Localized holographic recording in doubly-doped $LiNBO_3$

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Holograms written with a femtosecond laser in $LiNBO_3$:Ce:Fe yield localized recording and erasure. High density storage is achieved without the $1/M^2$ loss in diffraction efficiency. Data is encoded with a spatial light modulator placed in the object beam. A plane wave reference beam interferes with the signal beam in the holographic medium as described in figure 1. In transmission geometry, formation of the grating occurs in a thin slice of width proportional to the pulse duration (~100 fs). During recording, a sensitizing beam is focused in the region of the grating formation, allowing a hologram to be recorded in the doubly doped $LiNBO_3$ crystal [1]. We use $LiNBO_3$:Ce:Fe which has absorption in the infrared. Blue sensitizing light (Argon 488 nm) sends electrons to cerium traps enabling recording with infrared beam. The information is stored in a thin slice and is not volatile upon read-out when the sensitizing beam is not present. Another data page can be recorded adjacent to the previous one by delaying the reference beam or shifting the medium and by tilting the angle of the reference beam.

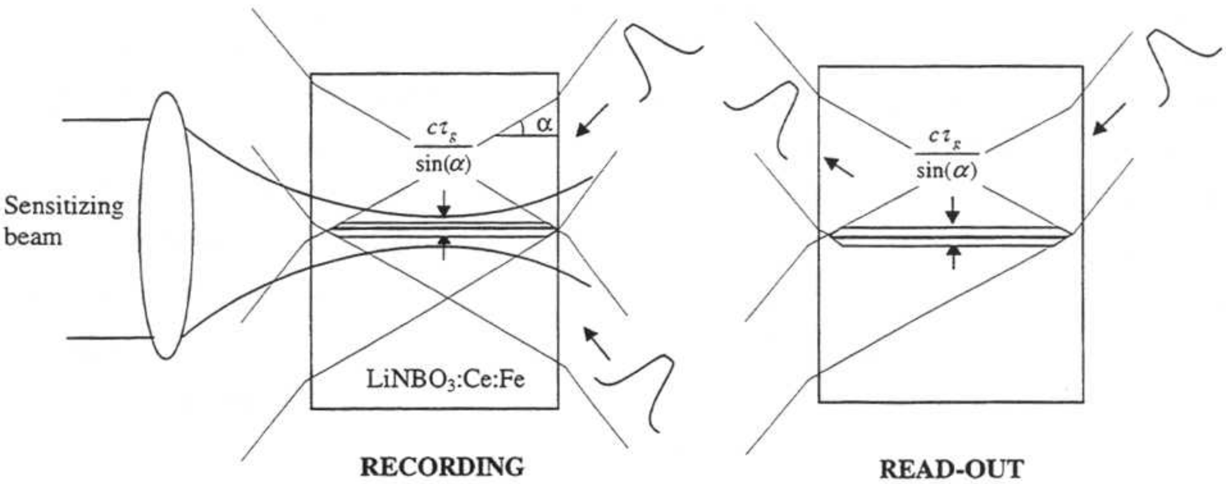

Figure 1: Recording and reading geometry

Two images were recorded, as described in figure 1, at the same location using angle multiplexing with femtosecond pulses (760 nm, 100 fs) in transmission geometry in $LiNBO_3$:Ce:Fe. Both reconstructed images are shown in figure 2.

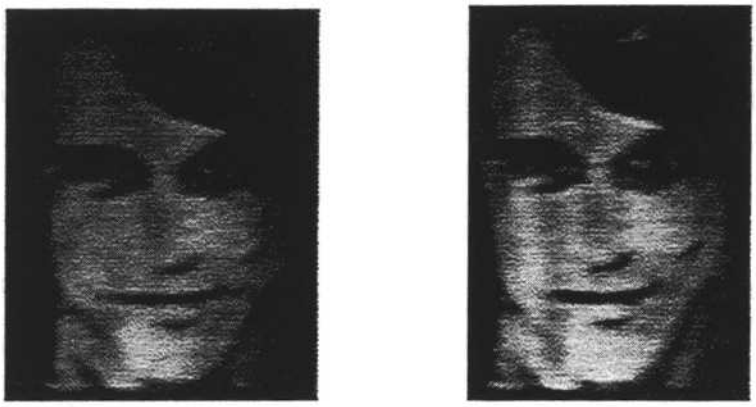

Figure2: Reconstruction of 2 images with 100 fs pulses in Ce-Fe doped $LiNBO_3$.

