Future Optical Disk Technologies

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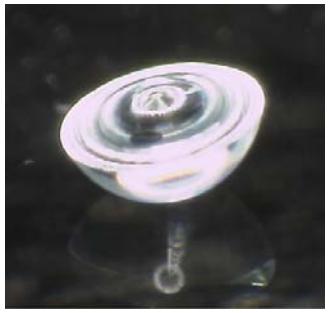
Abstract

We discuss R&D progress in various areas of optical data storage with emphasis on technologies that aim to reach beyond the capabilities of HD-DVD and Blu-Ray formats. Presently, near-field optical recording seems to be the front-runner in the race for fourth-generation optical storage products. Holography and various Multilayer schemes also appear to have a chance in the competition for fourth- and fifth-generation market share. We describe the fundamentals of the technologies currently under investigation in various laboratories worldwide, and offer a comparative analysis of their potentials and their shortfalls.



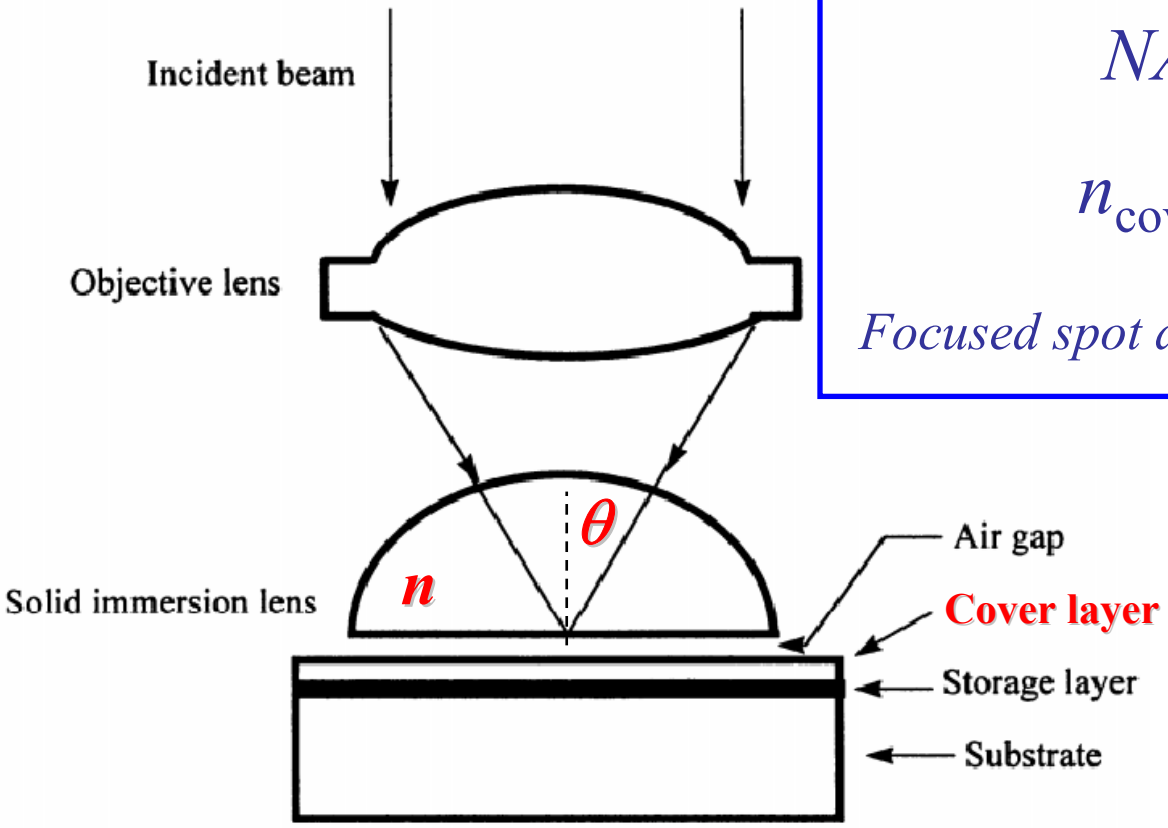
Near-field Optical Recording using Solid Immersion Lens (SIL)

