MULTILAYER OPTICAL MEMORY BASED ON ORGANIC LIGHT-SENSITIVE RECORDING MEDIA

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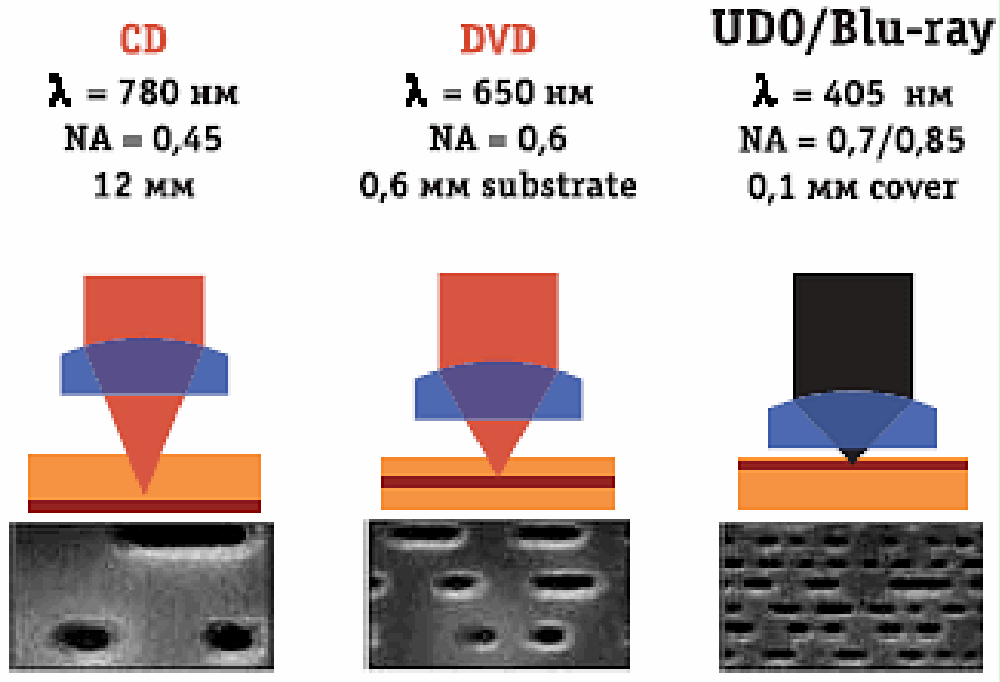
INTRODUCTION

Progress of information basis requires the improvement of the computerized technique in the direction of increasing its possibility to storage the large data massive and fast processing

Limiting bit density for magnetic disks is 230 GBit/in^2 and information capacity may increase up to 20 GB

The rate of data processing will achieve 1 GB /s.

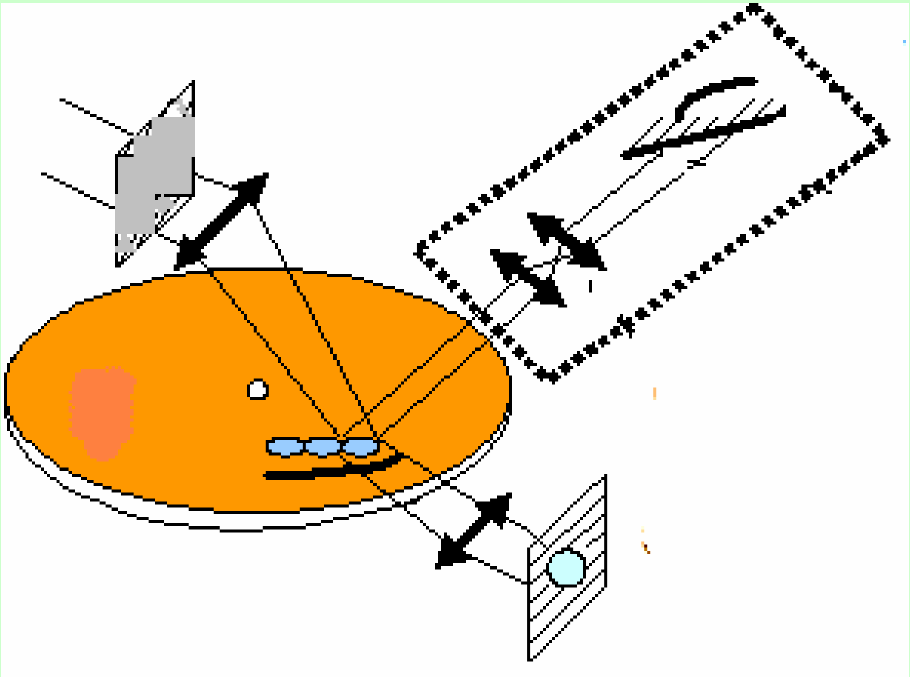


Blu-ray Disc Association has been developed ODs with information capacity of 25 GB (or 50 GB for DVD)

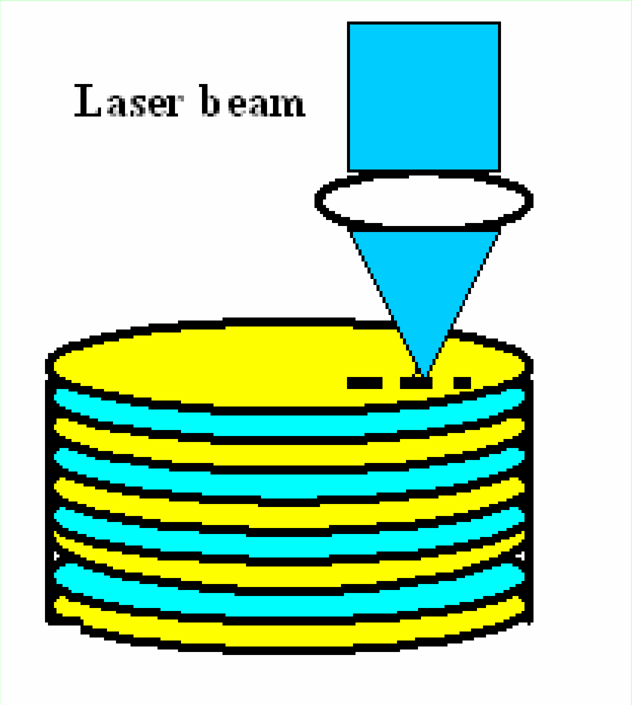
INTRODUCTION

The following perspectives are connected with making three-dimensional (3D) volume optical memory. This optical memory may provide density of more 10^{12} bit/cm^2 or 1 Tbit/cm^3

