Three-dimensional multi-layered fluorescent optical memory using two-photon reduction of Au(III)-ions

RIKEN
(The institute of physical and chemical research)
Takuo Tanaka

Oct/17/2006 ISOM06@Takamatsu 14:30~ 20min

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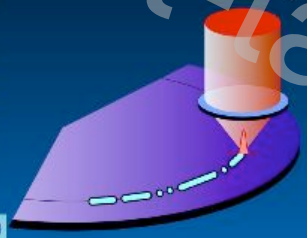
Outline

1. Background
   Why fluorescent recording/reading?
   - Two-photon recording and confocal read-out
2. Recording Material
   Rhodamine-B and Au(III) doped PMMA medium
3. Experimental results

To solve the problem in density limitation

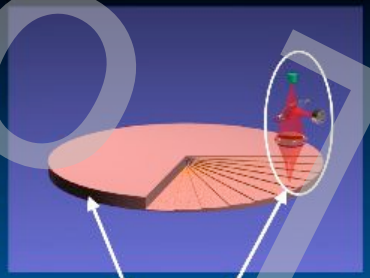
1. Decrease the size of laser beam spot
   Short wavelength laser, Near-field recording....
2. Enlarge the recording area (space)
   Multiplexing, Multi-dimensionalize

3D multi-layered storage
2D -> 3D



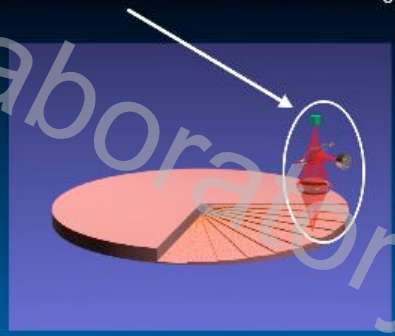
$$\phi = 1.22\frac{\lambda}{sin\theta}$$

Three-dimensional multi-layered memory



1. Pickup for 3D recording / reading
2. Recording Medium

Which method is suitable for 3D recording?

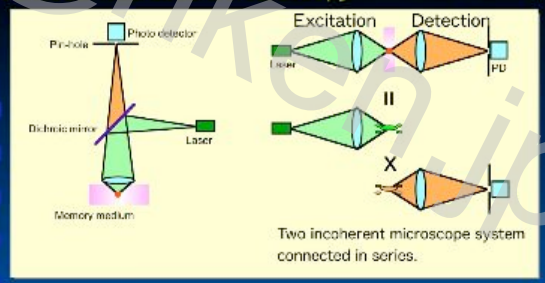


3D resolving power is necessary for optical pickup of 3D multi-layered memory

- Confocal microscopy
  in particluar Cofocal fluorescent microscopy
- Two-photon microscopy

3D resolving power

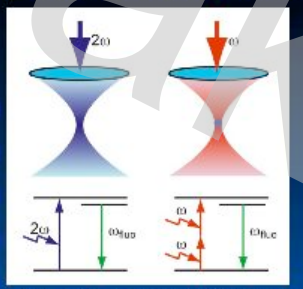
Confocal fluorescent microscopy



Point spread function of confocal system → the square of the PSF of incoherent system.

3D resolving power

Two-photon absorption / fluorescence

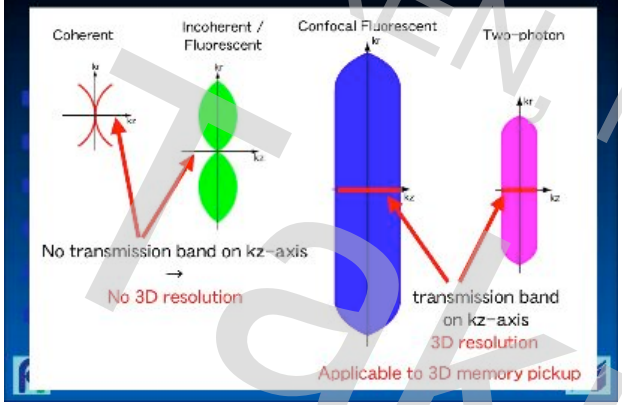


Confinement of photons spatially and temporally

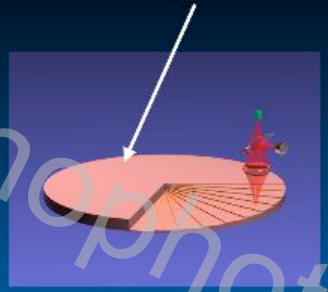
Tightly focusing of f-sec laser

- 2 photons are absorbed simultaneously.
- Probability ∝ the square of light intensity. (Non-linear effect)
- Only at the focusing spot -> light is absorbed.
  Other area -> transparent. <- light can penetrate deeply (no absorption, small scattering coefficient)