$$\lambda_o \sim 0.4\mu m$$

$$NA_{eff} = n \sin\theta$$

$$n_{\text{cover\_layer}} \sim n_{\text{SIL}}$$

$$\textit{Focused spot diameter} \sim \lambda_o/(n \sin\theta)$$

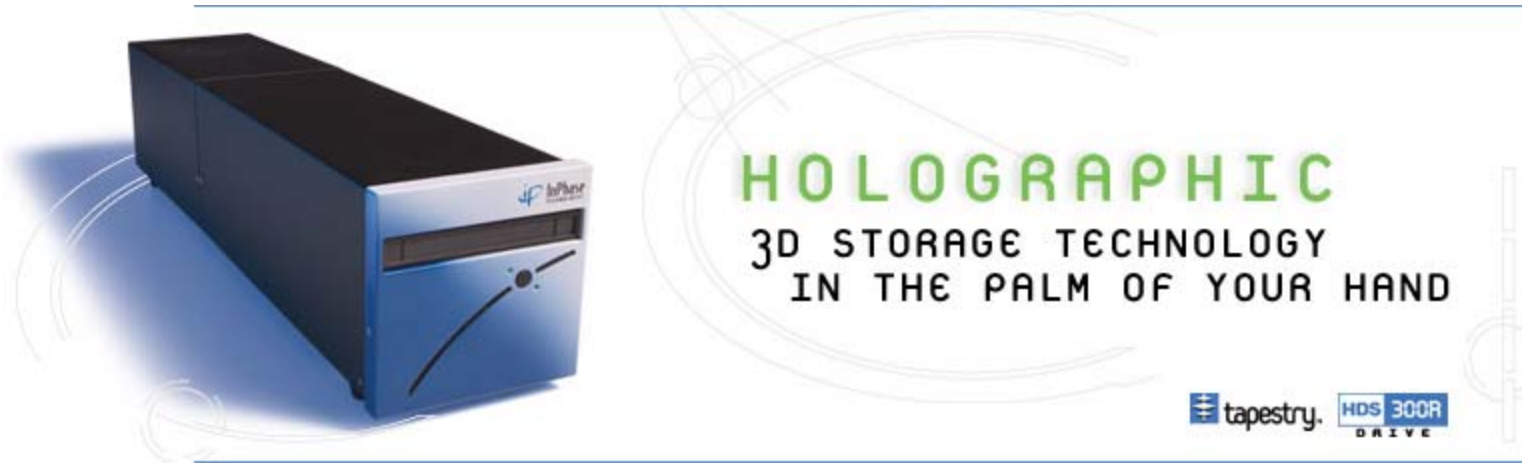


Servo gap control

Double-layer disk

Capacity ~ 100-200 GB

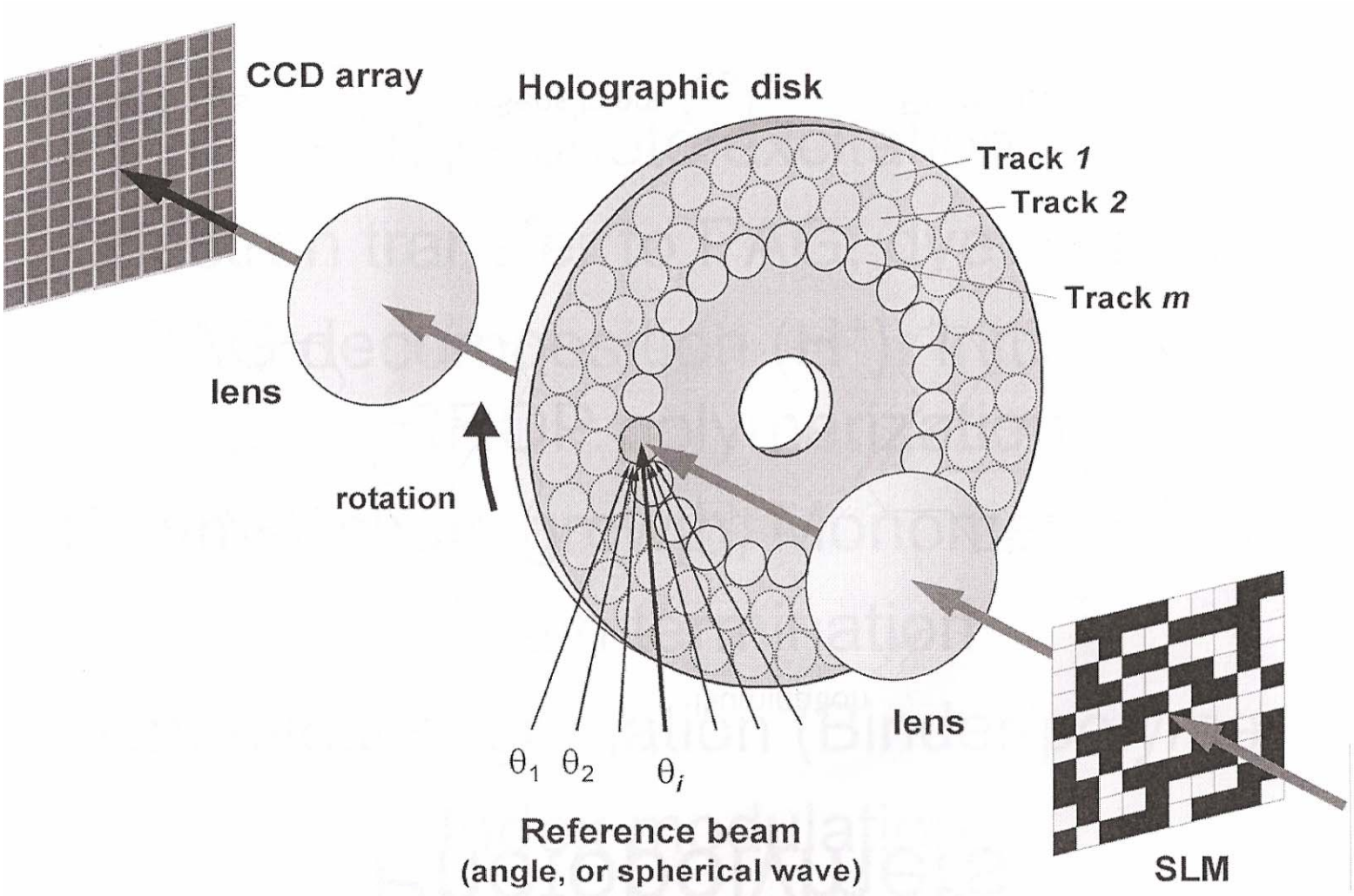
Holographic Data Storage



INPHASE TECHNOLOGIES DEMONSTRATES FIRST COMMERCIAL HOLOGRAPHIC STORAGE PRODUCT AT IBC 2006; ANNOUNCES FIRST OEM DEAL WITH IKEGAMI FOR EDITCAM ARCHIVE SOLUTION