The recording and erasure curve measured without the presence of sensitizing light is shown in figure 3. Diffraction efficiency of 2.5 % is measured at saturation.

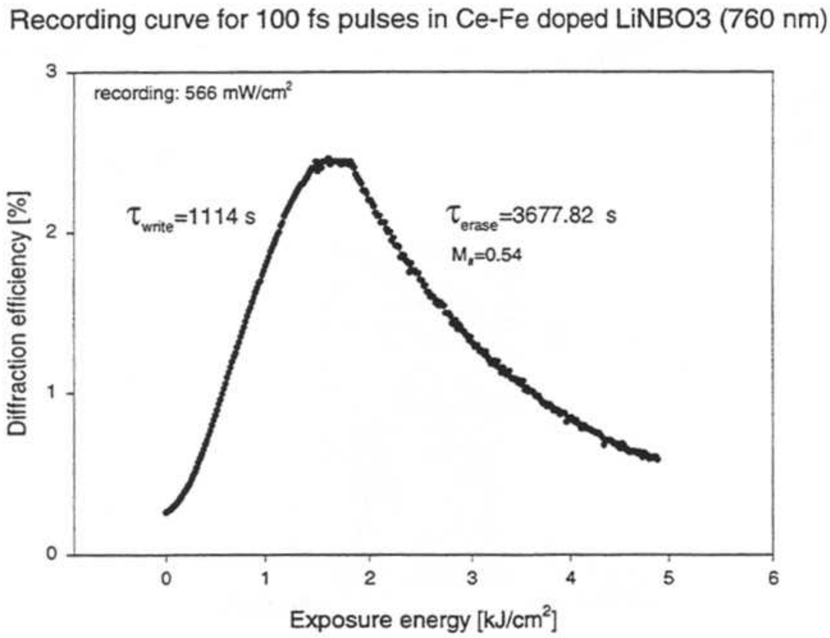

Figure 3: recording and erasure curve for femtosecond recording

High density storage and diffraction efficiency can be achieved by shifting the recording medium by an amount such that successive holograms do not overlap with the ones previously recorded. This can be achieved because both the recorded hologram and sensitizing light beam are spatially localized. As a result, successive recorded holograms do not erase previously stored holograms The proposed multiplexing (time delayed reference beam or medium shift) is effectively a dense spatial multiplexing. To compare the performance of this method with cw recording, we compute the equivalent number of non overlapping pulse holograms that can be recorded in the area occupied by the cw beam. The width of the grating produced by the pulse recording is approximately $c \times \tau_g/\sin(\theta/2)$ where τ_g is the pulse duration and θ the angle between reference and object beam. In the experiment this width is equal to 87 µm. The required beam overlap for cw recording is equal to 6.0 mm with our experimental parameters (crystal length = 5 mm, θ=40 degrees). Therefore, the number of pulse holograms that can be recorded is ~70. The equivalent $M_{\#}$ for pulse recording is equal to:

$$M_{\#,pulse} = \sqrt{2.5\%} \times 70 = 11.06$$

The $M_{\#}$ for cw recording is 3.21. In terms of final diffraction efficiency, pulse recording gained a factor of ~12. By decreasing the pulse duration, we expect to further increase this ratio.

References`

[1] A. Adibi, K. Buse, D. Psaltis, "Non-volatile holographic storage in doubly doped lithium niobate crystals", Nature, vol 393, June 1998.