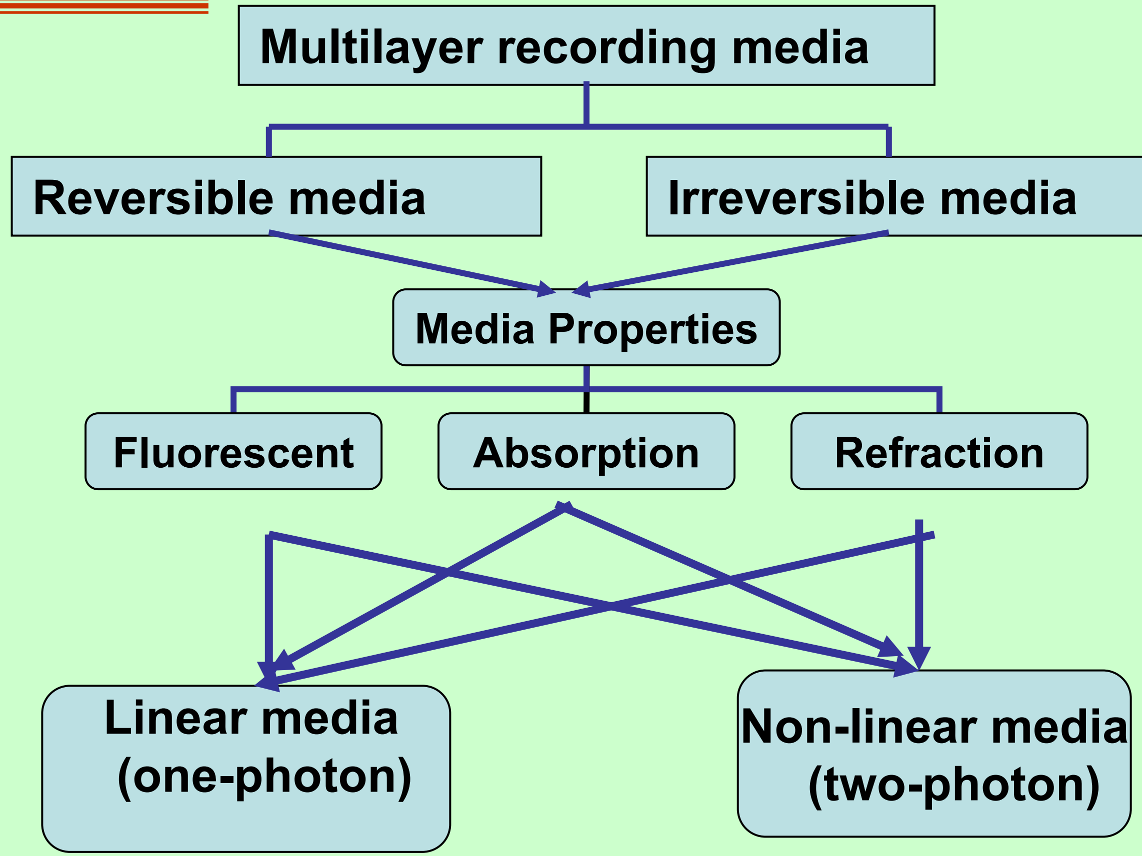
Holographic optical memory



Multilayer optical memory

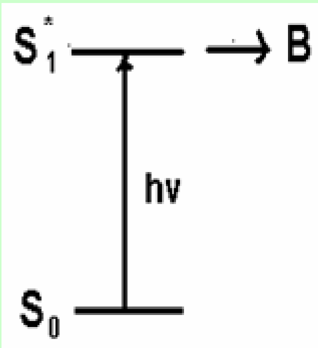


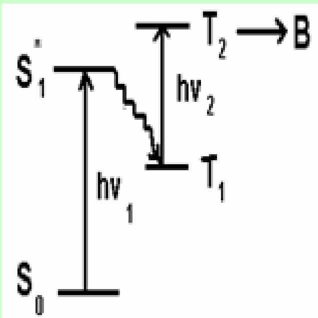
INTRODUCTION

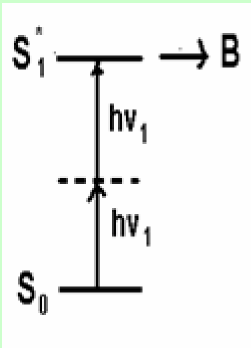


Advantages:
-low threshold;
-possible miniaturization of the light source

Disadvantages:
-darkness of the entire medium volume



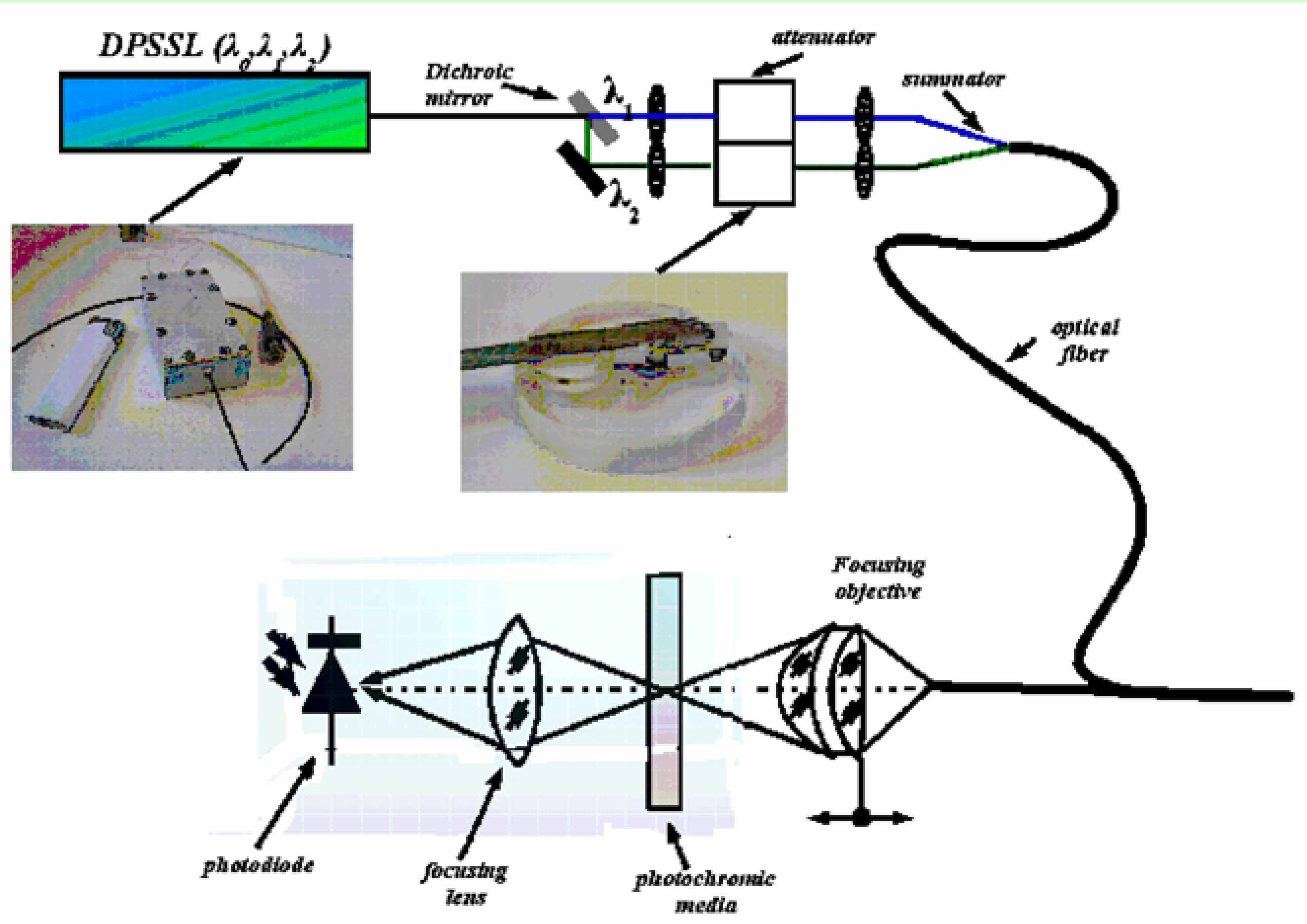


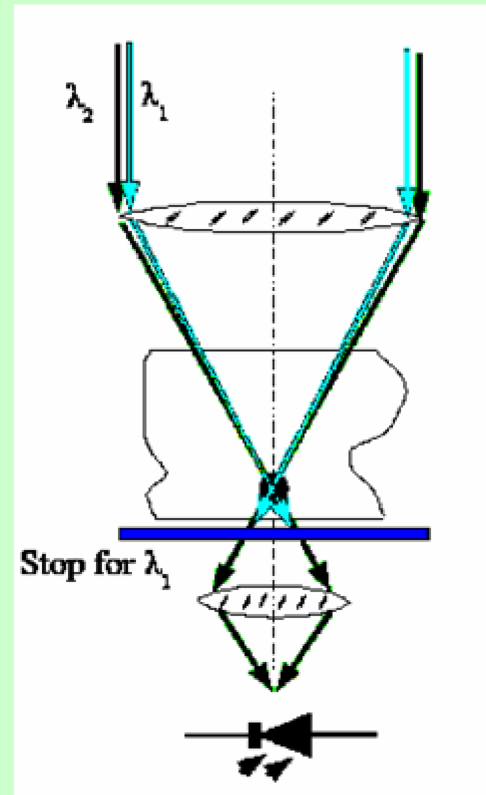


Advantages:
-alterring of the medium state in local volume

Disadvantages:
-high threshold;
-complexity of miniaturization of the light source