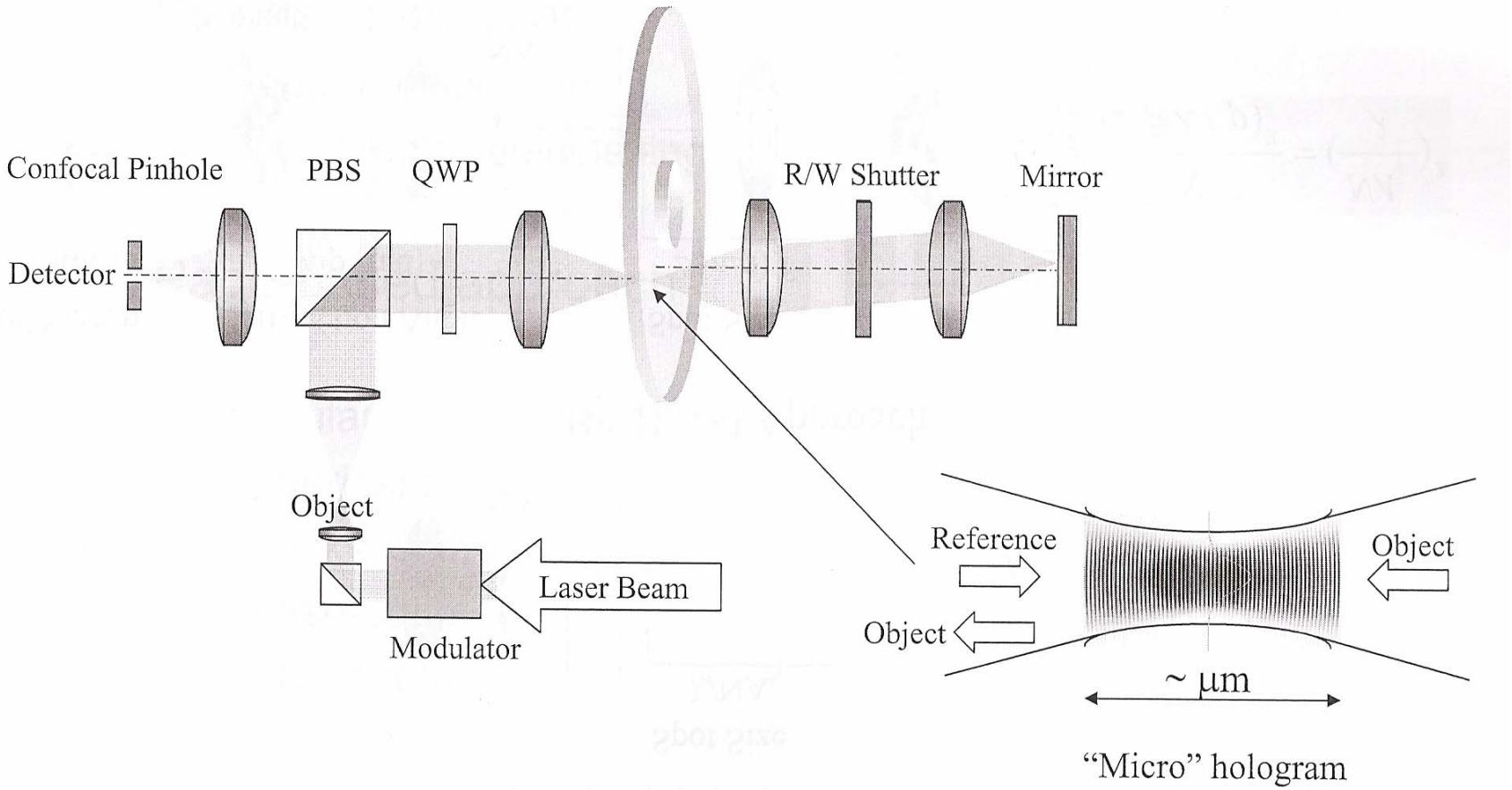
Tapestry™ 300-R Enables 300 Gigabytes On a Single Disk at 20 Megabytes Per Second; Product to Ship to Initial Customers at End of 2006

