

UNCLASSIFIED

Defense Technical Information Center
Compilation Part Notice

ADP012325

TITLE: Human Brain Like Memory Behavior in the Magnetic Domain
Expansion Type Magneto-Optical Disk

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: Applications of Ferromagnetic and Optical Materials, Storage and
Magnetoelectronics: Symposia Held in San Francisco, California, U.S.A. on
April 16-20, 2001

To order the complete compilation report, use: ADA402512

The component part is provided here to allow users access to individually authored sections
of proceedings, annals, symposia, etc. However, the component should be considered within
the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP012260 thru ADP012329

UNCLASSIFIED

Human Brain Like Memory Behavior in the Magnetic Domain Expansion Type Magneto-Optical Disk

Norio Ota, Hiroyuki Awano, Manabu Tani and Susumu Imai

R&D Division, Hitachi Maxell Ltd.

6-20-1 Kinunodai, Yawaramura, Ibaraki 300-2496 Japan

ABSTRACT

Magnetic Amplifying Magneto-Optical System (MAMMOS) shows human brain like memory behavior. Magnetic field and laser power have threshold to recover the stored memory like the human response of remembering. MAMMOS also has a feature to amplify very small recorded signals like our recovery of memory, e.g. fifty years ago episode.

By adding the meaningful information on the magnetic field pattern, we can get some correlation between our memory and external stimulation. Such scheme is named as "the Active readout MAMMOS" which is analogues to the human process of remembering the memory.

If the applied field pattern and timing phase just coincide with stored information, there occurs the coherent amplification of MAMMOS signal. We can utilize such phenomena as the trigger of "Memory Association".

INTRODUCTION

Human brain long term memory is so mysterious comparing the current man made disk storage like magnetic disks and optical disks. During our life, we may store so huge memory contents inside our brain. In our usual daily life, we never aware of such terribly giant memories, almost seems that we had forgotten almost 99.9% or more. However, once we are stimulated by specific scenes or sounds, we can clearly remember the old episode.

Recent study on brain's long term memory [1] shows very interesting hypothesis, that is, memory perception (writing) and memory retrieval (readout) are bi-directional signaling between temporal cortex (TE) and peripheral cortex (PRh). By the visual pair-association task tested in monkey brain, long term memory stored in PRh are retrieved TE neurons.

Magnetic amplifying magneto-optical system (MAMMOS) gives very huge capacity rewritable disk by using a domain expansion phenomenon in a readout layer overlaid on a recording layer [2,3]. In the area of Magneto-Optical disk storage, the analogy of PRh to the recording layer and TE to the readout layer is useful to create the new type of human made memories. In the very high density area overcoming the optical resolution limit, MAMMOS shows very high signal to noise ratio [3]. For readout, we used mono tone-single frequency external magnetic field to expand and collapse the magnetic domain. In this scheme, external magnetic field only plays giving the excitation energy to readout very faithfully a series of chained stored information.

However, once we changed such scheme, that is, if we intentionally give the some meaningful information on the external magnetic field on behalf of mono-tone field repetition, we can expect human brain like memory behavior in MAMMOS as a new type of association memory, which retrieves long term memory stored in the recording layer. Here, we firstly show such experiments under the name of “Active readout MAMMOS”.

PRINCIPLE OF BASIC MAMMOS AND EXPERIMENTS

MAMMOS disk has two magnetic layers as shown in figure 1, one is a recording layer which stores very high density magnetic domains recorded by magnetic field modulation method [4]. Material is TbFeCo amorphous film with 40nm thickness. Another one is 20nm thick readout layer (expansion layer in the figure) made by GdFeCo with a low Coersive force H_c . This readout layer is magneto-statically coupled with TbFeCo recording layer.

By applying a focused laser beam on such coupled films to elevate the temperature to about 120 C, one recorded domain is easily copied to a readout layer. Just at the same timing, the external magnetic field of about 200 Oe is applied upwards. This field causes the expansion of the copied domain in the readout layer, which brings a very large signal enhancement.

Recent results show very remarkable results [5], that is, only 20nm length recorded mark is expanded to 1200nm wide size giving full amplitude saturation level signals. Amplification ratio is 60 (6000%).

