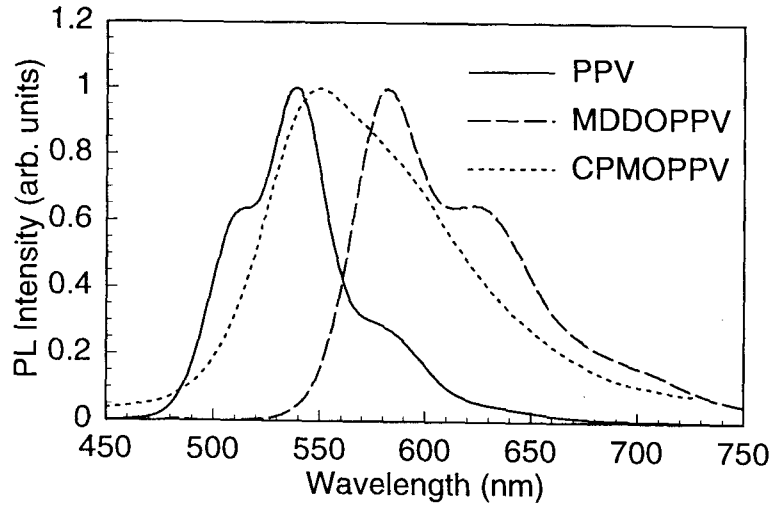

Fig. 4 PL spectra of PPV, MDDOPPV, CPMOPPV.

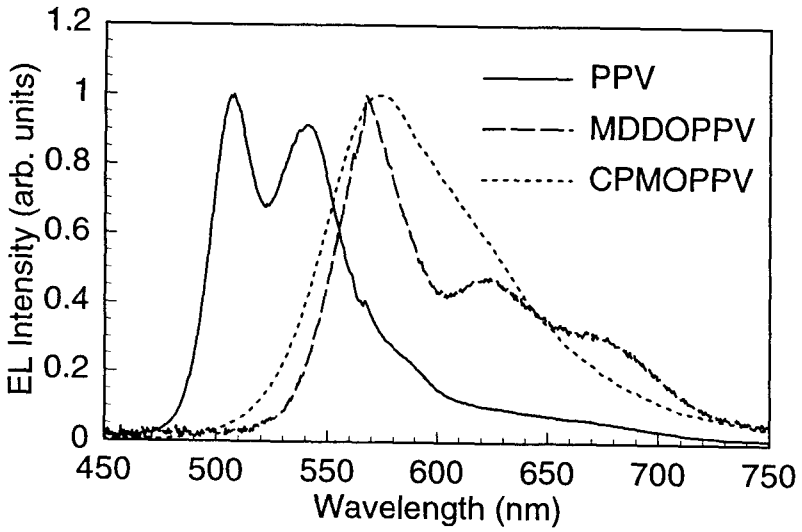

Fig. 5 EL spectra of PPV, MDDOPPV, CPMOPPV.

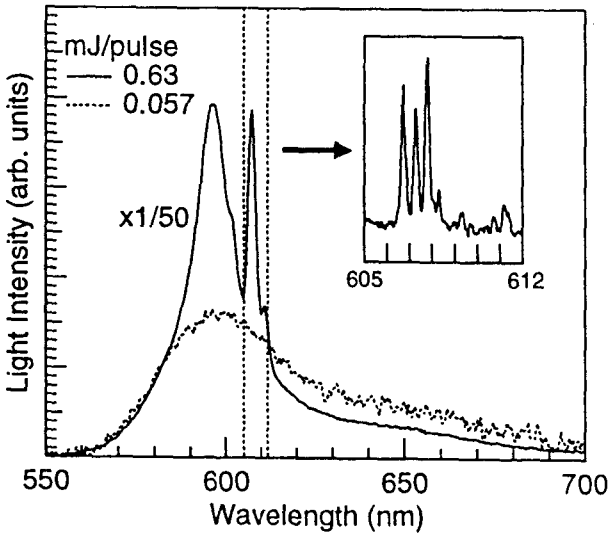

Fig. 6 Spectral narrowing and lasing of green opal infiltrated with MDDOPPV.

(2-(5-carboxypentyloxy)-5-methoxyphenylene)vinylene) (CPMOPPV) [6]. All these derivatives are highly luminescent.

Figure 5 indicates the EL observed in the diode with the structure of ITO/PPV derivative/Al. Intense EL was realized in these PPV derivatives.

All these soluble conducting polymers can be well infiltrated in synthetic opals. Upon optical excitation with the SHG of Nd YAG laser of the opals infiltrated with these conducting polymers, spectral narrowing and lasing can be observed as shown in Fig. 6 for example. It should be mentioned that for lasing the combination of wave length of luminescent material and the periodicity of the opal is confirmed to be important. These results are discussed by taking the optical feed back and confinement of light in the opal matrix into consideration.

Acknowledgement

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