Holographic Disk Architecture



Prof. L. Hesselink, Stanford University

Bit-based Holographic Data Storage



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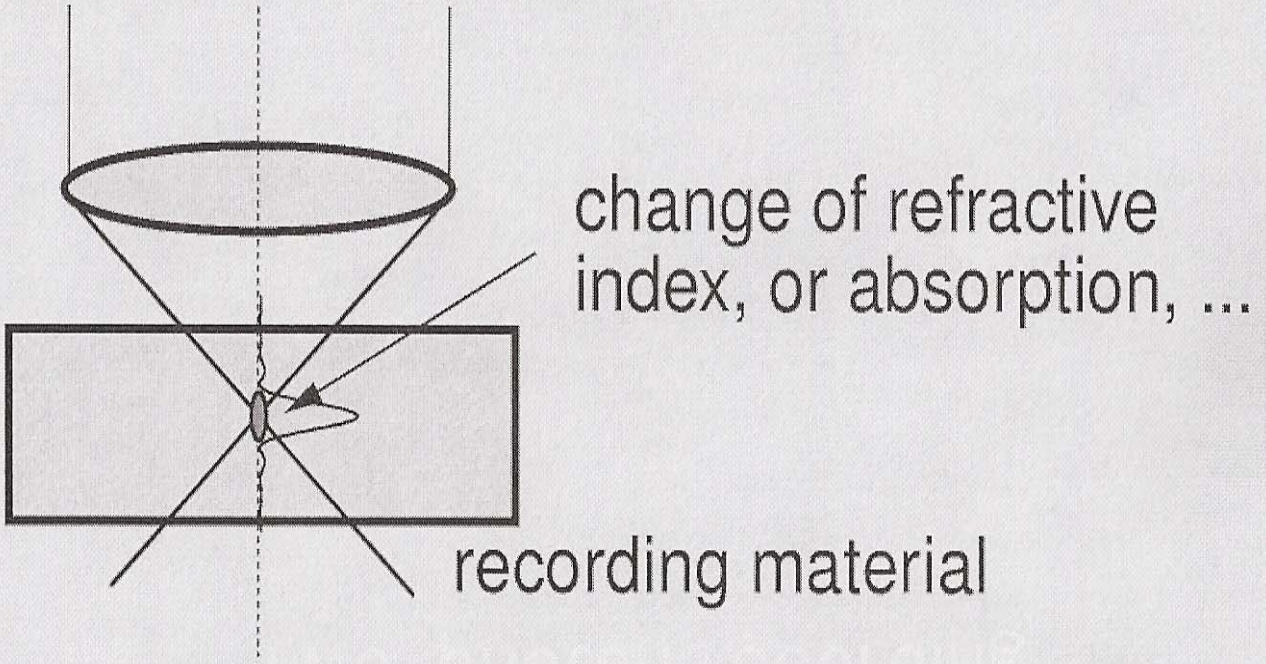
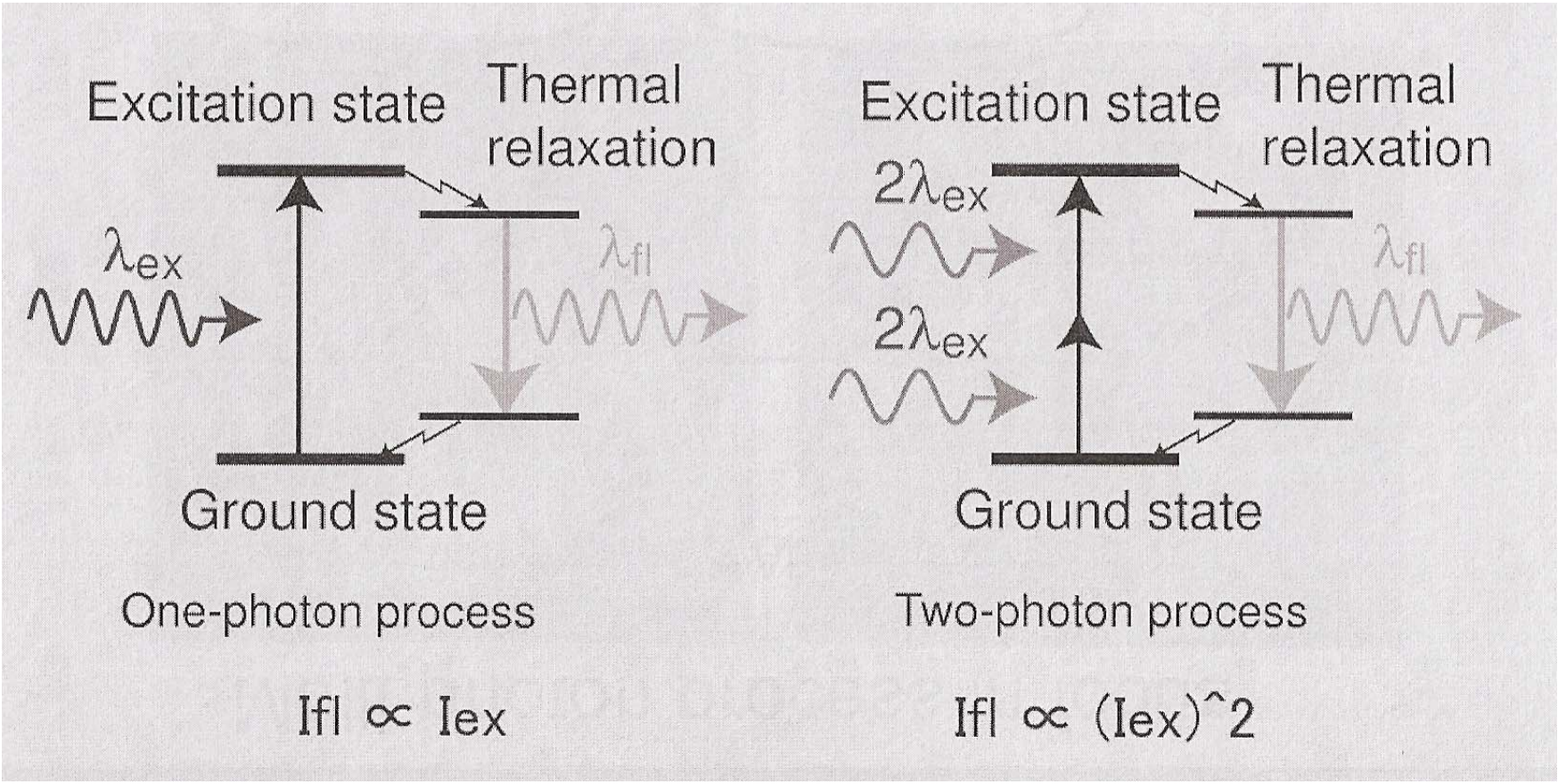
Multilayer Recording: Nonlinear Media