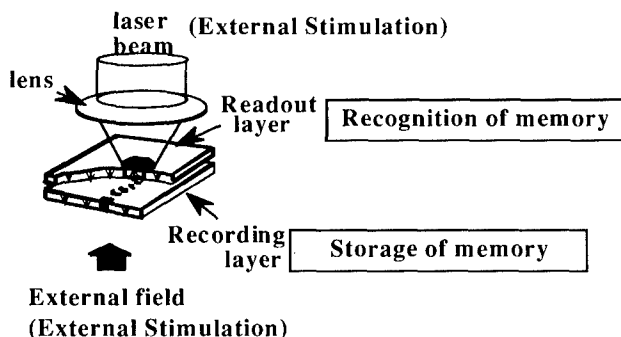


Figure 1. Principle of Magnetic AMplifying Magneto-Optical System (MAMMOS). A recording layer stores very tiny high density magnetic domains. By elevating a temperature by a focused laser beam, a domain is copied to a readout layer, and expanded by an upward direction external field.

Figure 2 shows a typical basic MAMMOS experiment. Wavelength of the laser is 680nm while lens numerical aperture is 0.55. For writing, laser power is 10mW at a linear velocity of 2.5m/s, applied magnetic field is 200 Oe. While for MAMMOS readout experiment, laser power is 2.8mW. Applied field has mono-tone single frequency (6.25MHz) with amplitude of +/- 200 Oe.

The shortest mark/space is 400nm with 160 nsec time period. Figure 2,C is an example of recorded magnetic field pattern equal to stored bit pattern like /100110100010...../. Figure 2, B shows a serial mono-tone external field excitation which causes a MAMMOS readout signal resulting in figure2, A. Full swing large signals are recognized showing very precise recorded pattern.

On the analogy of human brain memory, such basic MAMMOS has two distinct features as like,

- 1) There is a certain threshold in laser power and magnetic field to remember the memorized contents deeply stored inside of the disk (recording layer). Laser power and magnetic field are regarded as the external stimulation like light beams and/or sounds surrounding us (human beings). Less laser power, less magnetic field brings nothing memory recovery as like our mind are almost calm against so many past memories. It is likely that our inside storage capacity looks so small in usual.
- 2) The amplification of memory elements is remarkable phenomena in MAMMOS. Our old memory (sometimes 50 years ago episode) may be stored in our brain as some elements with very small signal. However, once we are stimulated by an exceptional happenings, for example when we accidentally met a lost lover on the street, we can clearly remember the fifty years ago scene, sounds, details of conversation and so on.

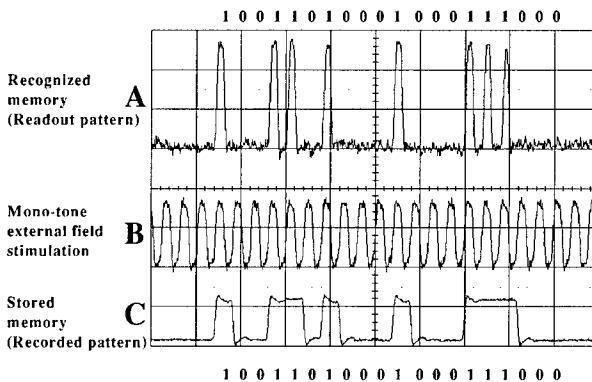


Figure 2. Basic MAMMOS experiments. Mono-tone single frequency modulated magnetic field amplifies recorded signals stored in a recording layer by a domain expansion mechanism in readout layer.

ACTIVE READOUT MAMMOS

Resemblance between Human brain memory and basic MAMMOS, we can consider new schemes of memory recovery, named the Active readout MAMMOS, in which we apply magnetic field pattern having meaningful digital information. One example is shown in figure 3. Applied external field pattern is illustrated in B, which has a series of digits /100110100010.../. Originally stored domains in a recording layer are in C. Only the positions coincided both applied field and recorded domains are amplified as big signals as shown in A.

Applied field pattern is a model of specific external stimulation like a beautiful scenery, comfortable sounds. If this new experience is not matched with old memorized one, we cannot remember it as a similar experience. Coincidence between B and A is not so good.

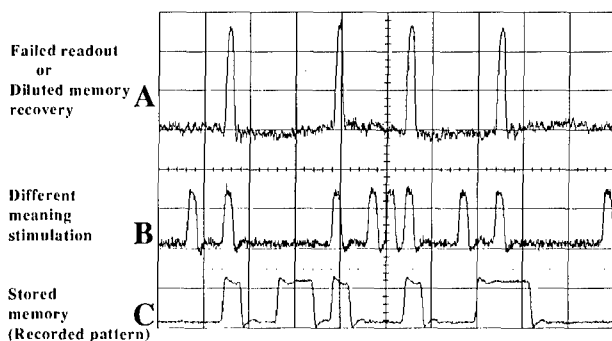


Figure 3. Active readout MAMMOS, applied field has a meaningful digital information (B). Only the matching portions with original recorded patterns (C) are amplified as MAMMOS readout patterns illustrated in A.