Multilayer one-photon optical memory

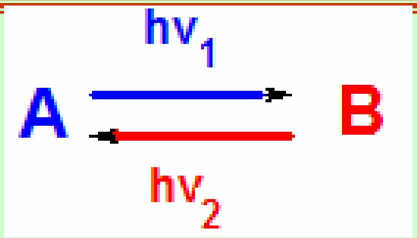


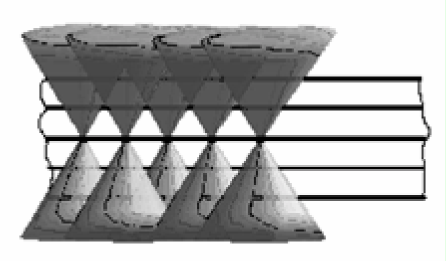


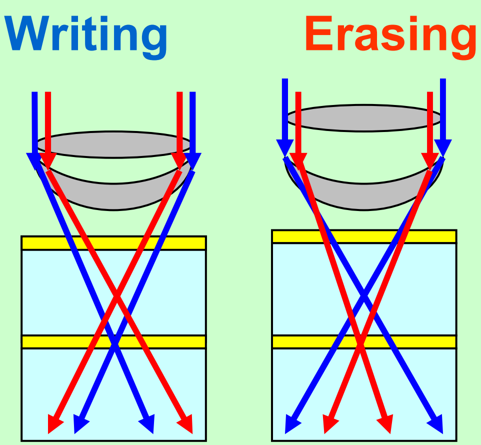
Patent Application WO 2006037279,G03C 1/73,13. 04. 06

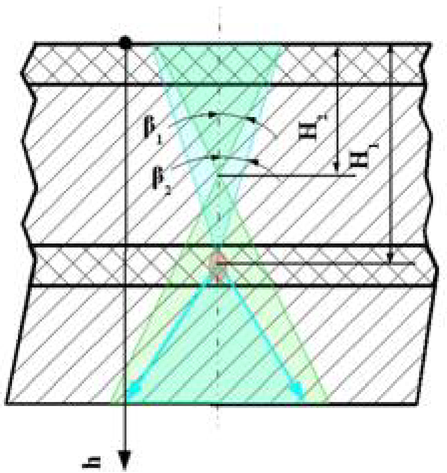
Number of layers –up to 30; number of cycles >10(6); capacity – more 100 GBytes

Multilayer one-photon working optical memory









For λ_1:

$$\frac{dI_1(h)}{dh} = -\alpha_1 I_1(h)$$

$$I_1(h) = \frac{P_1(h)}{\pi (H_1 - h)^2 tg^2 \beta_1}$$

$$\alpha_1(h) = \alpha_{max} - \frac{\alpha_{max} - \alpha_0}{1 + I_1(h)/I_{thr}}$$ - absorbtion for λ_1

where
I_1 – intensity for λ_1
P_1 – power for λ_1

For λ_2:

$$\frac{dI_2(h)}{dh} = -\alpha_2 I_2(h)$$

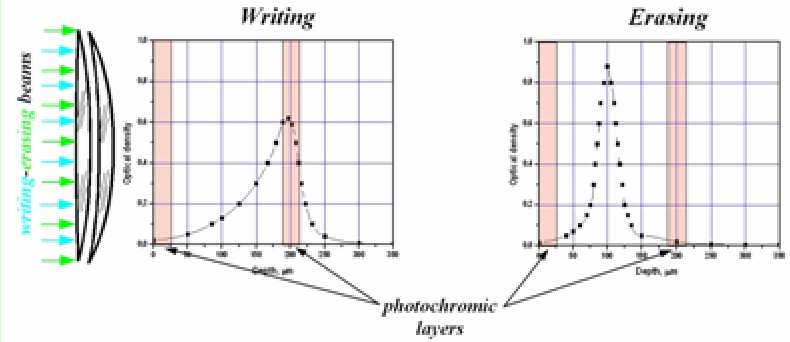
$$I_2(h) = \frac{P_2(h)}{\pi (H_2 - h)^2 tg^2 \beta_2}$$

$$\alpha_2(h) = \frac{\alpha_1(h)}{1 + I_2(h)/I_{thr}}$$ - absorbtion for λ_2

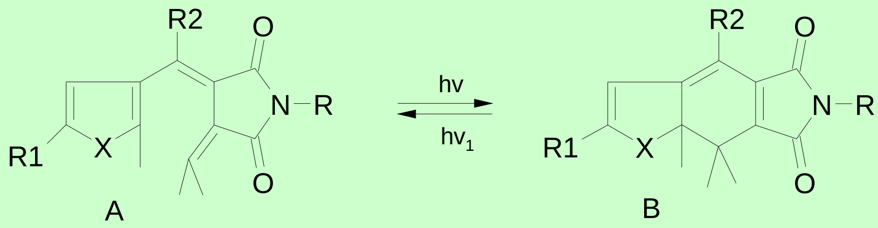
where
I_2 – intensity for λ_2
P_2 – power for λ_2

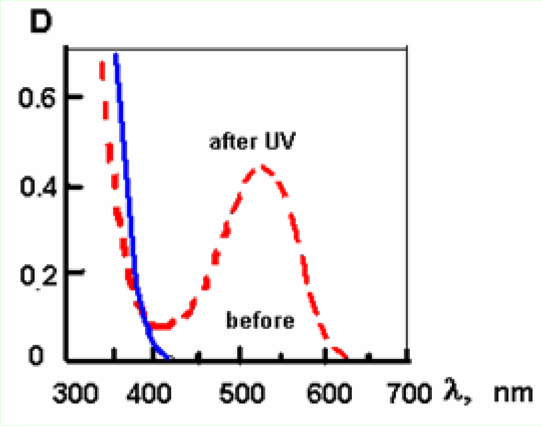
$D_{\lambda_1}(h)$ - optical density for λ_1

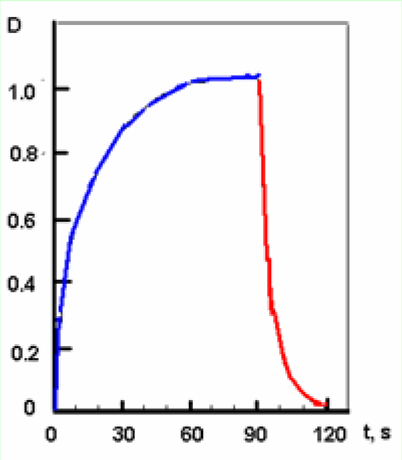
$$\left.\begin{aligned} \alpha_1(h) &\approx D_{\lambda_1}(h) \\ \alpha_2(h) &\approx -\Delta D_{\lambda_1}(h) \end{aligned}\right\} \Rightarrow \boxed{D_{\lambda_1}(h) \approx \alpha_1(h) - \alpha_2(h)}$$



Photochromic Media for One- Photon Working OM

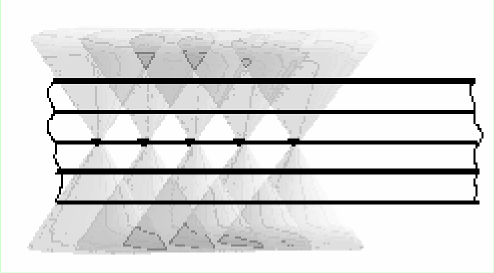




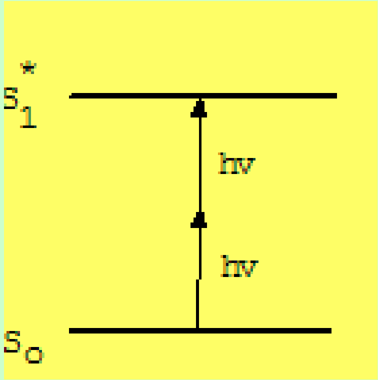


Fulgimide	Polymer	Content of fulgimide (weight %)	Film thickness, microns	$\lambda^{B}max$, nm	D^{phot}_{max}	N, cycles
F1	polycarbonate	4,1	20	528	0,09	$>10^4$
F1	polystyrene	4,1	20	526	0,12	
F2	polycarbonate	4,2 4,2	20 30	533 545	0,3 0,4	$>10^4$

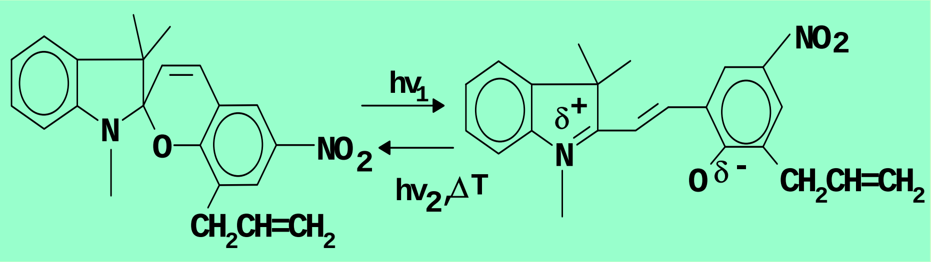
Multilayer two-photon working optical memory