Nonlinear response of recording medium to light intensity — Two photon process



Prof. Y. Kawata, Shizuoka University, Japan

2-Photon Excitation



Prof. Y. Kawata, Shizuoka University, Japan

Transmission of light through subwavelength slits and apertures: Applications in near-field optical recording

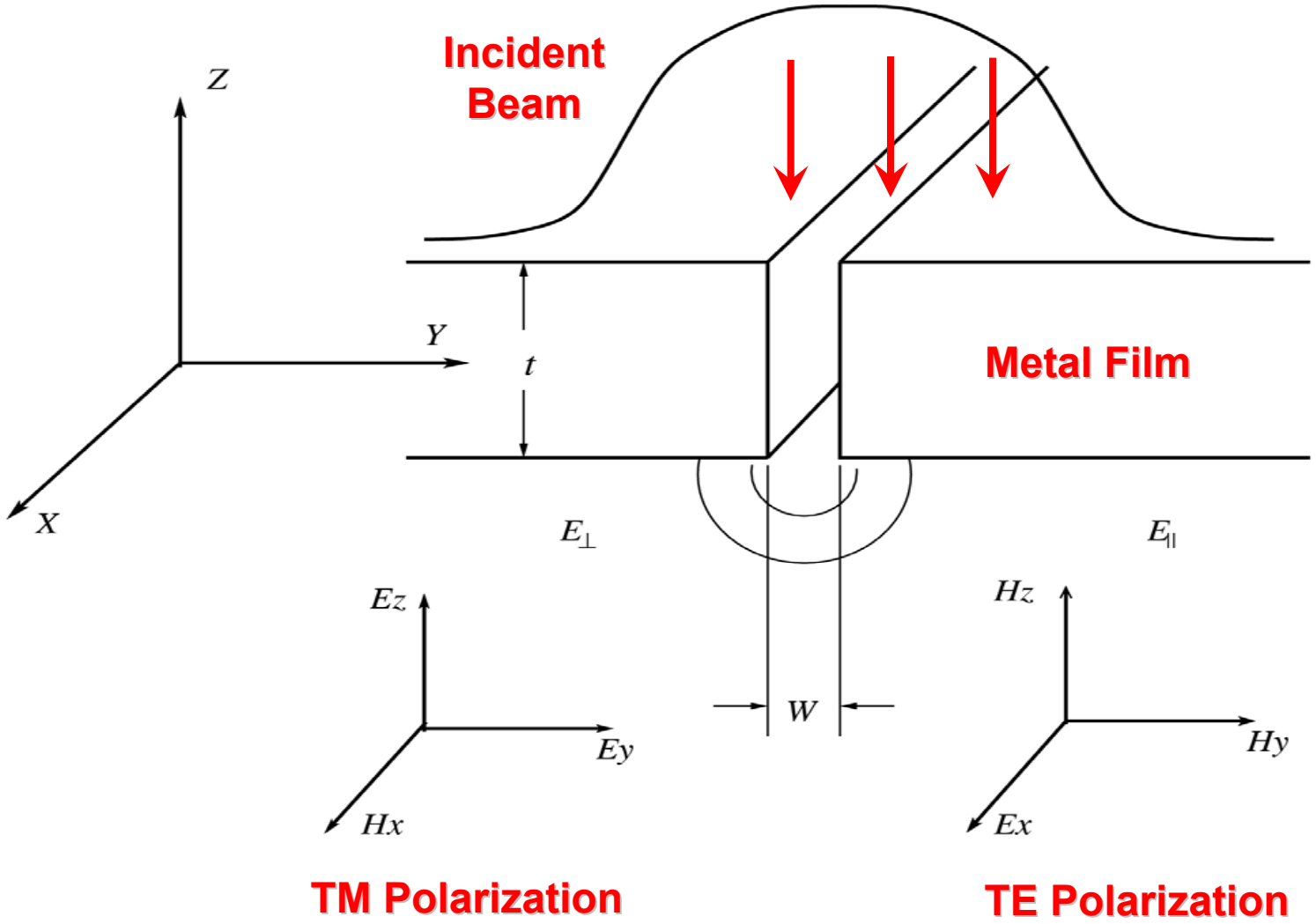
- A. Zakharian, M. Mansuripur, and J. Moloney, "Transmission of light through small elliptical apertures," *Opt. Express* 12, 2631-2648 (2004)
http://www.opticsinfobase.org/abstract.cfm?URI=oe-12-12-2631

- Y. Xie, A. Zakharian, J. Moloney, and M. Mansuripur, "Transmission of light through slit apertures in metallic films," *Opt. Express* 12, 6106-6121 (2004)
http://www.opticsinfobase.org/abstract.cfm?URI=oe-12-25-6106

