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Lasing behavior in DCM-doped PVK microcavity

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Abstract

A surface emitting microcavity was formed by sandwiching a polymer film containing PVK, Alq_3 and DCM between a distributed Bragg reflector (DBR) with a reflectivity of 99% and a silver film (300 nm). The lasing phenomenon was observed in DCM-doped PVK microcavity. The full width at half maximum (FWHM) was 0.6 nm with the peak wavelength at 603 nm. The threshold energy for lasing was estimated to be about 2.5 μJ per pulse.

Keywords: Polymer lasing; Microcavity; Optically pumped laser

1. Introduction

Recently, polymer lasing has attracted much attention because of its academic interest and potential application in modern display technology and integrating optical field [1,2]. Since the first report of polymer lasers based on poly(*p*-phenylene vinylene) (PPV) with the microcavity by Tessler et al. [3] and on poly[2-(2′-ethylhexyloxy)-5-methoxy-1,4-phenylene vinylene] (MEH-PPV) film without the microcavity by Hide et al. [4] in 1996, a variety of conjugated polymers have been reported to exhibit the lasing behavior [5–9]. It was found that the photoluminescence (PL) spectrum line width of polymer could be narrowed by using a microcavity structure. Microcavities have recently attracted a great deal of attention since they are a useful tool to tailor the emission of such conjugated polymer devices [10–12]. They also confine the direction and frequency of oscillating light to ensure the monochromaticity and directionality of the radiated light. In this paper, we present the lasing behavior in a DCM-doped PVK microcavity.

2. Experimental

The distributed Bragg reflector (DBR) mirrors have nominally greater than 99% reflectivity at normal incidence from 580 to 620 nm. The DBR consists of 1/4-wavelength dielectric layers with alternating high and low index. The high reflectivity over such a broad wavelength range results from the many layers with different layer thicknesses such that longer wavelengths are reflected deeper inside the stack. The DBR was fabricated onto the quartz substrate. A solution of 40 mg PVK, 25 wt.% of Alq3 and 0.05 wt.% of DCM1 in 2 ml of chloroform was spin-coated onto DBR to make the polymer film [13,14].

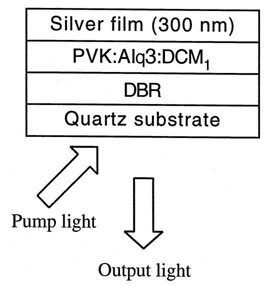

Fig. 1. The structure of the polymer surface emitting microcavity.

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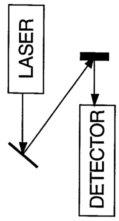

Fig. 2. The light path of the measurement.

The film thickness can be controlled by adjusting the solution concentration or turning speed of the spin-coating machine. The thickness of polymer film was measured with a Dektak profilometer. The sample was roasted in the oven for 30 min at 50°C. The polymer films were protected in nitrogen atmosphere for all steps. Then a silver film of 300 nm thickness was thermally evaporated onto the polymer film at 2×10^{-5} Torr vacuum pressure. The structure of polymer surface emitting microcavity is shown in Fig. 1.

The configuration of optical measurement is shown in Fig. 2. The sample was optically pumped with 220-ps pulses at 82 MHz repetition rate by a 514.5-nm line of Ar^{+} laser. The detecting spectrum range is from 540 to 640 nm.

3. Results and discussion

Lasing phenomenon was observed when the monopulse energy reached 2.5 μJ (threshold energy). When the monopulse energy goes up to 3.5μJ, the full width at half maximum (FWHM) of the lasing peak is 0.6 nm, with the peak wavelength at 603 nm. The fluorescence spectrum and lasing spectrum obtained from the polymer surface emitting microcavity are shown in Figs. 3 and 4, respectively. In the experiment, it was found that microcavity is the key structure for achieving high gain. Such a structure will alter the emission properties of any emitter within the microcavity. The geometry of the microcavity alters the

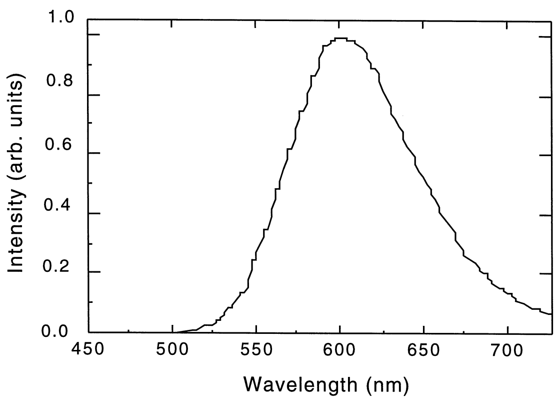

Fig. 3. The fluorescence spectrum of the microcavity below the lasing threshold.

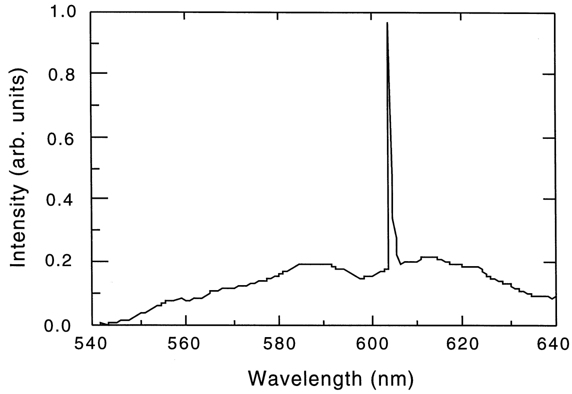

Fig. 4. The lasing spectrum obtained from the polymer surface emitting microcavity.

spontaneous emission rate of the emitting dipoles therein, allowing emission only at the resonance wavelengths of the cavity. This narrows the broad emission spectrum of conjugated polymer [15,16]. This DCM-doped polymer film as a gain medium made it possible to realize polymer microcavity laser. A further study is in progress.

4. Conclusion

In summary, we found that the lasing phenomenon was observed in DCM-doped PVK microcavity. The full width at half maximum (FWHM) was 0.6 nm with the peak wavelength at 603 nm. The threshold energy for lasing was estimated to be about 2.5 μJ. The results show that microcavities are key structures for achieving polymer lasing. DCM-doped polymer films as gain medium make it possible to realize polymer microcavity laser.

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