Optical Transfer Functions (OTFs) of various systems

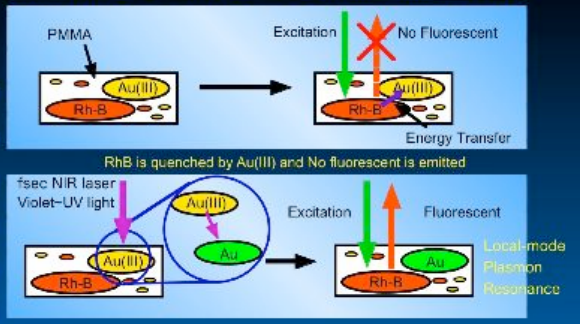


Recording Medium for 2-photon recording and fluorescent reading

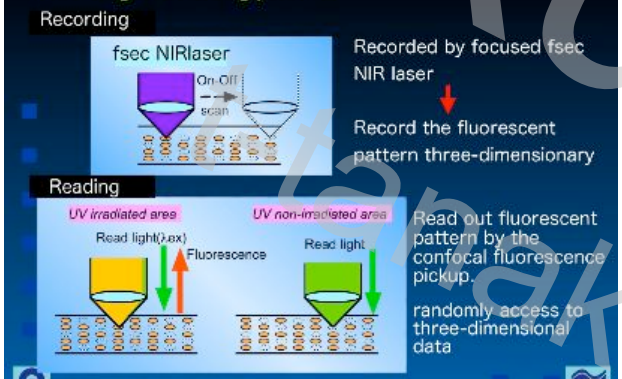


T. Tanaka, et.al Opt. Commun. 2002

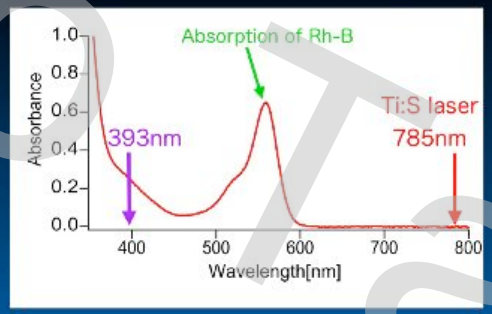
Recording mechanism on Rhodamine-B/Au(III) doped PMMA



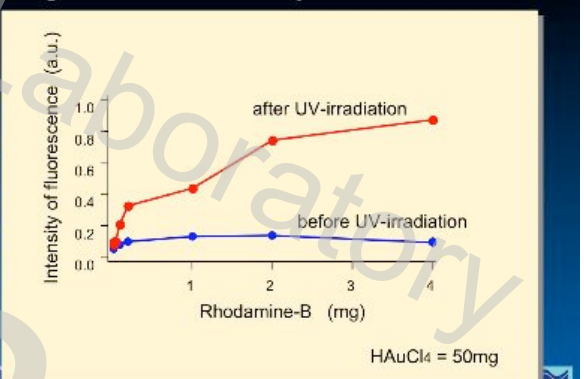
Recording and reading process



Absorption spectrum

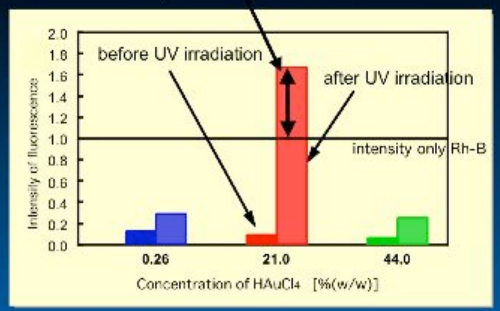


Change of fluorescence intensity



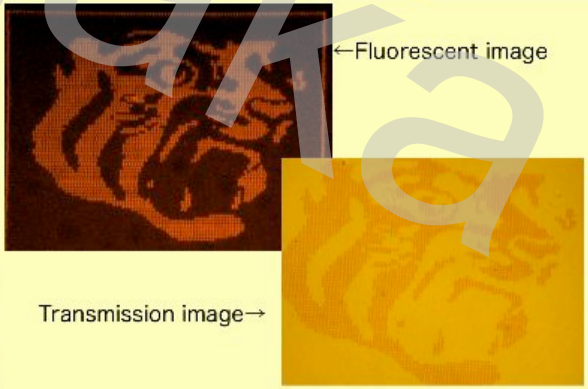
Contrast of fluorescence vs concentration of HAuCl4