IN-PHASE ACTIVE READOUT MAMMOS

If the phase and digital patterns of external field just coincide with original recorded patterns as shown in figure 4, B and C, we can recognize the amplified read out pattern in A as like just exactly the same pattern with B. Comparing with in-put magnetic field pattern B and out put signal pattern A, we can notice that the original recorded pattern is also the same which means we already experienced the similar thing in the past.

This means some kind of Memory Association, or the starting trigger of the memory association. When we notice such nice coincidence between A and B, we may have psychological satisfaction or pleasure in brain. This satisfaction brings a trigger of reading out the succeeding memory contents stored in the next paragraph or sometimes linking to other disks having the similar coincide facts. In our daily expression, it is so called "Memory Association".

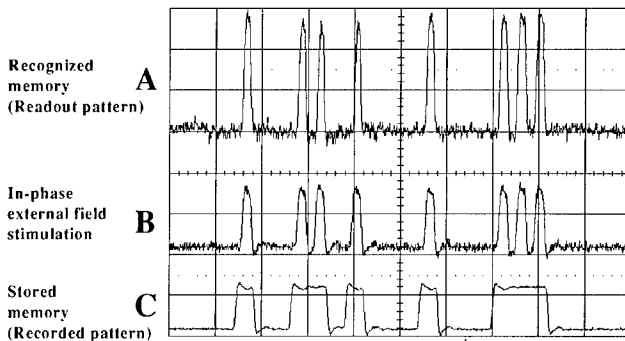


Figure 4. Memory recognition scheme by In-phase Active readout MAMMOS. When the magnetic field pattern and timing phase (B) just coincide with memorized contents (C), recognized pattern (A) shows the best matching with in put pattern. This may suggest the scheme of Memory Association device.

OUT- OF- PHASE ACTIVE READOUT MAMMOS

In active readout MAMMOS, if the timing phase of magnetic field had some shift as shown in figure 5,B and C, there occurs a failure of memory recovery (see figure 5,A). This suggest that we may see in our eyes, hear by ears physically what we already experienced, but never notice the fact until we get some phase matching. In Japan, there is a very famous proverb, “Looking but not seeing”.

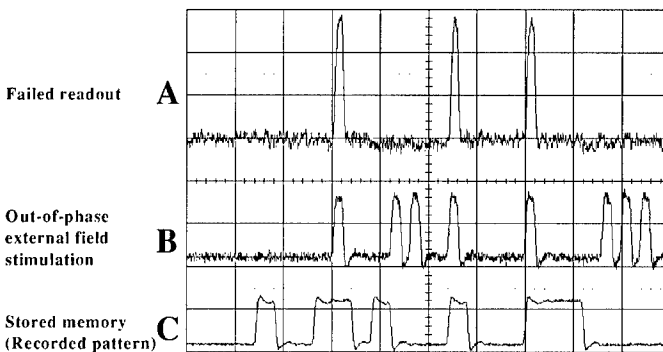


Figure 5. Failure of memory recovery by a out-of-phase external field excitation in Active readout MAMMOS

CONCLUSIONS

Using the phenomena of Magnetic Amplifying Magneto-Optical system (MAMMOS), we proposed a new memory scheme showing human brain like memory behavior, named Active readout MAMMOS.

- 1) Basic MAMMOS has two features analogues to human memory behavior, one is threshold strength of magnetic field and laser power(external stimulation) to recovery the old memory . Another is an amplification of very small recorded signal like man remembering the 50 years ago episode.
- 2) By applying the magnetic field corresponding to the previously determined information, the MAMMOS readout signal shows logical "AND" states between the stored memory and field patterns. This active readout MAMMOS is similar to the psychological interaction between our memory and external stimulation.
- 3) If magnetic field pattern and timing phase just coincide with memory contents, there occurs coherent excitation of MAMMOS signal. We can utilize such status as the trigger of Memory Association.

REFERENCES

1. Y. Naya, M. Yoshida and Y. Miyashita, Science, **291(5504)**, 661 (2001)
2. H.Awano,S.Ohnuki,H.Shirai,N.Ohta,A.Yamaguchi,S.Sumu,and K.Torazawa, Appl.Phys.Letters, **69**, 4257 (1996)
3. H.Awano and N.Ohta, IEEE J.Selected Topics in Quantum Electronics, **4**, 815 (1998)
4. H.Miyamoto,T.Niihara,H.Sukeda,M.Takahashi,T.Nakao,M.Ojima and N.Ohta, J.Appl.Phys., **66**, 6138 (1989)
5. H.Awano,M.Sekine,M.Tani,N.Kasajima,N.Ohta,K.Mitani,N.Takagi and S.Sumu, Jpn.J.Appl.Phys., **39**, 725 (2000)