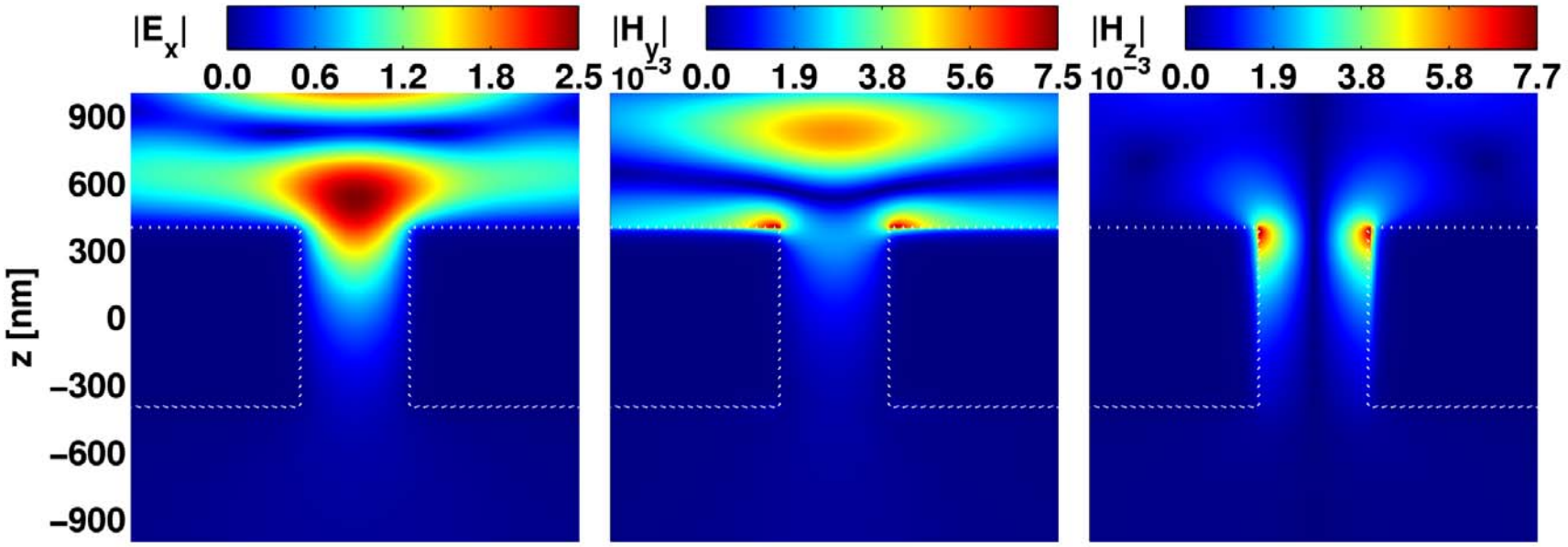
- Y. Xie, A. Zakharian, J. Moloney, and M. Mansuripur, "Transmission of light through a periodic array of slits in a thick metallic film," *Opt. Express* 13, 4485-4491 (2005)
http://www.opticsinfobase.org/abstract.cfm?URI=oe-13-12-4485

- Y. Xie, A. R. Zakharian, J. V. Moloney, and M. Mansuripur, "Transmission of light through periodic arrays of sub-wavelength slits in metallic hosts," *Opt. Express* 14, 6400-6413 (2006)
http://www.opticsinfobase.org/abstract.cfm?URI=oe-14-14-6400

Transmission of light through sub-wavelength slits in a metallic film depends strongly on the polarization state