Enhancement by surface-plasmon resonance

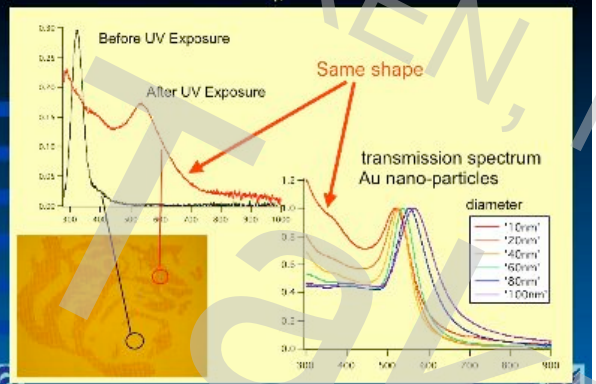


Recorded Fluorescent pattern

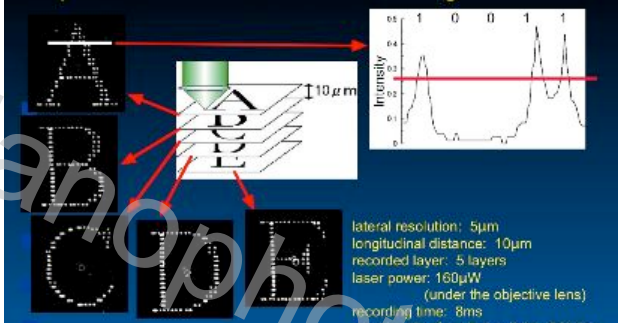
Fluorescent image & transmission image



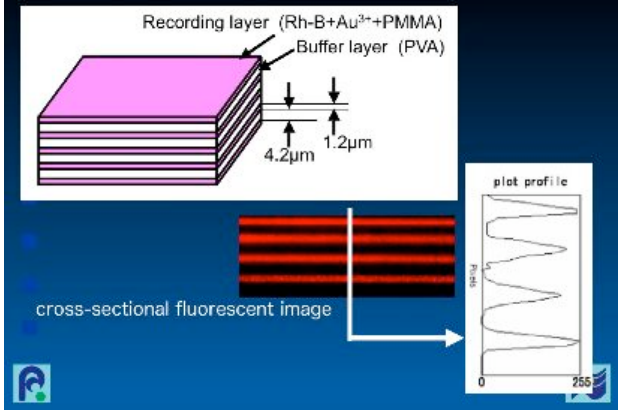
Size of reduced Au nano-particles

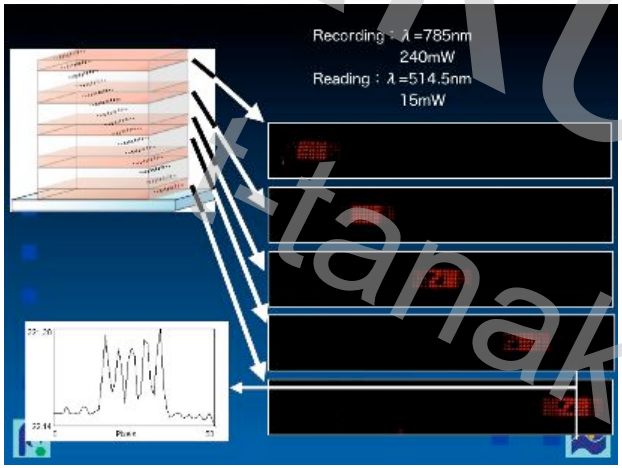


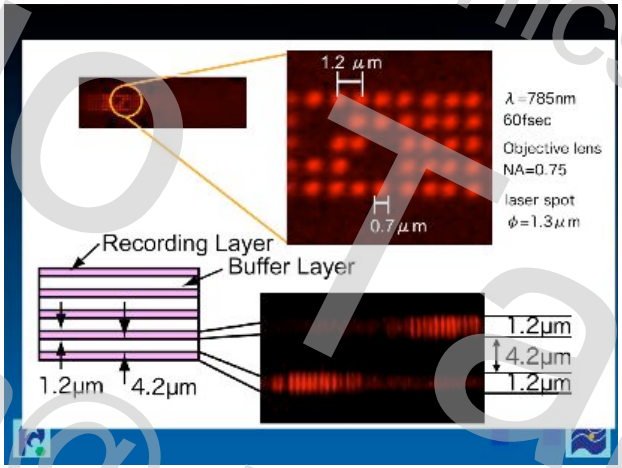
Experimental Result of 3D recording



Multilayered Recording Medium







Developed recording medium for 3D memory

Summary

1. Proposed new recording material.
   It can store 3D bit data as fluorescent pattern using the interaction between dye molecules and gold ions/nano-particles.

2. Demonstrated two-photon fluorescent recording and confocal reading of 3D data.

3. Multi-layered recording structure with buffer layers and its experimental result are demonstrated.
   Reflection from the boundary can be used focusing and tracking servo.

Towards dynamic testing