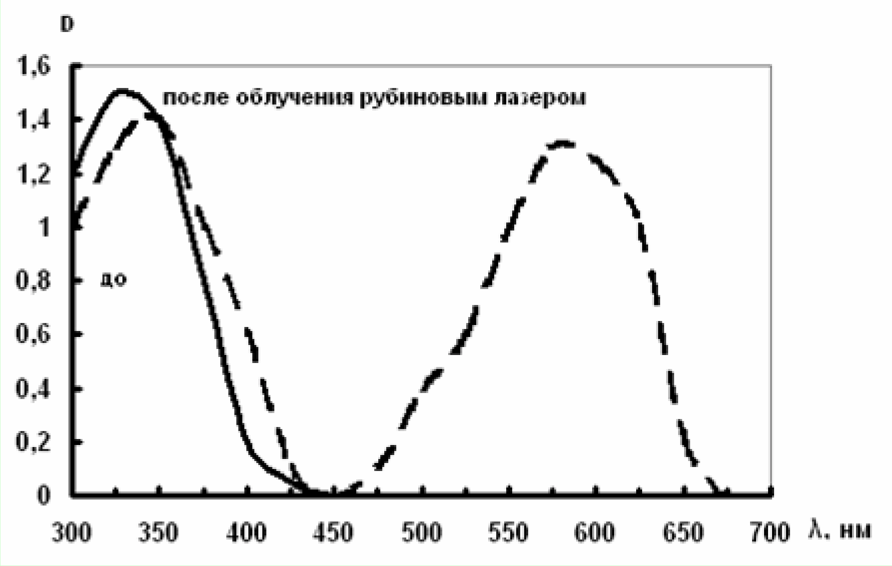


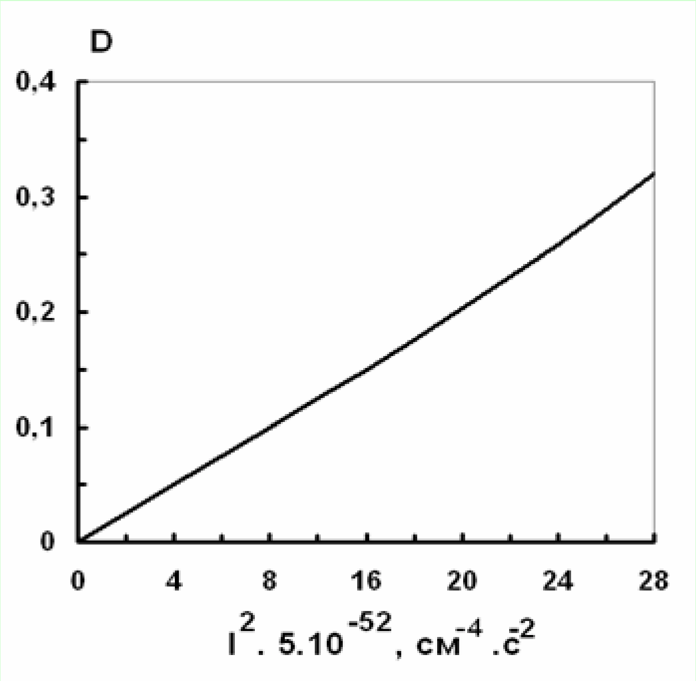
Two-Photon Photochromism



Mandjikov, Barachevsky et. al.,1972

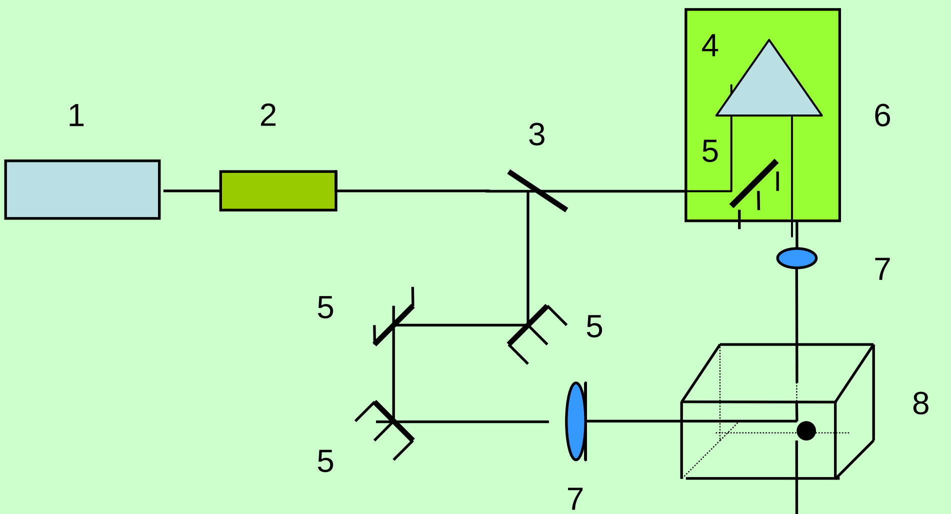


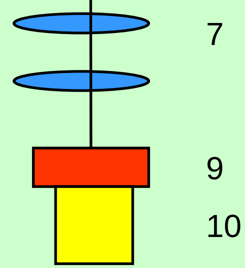




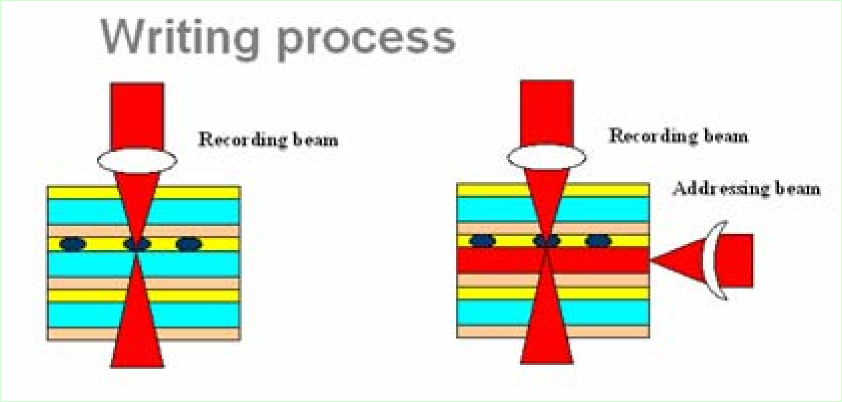
Multilayer two-photon working optical memory

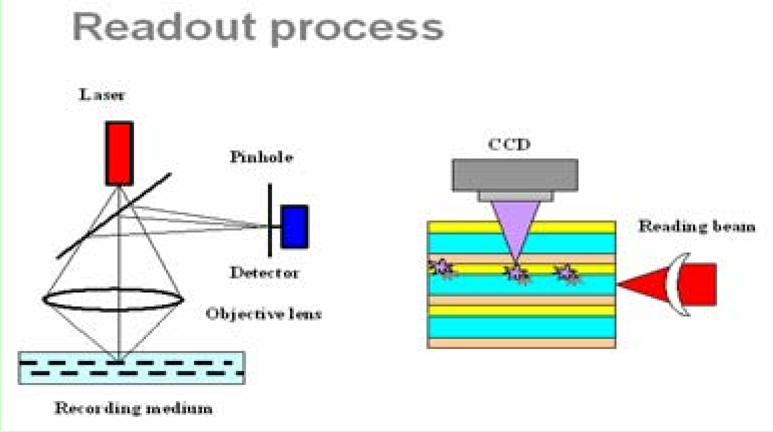
P.M. Rentzepis, 1989





1-laser, 2-frequency converter, 3- beam splitter, 4-prism, 5-mirrors, 6-delay line, 7-lenses, 8-photochromic recording media,
9-polychromator, 10-irradiation detector





Photochromic media for multilayer two-photon working optical memory

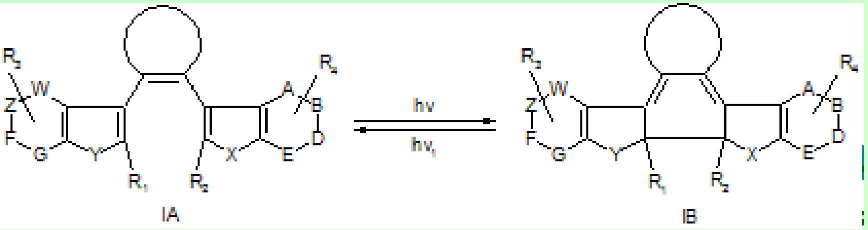
The concrete requirements are:

large cross-section of light absorption;
high efficiency of photochemical transformations;
thermal stability of forms A and B;
high stability of both forms to irreversible phototransformations;
non-destructive and efficient readout of recorded information by the certain method (fluorescent, refractive, reflective, polarization)