Light polarized parallel to the slit does not get through

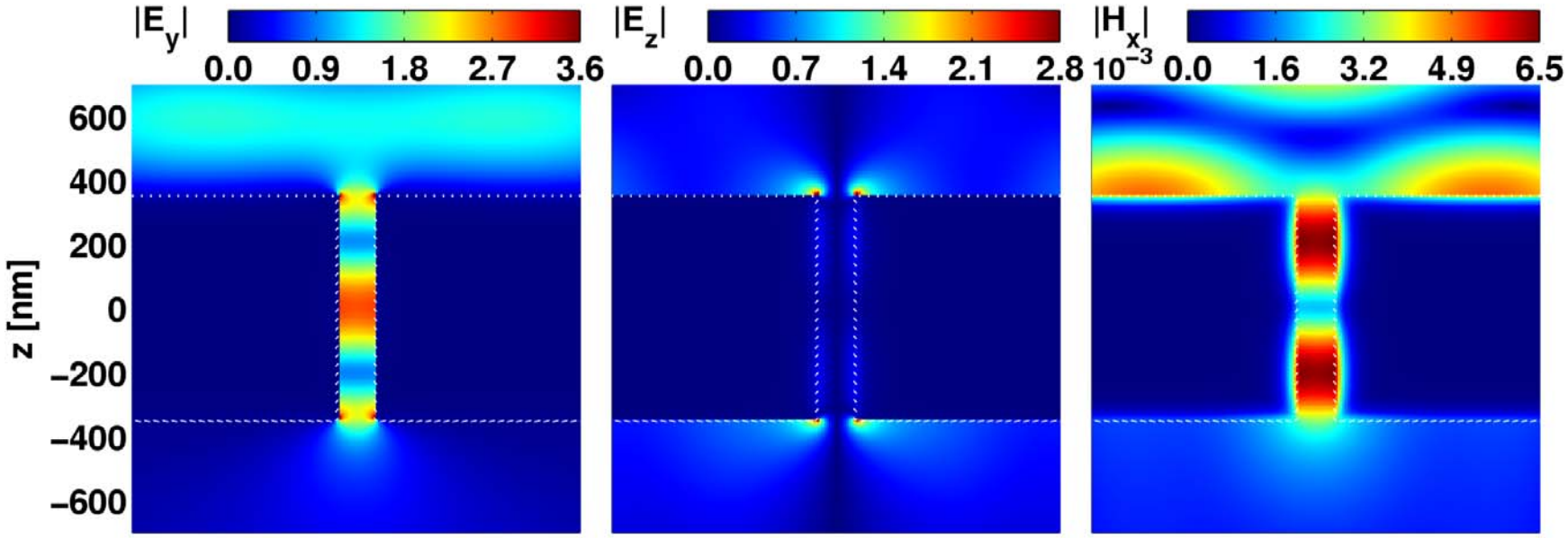


λ=1.0μm

Silver film thickness = 0.8μm

Slit-width = 400nm

High transmission efficiency requires that incident polarization be perpendicular to the slit

