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# **Application of Hybrid Polymer as Laser Devices Based on 2D Grating with Square Structure**

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Sahrul Hidayat, **Fitrilawati**, Ayi Bahtiar,  
Rustam Eefendi Siregar, Rahmat Hidayat, M Ozaki

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## Application of Hybrid Polymer as Laser Devices Based on 2D Grating with Square Structure

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### Abstract

Two dimensional gratings have been fabricated by laser interference method on hybrid polymer films doped with 4-dicyanmethylene-2-methyl-6-(p-dimethyl-aminostyryl)-4H-Pyran (DCM). The gel precursor of hybrid polymer was synthesized by sol-gel route using 3-(trimethoxysilyl)-propyl-methacrylate (TMSPMA). The film was exposed by laser interference of Nd-YAG laser yield square lattice of 2D-grating with periodicities 391 nm and 405 nm. The characteristic of lasing was investigated using strip-line excitation light of second harmonic generation (SHG) of Nd-YAG laser ( $\lambda = 532$  nm). The lasing wavelengths are observed at  $(588 \text{ nm} \pm 2)$  and  $(606 \text{ nm} \pm 2 \text{ nm})$  for grating period of 391 nm and 405 nm, respectively. The spectral width of lasing is about 2 nm at pumping power 6.6 mJ/pulse.cm<sup>2</sup>.

**Keywords:** 2D grating, Square structure, Hybrid polymer, Laser.

### 1. Introduction

Lasers are devices that amplify or increase the intensity of light to produce a beam in certain directional and high intensity that typically has a very pure frequency or wavelength. The typical laser device consists of an amplifying or gain medium, a pumping source to input energy into the device, and an optical cavity or mirror arrangement that reflects the beam of light back and forth through the gain medium for further amplification.

A new class of laser systems occurs when the dielectric microstructure responsible for light scattering consists of a periodic array of identical unit cells. Photonic crystals are periodic dielectric structures exhibiting strong Bragg scattering as well as microscopic resonance scattering of electromagnetic waves. Under suitable circumstances with respect to material composition, topology, and lattice symmetry, a forbidden frequency range may be created. A forbidden frequency range is known as the photonic band gap. Photonic band gap able to modify the density of electromagnetic modes and enhance spontaneous emission, therefore photonic crystal can be used as laser resonator<sup>1,2)</sup>. There are two types of lasers associated with photonic crystals. The first is the band edge micro laser, in which the light emission occurs at the photonic band edge. The second is the defect mode micro laser, which utilizes a localized state defect mode as a laser cavity<sup>3)</sup>.

M. Maier *et al.*<sup>4)</sup> have reported fabrication and analysis of laser resonator with two dimensional distributed feedbacks from photonic crystal. The gain medium consists of 2-(4-biphenyl)-5-(4-tert-

butylphenyl)-1,3,4-oxadiazole host doped with Coumarin 490 and DCM and is deposited on patterned Si/SiO<sub>2</sub> substrate. Two dimensional structure of Si/SiO<sub>2</sub> substrate was fabricated using electron beam lithography.

Recently, hybrid polymer as one of sol-gel materials is good candidate for optical devices. They have several advantages for application as optical devices, such as easy in synthesizing and patterning process, easy customized by add some functional material, and exhibit a good transparency in optical region<sup>5)</sup>. Several fabrication processes for optical devices have been developed, such as photo lithography, electron beam lithography, and embossing<sup>6,7)</sup>. A simpler method for fabrication the two dimensional structure from hybrid polymer is photo-lithography using Lloyd mirror interference method<sup>8)</sup>.

In this paper we report about the lasing performance of two dimensional photonic crystal using hybrid polymers as base material. The gel precursor of hybrid polymer synthesized by sol-gel method and doped with DCM. Two dimensional micro-structures was fabricated using Lloyd mirror interference method. The photo polymerization process of precursor hybrid polymer was also investigated using IR spectrophotometer.

### 2. Experiment

The gel precursor of hybrid polymer was synthesized by sol-gel method using TMSPMA as monomer. TMSPMA was obtained from Aldich. Chloroform (CHCl<sub>3</sub>), ethanol (C<sub>2</sub>H<sub>5</sub>OH), and HCl (aq)