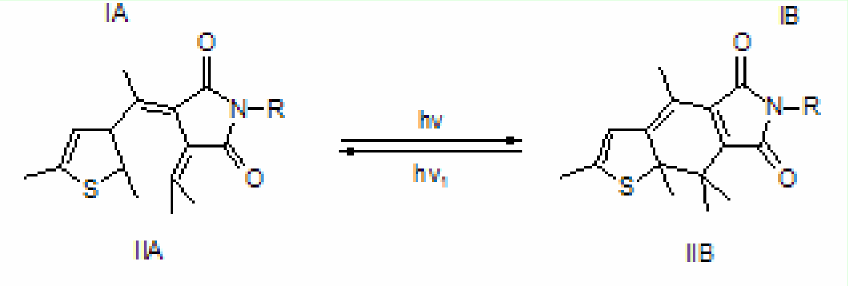
Among the photochromic substances the compounds manifesting the valence isomerization are characterized by the best properties and meet the conditions of this application.

Photochromic compounds

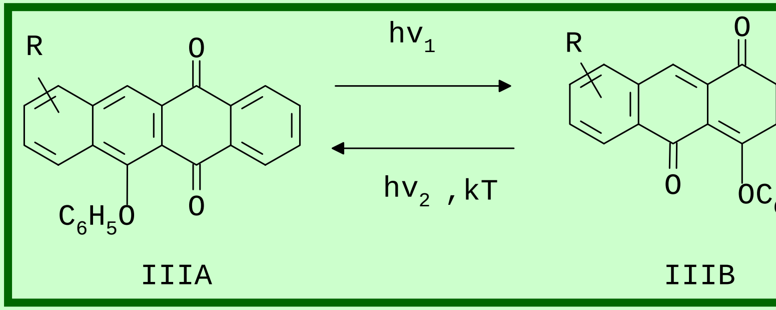
Diarylethenes



Fulgimides

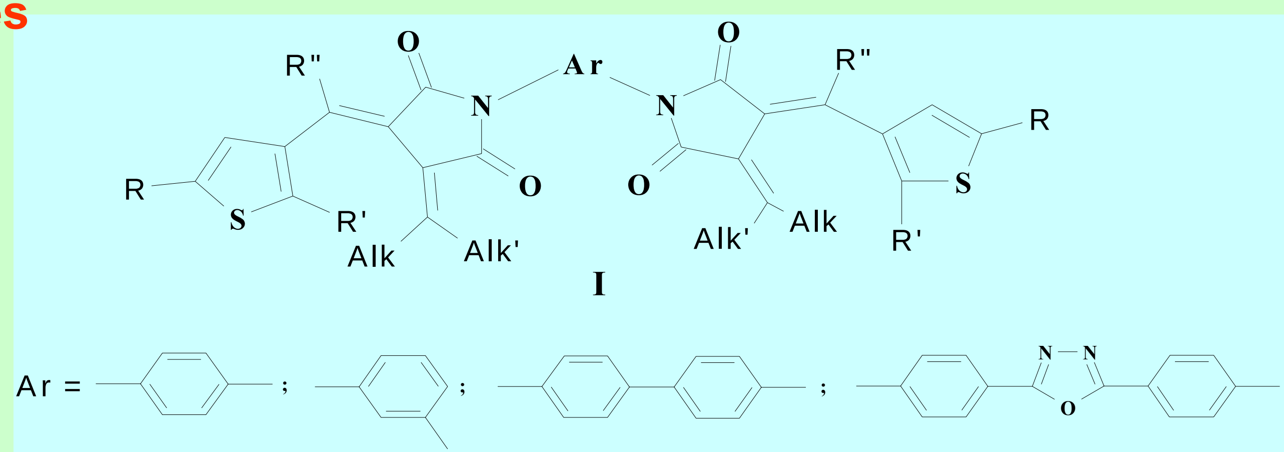


Phenoxy-quinones



Photochromic media for multilayer two-photon working optical memory

Fulgimides



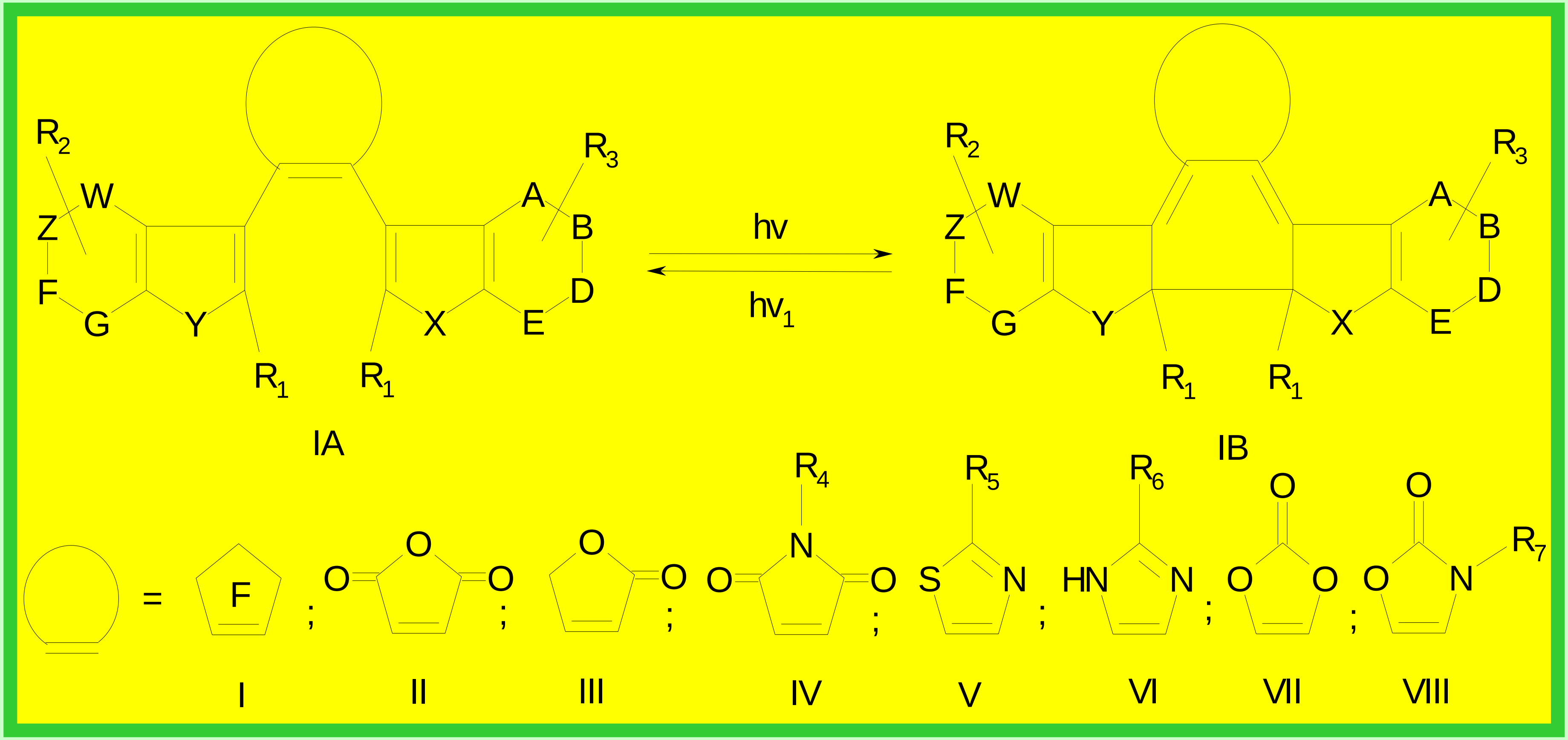
R = H, Alk, OAlk, Hal, CHO, CO_2H, CH_2OH, CH_2Hal, CH_2OMe,
R' = H, Alk, OAlk, Hal, CHO, CO_2H, CH_2OH, CH_2Hal, CH_2OMe,
R" = Alk, Ph

