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NANO-APERTURE DESIGN FOR VERTICAL-CAVITY SURFACE-EMITTING LASER USING THE SHAPE OPTIMIZATION PROCEDURE

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Abstract

In the optics field, many researches proposed various shapes of nano-aperture whose transmission efficiency is over 1 challenging the prediction about the diffraction limit [1]. Extra-ordinary transmissions are occurred at some specific resonance condition and it is named as the surface plasmon effect [2]. Although a small variation of geometric factors in such a nano-aperture causes dramatic performance improvement [3], applications of systematic optimization approach are rare. The vertical-cavity surface-emitting laser (VCSEL) is another prospective application of the nano-aperture and it is widely used in the optical communication for infra-red frequency range as well as the near field memory system for high-density recording. The grating structure of the metallic layer is proposed for higher throughput of optical near field [4].

It is targeted to obtain the optimal 2D cross sectional shape of the metal layer in the VCSEL system to enhance the wave transmission through a nano-aperture and we also propose 3D design of VCSEL. For the design methodology, we adopted the phase field shape optimization method using the reaction diffusion equation combined with the double well potential for avoiding gray scale representation and obtaining simplified structure by controlling the diffusion coefficient. It is noteworthy that the structure scale in this field is too small to admit complex shapes if the real application would be taken into account.

The nano-aperture model is composed of three parts. At first, the 850nm wavelength incident light in near infrared wavelength range goes from the upper air portion. Subsequently, it passes through the silver (Ag) nano-aperture area and propagates in the amorphous silicon (a-Si) layer. The perfectly matched layer (PML) is located around Ag and a-Si layers. The design objective is for maximizing the field strength intensity in the specified measuring area and we evaluated it by calculating the Poyinting vector value of the area. The prototype model is set as the whole design domain is filled with Ag material. The FEA is implemented by the commercial finite element analysis package COMSOL ver. 3. 5, and the optimization process is carried out by Matlab programs. The optimized model shows almost two times larger performance enhancement in comparison with the prototype model.

References

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