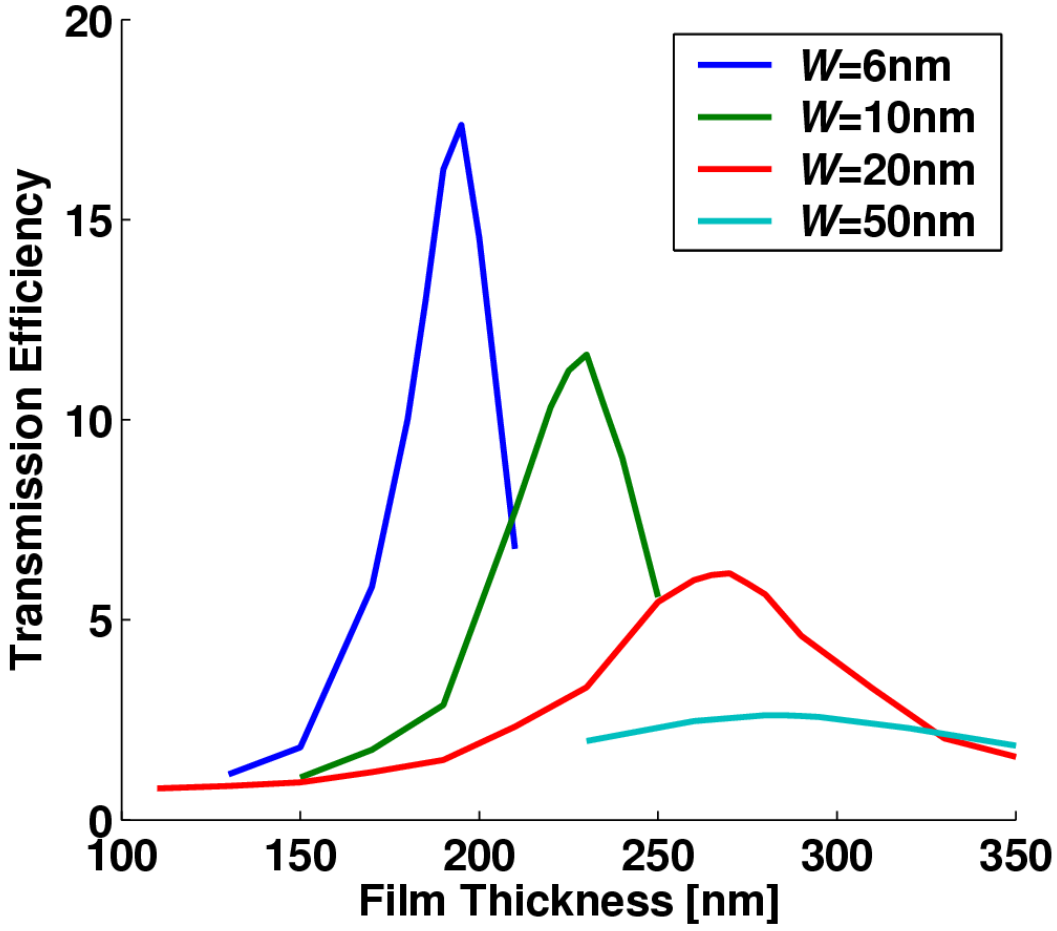


λ=1.0μm

Silver film thickness = 0.7μm

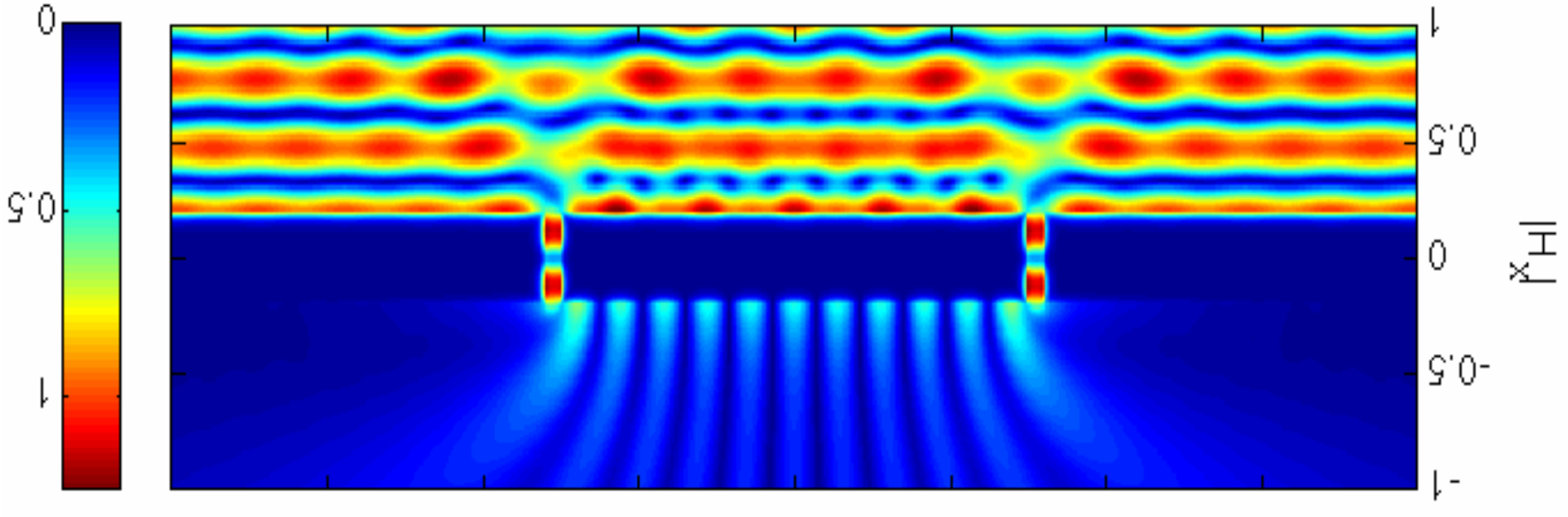
Slit-width = 100nm

High transmission efficiencies from narrow slits

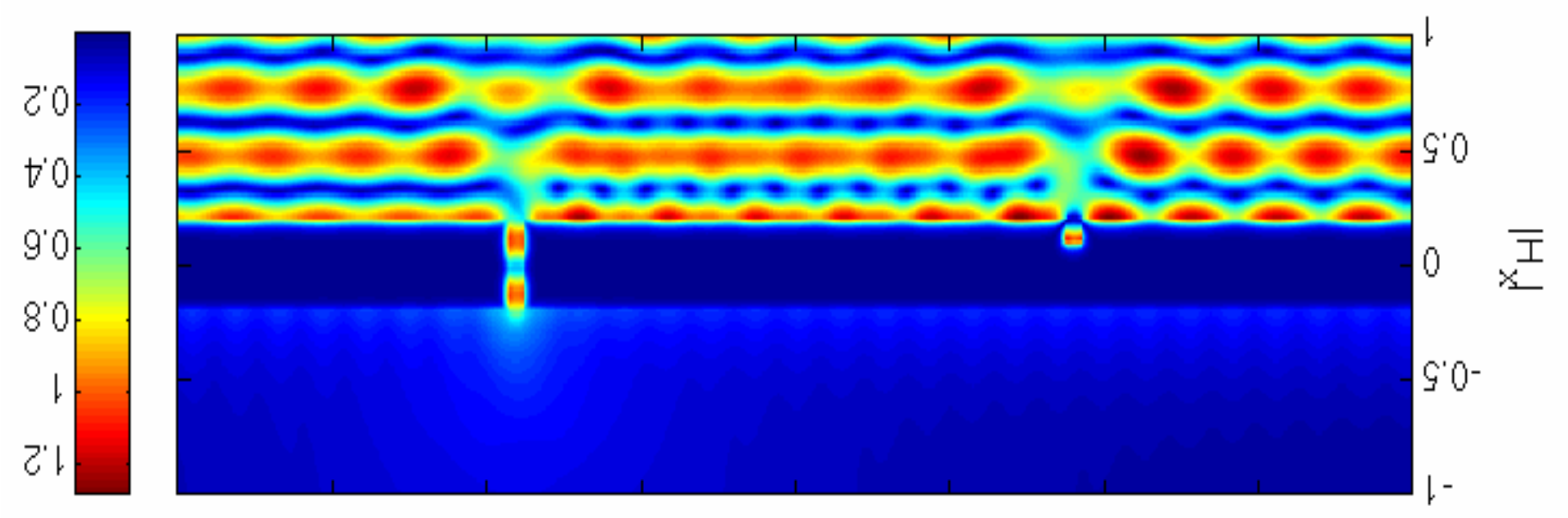


Transmission through double-slit

(400nm-thick gold film, λ = 850nm, slit width = 100nm)



Transmission through 100nm slit mediated by distant groove ($\lambda = 850$nm)



Conclusions

- By adopting near-field read/write schemes based on Solid Immersion Lens, extensions of the current CD, DVD, BD technologies will continue to improve the density/data rate of optical disks.

- Variations on holography (e.g., bit-based) and alternative optical schemes (e.g., 2-photon) compete to exploit the third dimension (substrate thickness), which has heretofore remained beyond the reach of conventional optical recording.

- Novel optical schemes based on sub-wavelength slits/apertures in metallic films exploit resonance phenomena (e.g., surface plasmon polaritons, cavity Fabry-Perot) in search of alternative near-field recording/readout methods.