Dye doped PMMA Microcavity Resonator Based on X-ray lithography

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Micro dye lasers have been widely used as tunable, coherent light sources for spectroscopic analysis in the visible wavelength region - from about 400 nm to 800 nm. [1-3]. The dielectric microstructures act as ultrahigh Q factors optical cavities, which modify the spontaneous emission rates and alter the spatial distributions of the input and output radiation. The microcavity structure is a Fabry - Perot - like cavity structure. The interaction of the confined cavity photon with the pumping light modifies the resulting spontaneous emission and optical properties. The proposed technique to generate the very fine flat surface is demonstrated by applying it for fabrication micro cavity. The polymer surface has been smooth enough to generate laser resonance in microcavities.

The dye laser cavities film are prepared by mixed the laser dye (Rhodamine 6G) with PMMA in the solvent. The solution is the mixture of methyl isobutyl ketone (MIBK) of 9 ml, chlorobenzene of 9 ml, ethanol of 2 ml, PMMA of 2 g, and Rhodamine 6G Chloride of 4.0 x 10^{-5} mol. The combination is MIBK, chlorobenzene, and ethanol as the solvent. For making the solid plastic laser cavity, the dye laser solution thin film is coated on a 4 inch (100) silicon wafer. The X-ray photoresist is PMMA therefore it is easy to pattern in PMMA resist only by development after x-ray exposure. This sheet PMMA is typically adhered to a metalized (by Al evaporation) 4 inch silicon wafer. To solidify the film, a baking process is held in a stove with the temperature 80 degree, and the baking time is 4 hours. An x-ray mask with a polyimide membrane and gold absorber was fabricated. The mask pattern is design as the cylinder array having a pitch of 330μm and the diameter of a cylinder are 100μm.

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The dosage is about 0.01Ahour. After developed in GG developer, the result observed by digital camera is shown in Fig1. The PMMA cavity is circle in shape and the thickness is 5 μm. In addition, the RMS value of the surface roughness which greatly influences the optical performance of micro-optical elements was within 30nm, less than one-tenth of wavelength.

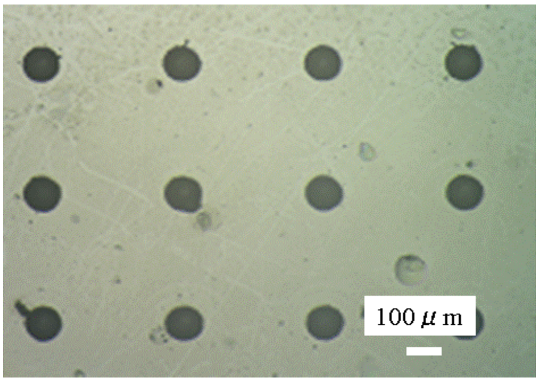

Fig.1 Fabricated microcavity

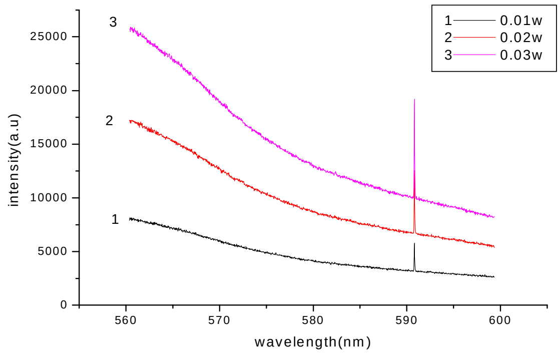

Fig.2 The emission spectrum of the cavity at different pumping powers

In order to confirm the dye laser property of microcavity, an experiment is held. The microcavities are excited by an obliquely incident laser beam of the second harmonic light. The incident angle is about 60degree from the normal. The dye laser in the PMMA shows a peak at about 592 nm. The emission power increases, the intensity of dye laser increases at the same wavelength (592nm). The microcavities are excited by an obliquely incident laser beam of the second harmonic generation light (532 nm) of an Nd: YAG laser (OHERENT Verdi 899, RING LASER). The emission laser from the microcavity is collected from the top of the cavity using a spectrometer with the resolution of 1200 line/mm gratings (SpectraPro-500i, USA). Figure 2 shows the spatially a spectra of the circle shaped cavities measured by different optical pumping powers. A sharp peaks superimposed on the broadband fluorescence spectrum at 592nm are observed. The fluorescence from the Rhodamine 6G is seen in the wavelength range from about 550 nm to 620 nm. A strong peak around a wavelength of 592 nm emerges from the fluorescence, as the average pumping power is above 10 mW.

Dye doped PMMA microcavities based on x-ray lithography process are fabricated. The lasing from the fabricated cavities is confirmed by a sharp peak in the emission spectrum. The dye laser microcavity resonators are pumping by the YAG laser (532nm). The output laser wavelength is 592nm.

References

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