Photochromic fulgimide	λ^{A} max, nm	λ^{B}max, nm	$Д^{phot}_{max}$	N, cycles
Fulgimide analog	325	522	0,75	$>10^4$
7a	335	530	1,48	$>10^4$
7b	310	530	1,05	$>10^4$
7c	335	530	1,24	$>3.10^4$
7d	335	530	0,90	$>3.10^4$

Patent Application WO 2006037279, G03C 1/73,13. 04. 06

photochromic media for multilayer two-photon working optical memory

Dihetarylethenes



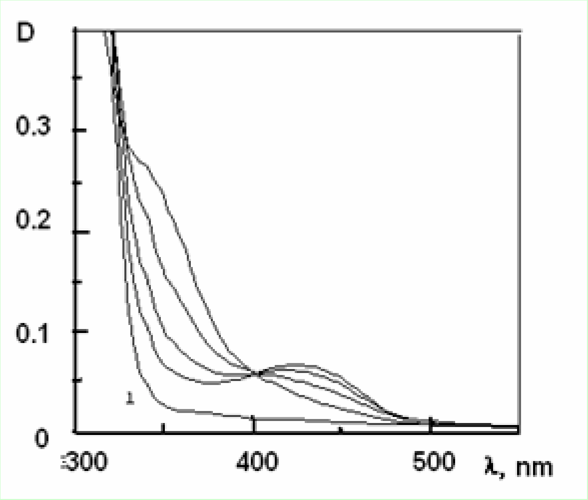
Photochromic media for multilayer two-photon working optical memory

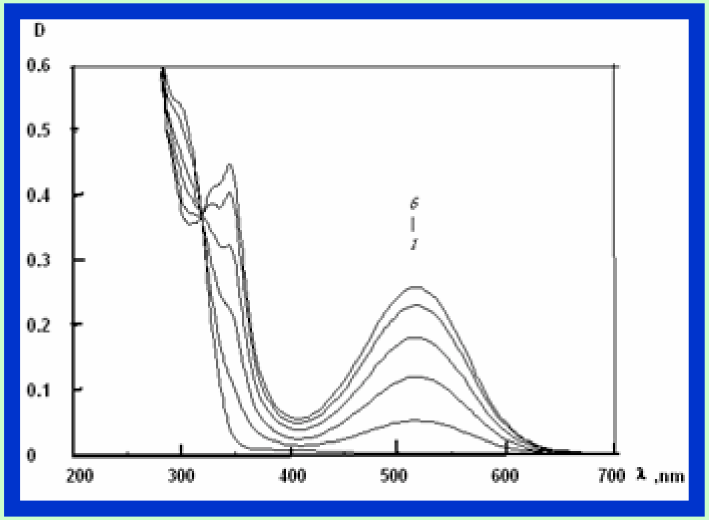
Cyclic ether dihetarylethene(1)

Maleimide dihetarylethene (2)

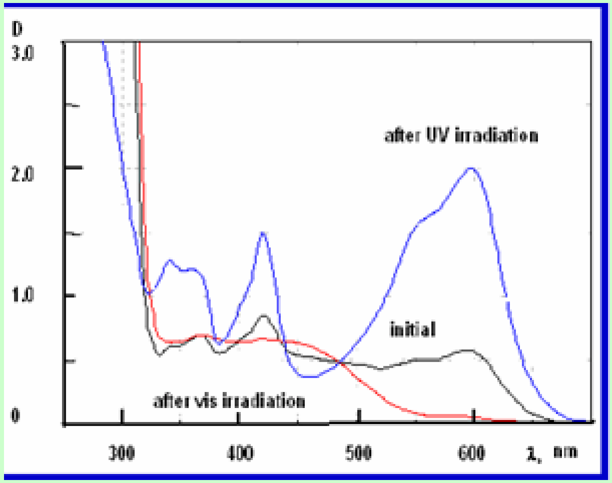
Perfluorocyclopentene diarylethene (3)

(1)

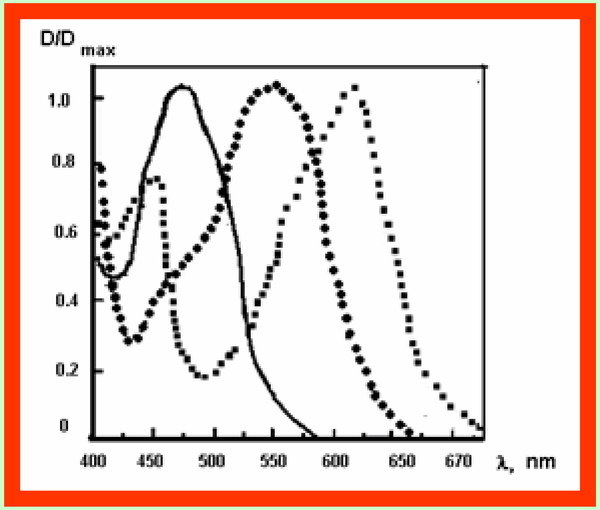




(2)

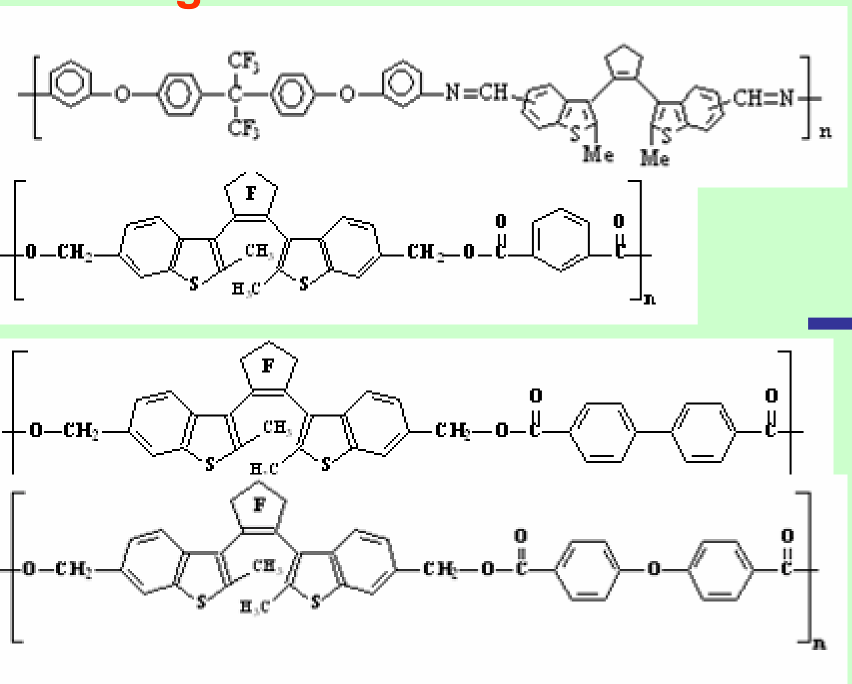


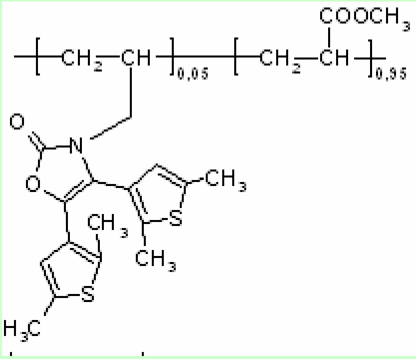
(3)

