

Simulations of Self-pickup Laser Diode Readout in Near-field High Density Optical Storage

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In high density near-field optical storage applications a laser diode is brought into close proximity of a recorded surface with the express purpose to circumvent the diffraction limit imposed upon the spot size, as schematically shown in Fig 1. In such a configuration, generally, there is no space for bulky elements employed in the usual far-field detection schemes. As an alternative, the disk induced effects of self-coupling and optical feedback, as manifested in modulation of diode voltage, operating wavelength or rear facet output power may be utilized for readout. In this paper, the issues of sensitivity, signal-to-noise-ratio, speed and other overall prospectus of such a near-field detection scheme are addressed via a theoretical analysis and numerical simulations.

Utilizing advanced finite difference and finite element simulations to solve the complete vectorial Maxwell equations, we analyze optical self-coupling and emission from a very small aperture (VSA) [1] milled into the front metal coated facet of a laser diode[2]. The calculated coupling coefficients were then applied as inputs to the dynamical laser model based on the weak optical feedback approximation [3]. The stochastic Langevin forces were included for modeling spontaneous and shot noises. In Fig. 2 the side view of light intensity emitted from the front facet coating ($\text{SiO}_2\text{-Al}_2\text{O}_3\text{-Ag}$ – air interface) is depicted. One can observe that the lateral intensity distribution is quite narrow (on the order of the subwavelength aperture size) within a small distances of the aperture (the near-field zone).

In phase-change (PC) optical media, data is recorded in a thin alloys layer through laser induced heating. The area effected by the focused beam results in either an amorphous or crystalline mark depending on the temperature reached and cooling rate .

We compared readback sensitivity of both edge emitters and VCSELs to a signal from the phase changing media (Fig. 3) when the detection is based on measuring the power output from the rear facet. We found that the absolute change of the rear facet output due to modulation of the external mirror reflectivity (marks on the PC disk) to be approximately the same for both types of lasers. Smaller “openness” and the larger (symmetric) mode area of VCSELs are compensated by a short cavity length leading to comparable sensitivity. The issues of magneto-optic detection using VSA laser diodes are also briefly discussed.

1. A. Partovi et al., “High-power laser light source for near field optics and its application to high-density optical data storage”, Applied Physics Letters, vol. 75, pp.1515 – 1517 (1999).
2. XFDTD by Remcom, Inc.; EMFLEX by Integrated Photonic Systems, Inc.
3. R. Lang and K. Kobayashy, “External optical feedback effect on semiconductor injection laser properties”, IEEE J. Quant. Electron., vol. QE-16, pp.347-355 (1980).

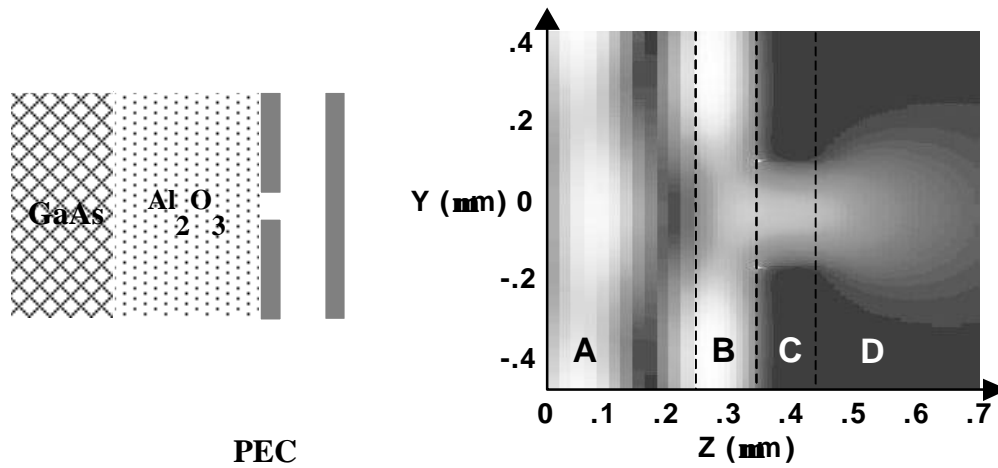


Fig.1. Schematic drawing of the structure in XFDTD simulations

Fig. 2: Light intensity distribution(EMFLEX) near the subwavelength aperture.Regions: A) SiO₂; B) 125nm Al₂O₃;C) 100nm Ag; D) Air. Aperture is air filled, with a square profile of linear dimension 250nm.

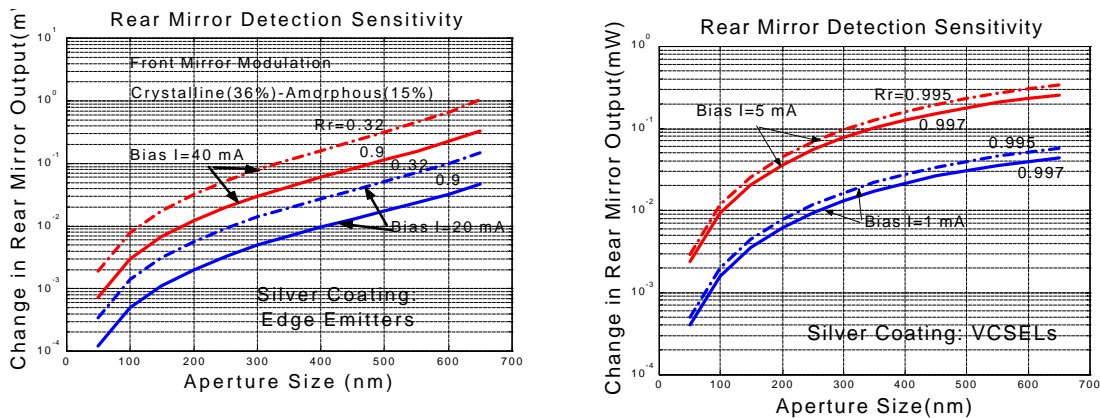


Fig. 3: Comparison of edge emitters (a) and VCSELs (b) rear facet output sensitivity to the phase changing media readout signal vs the very small aperture size in the silver front facet coating.