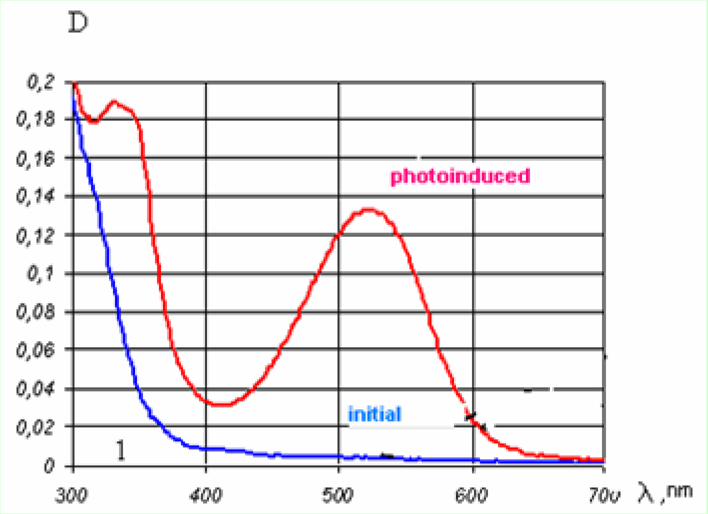


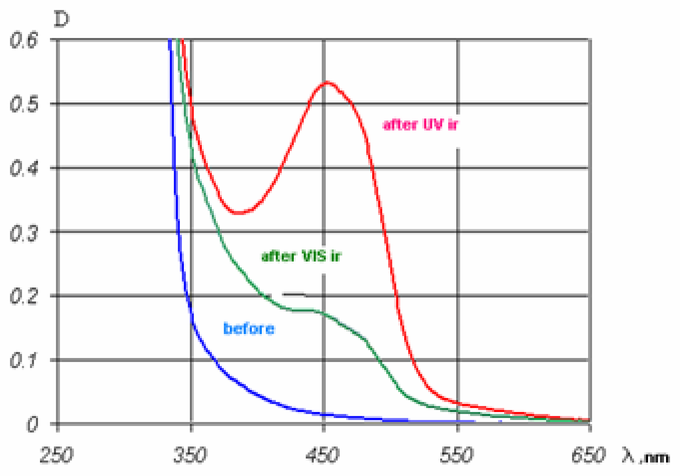
Photochromic media for multilayer two-photon working optical memory

The synthesized photochromic polymers provide the large concentration light-sensitive centers and different spectral properties for recording media



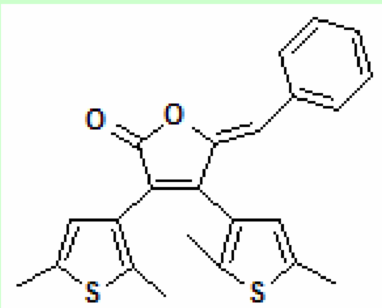


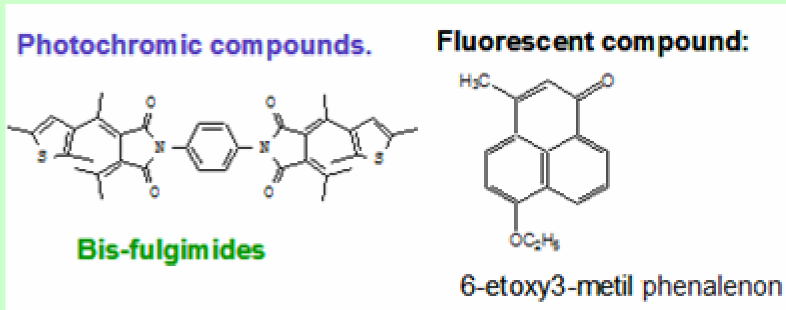


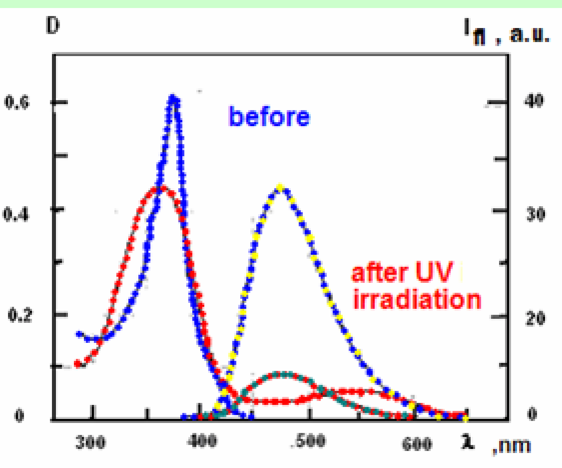


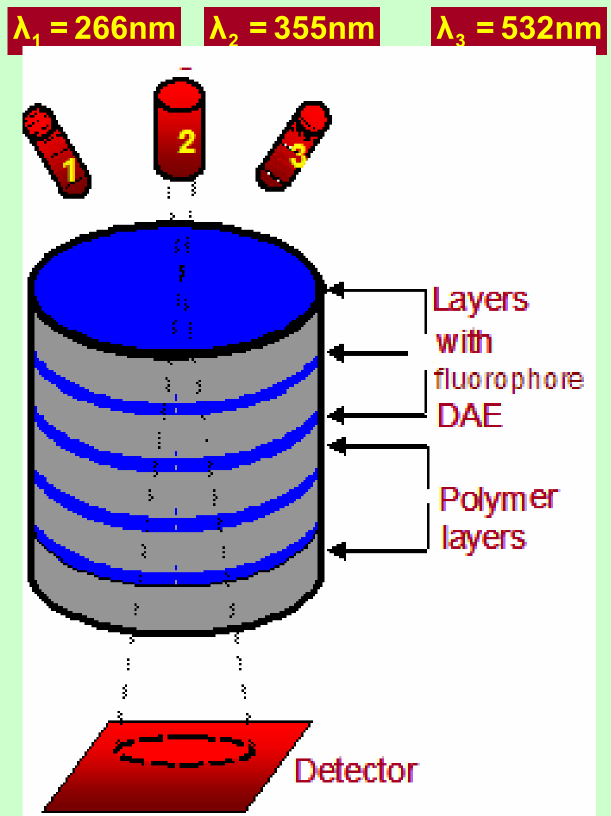
Photochromic media for multilayer two-photon working optical memory

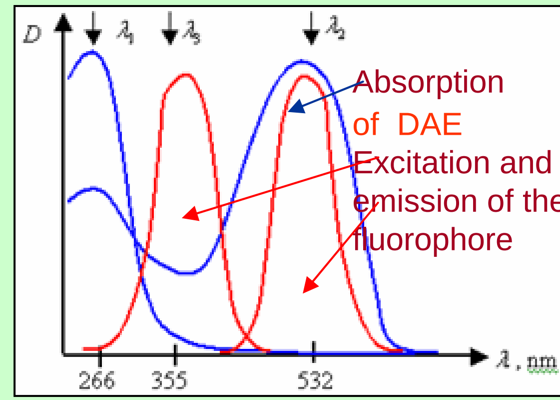
Fluorescent readout

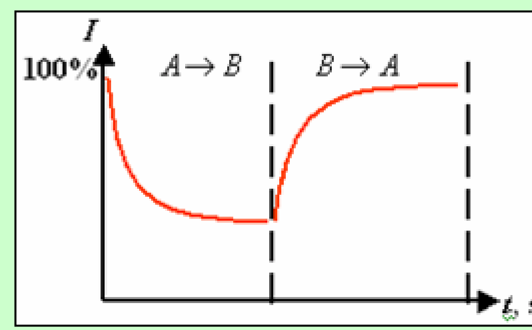








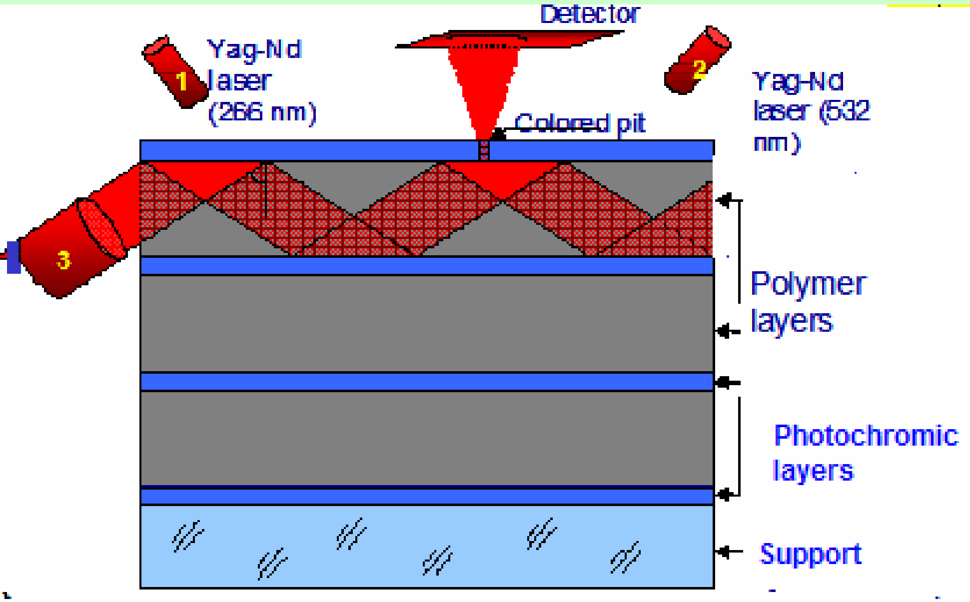




Modulation of the emission intensity for the fluorophore.

Photochromic media for multilayer two-photon working optical memory

Refractive readout



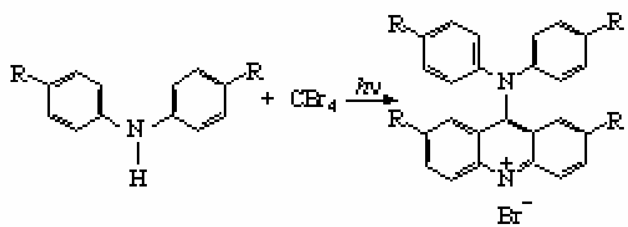
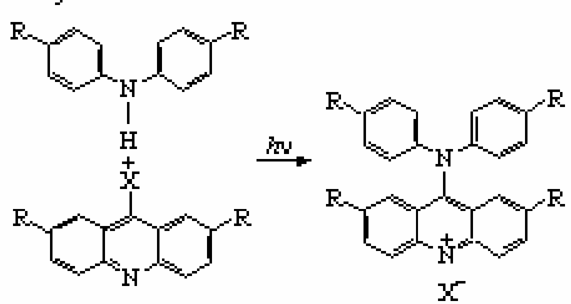
$$n_A^{632.8} < n_p \leq n_B^{632.8}$$

Photochromic compound	λ_A,nm	λ_B,nm	k_{A-B}, s^{-1}	k_{B-A}, s^{-1}	$n_A^{632\ nm}$	Δn
DAE-2	300	510	0.06	0.04	1.73	0.02
DAE-3	280	490	0.014	0.02	1.73	0.02
DAE-4	290	515	0.02	0.018	1.74	0.03
DAE-5	290	520	0.13	0.10	1.72	0.02
BF-1	330	528	0.66	0.42	1.74	0.02
BF-2	325	525	0.45	0.31	1.73	0.02

Light-Sensitive irreversible media for archive one – or two-photon OM

Photofluorescent Media

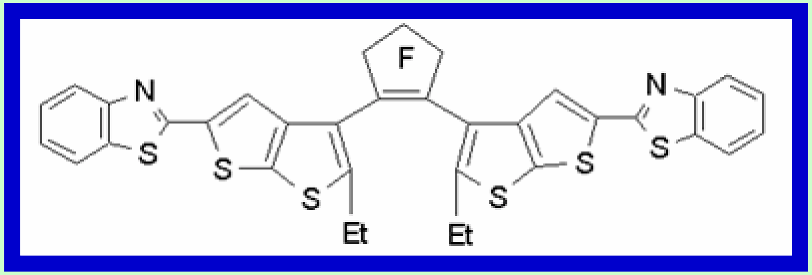
The several photoluminescent organic systems developed may be used for making irreversible recording media with luminescent read-out for 3D archive OM

Photoreaction	Spectral range of sensitivity, nm	Spectral range of luminescence, nm
Aromatic azides $Ar{-}N_3 \xrightarrow{h\nu} Ar{-}NH_2 + Ar{-}NHR$	< 440	400–650
Diarylamine and tetrabromomethane 	< 450	λ_{max} = 670 (salt form) λ_{max} = 520 (base form)
Diarylamine and acridine halide  X= Cl, Br	< 430	λ_{max} = 670 (salt form) λ_{max} = 520 (base form)

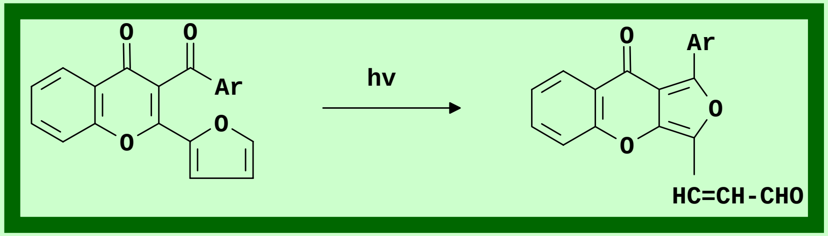
Light-Sensitive irreversible media for archive one – or two-photon OM

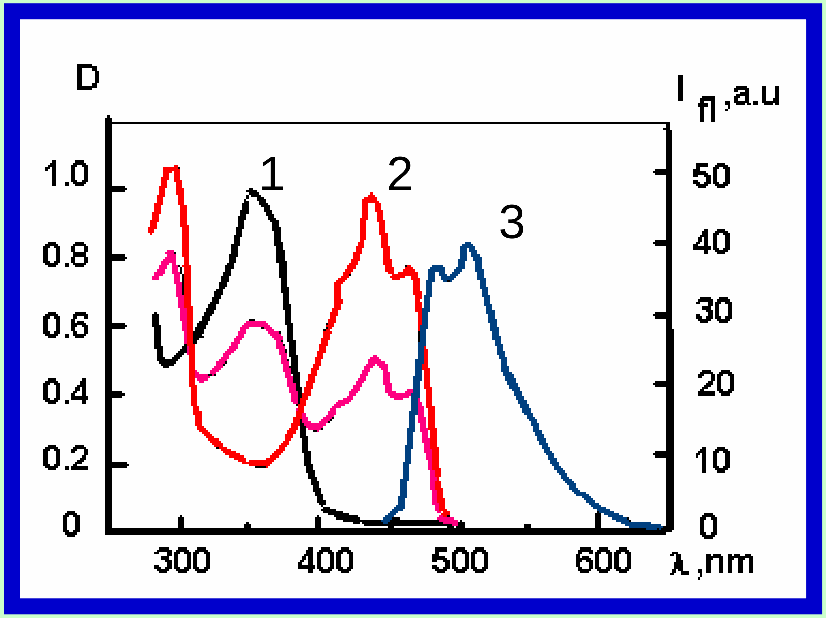
Photofluorescent Media

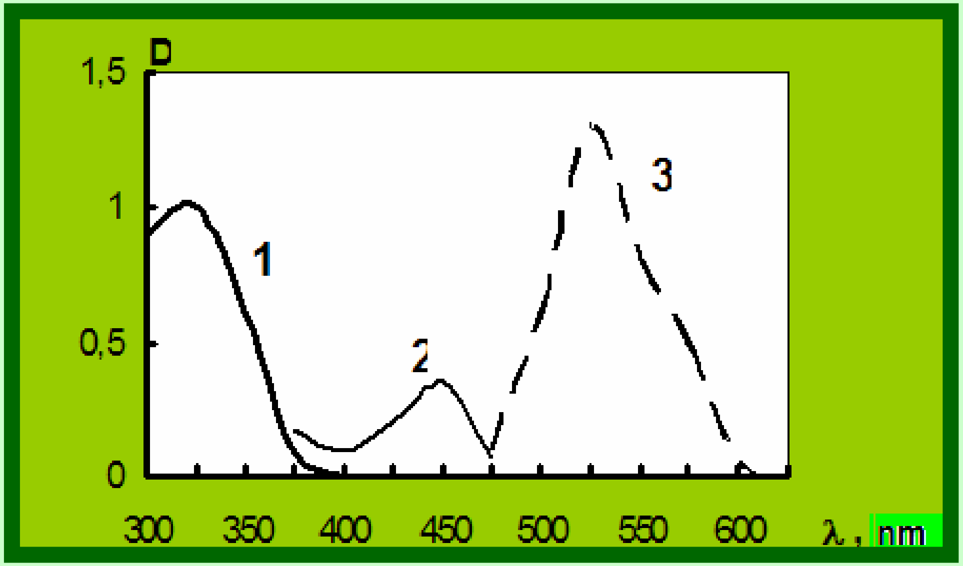
Dihetarylethene



3-(p-anisyl)-2-(2’-furil)-chromene







Conclusions

More 100 thermal irreversible photochromic compounds including substances with the best properties providing their application as light-sensitive components of photochromic recording media have been synthesized

New photochromic recording media with the best properties providing their application in one- and two-photon 3D bitwise working optical memory have been worked out.

Two methods for nondestructive readout based on photoinduced changes of fluorescence and refraction index have been developed for working optical memory.

Prototype of the device for one-photon working optical memory based on photochromic recording media has been produced.

Developed media were tested with positive results for application

A number of irreversible light-sensitive photofluorescent organic recording media for making archival optical memory has been proposed.