MAGNETO-OPTICAL CYLINDRICAL MAGNETIC DOMAIN MEMORY

BACKGROUND OF THE INVENTION

Magnetic domain behavior in general has been studied extensively for many years and the knowledge gained has made possible many techniques and products for the storage and processing of digital information. Thus, magnetic cores, recording wire, tape, drums and discs each broadly utilize some characteristic of magnetic materials. Most of these devices utilize amorphous, opaque ferromagnetic materials and are constrained by the geometry of the magnetic material into two dimensions. Furthermore, in these devices the axis of magnetic polarization employed is usually in the plane of the magnetic medium. They are generally constructed of solid magnetic materials or thick films and the domains therein are in most cases multiple groups rather than singular in nature. Furthermore, the most versatile of these memories, the random access core memory operates with "destructive readout", i.e., the information contained in the memory is destroyed during the reading process and must be subsequently restored and reinstated.

The development of magnetic devices utilizing the concept of a small discrete zone or domain which is moveable in a thin film of magnetic material when means are provided for moving the domain through the film is illustrated in such U.S. Pats. as Nos. 2,919,432; 3,068,453; and 3,125,746 all issued to K. D. Broadbent. The utilization of such moveable magnetic domains in certain single crystal ferromagnetic materials is discussed in U.S. Pat. No. 3,513,452 issued to A. E. Bobeck et al. and in an article which appeared in the June 1971 issue of the magazine "Scientific American" written by Andrew H. Bobeck and H. E. D. Scovil and entitled "Magnetic Bubbles." The magnetic domains or bubbles discussed therein and in the bibliography thereof can be made to assume a right cylindrical shape and can be generated, obliterated, displaced and detected in two dimensions. The axis of magnetic polarization of these bubble domains caused by the magneto crystalline anisotropy lies along the axis of the right cylinder bubble and is chosen to be perpendicular to the plane of the major surface of the magnetic medium or crystal which is the plane in which the bubbles move. Since many of these single crystal materials used are transparent, it becomes possible to monitor domain behavior with the aid of the Faraday effect, that is, the change in the state of polarization of polarized light which is produced when it passes through a magnetic field such as that of the bubble.

The single crystal growth technology developed for the fabrication of active electronic devices employing piezoelectric and semiconducting phenomena and the crystallographic and photolithographic processing techniques previously developed for the manufacture of semiconductor devices and integrated circuits can all be used to fabricate the type of single crystal magnetic domain devices described herein.

While the devices described herein utilize the basic phenomena and scientific laws discussed in the article by Bobeck et al. and the bibliography thereof, it should be pointed out that the devices developed by Bobeck and his associates are primarily intended for use in the central offices of telephone systems where inexpensive large scale, slow access, serially operated devices are desired. The design of devices described by Bobeck thus assumes that bubbles make good shift register memories, that they are useful because they will give maximum bit packing density, that garnets are better than orthoferrites for these purposes and such that bubble systems must be relatively slow in operation by their very nature. The devices described herein, on the other hand, are postulated on the premises that such bubbles can be used to make good random access high speed nondestructive readout or associative memories, that bubbles do not have to be packed to extreme density in order to be highly useful even in large scale or mass memories, that bubble systems can be constructed for fast operation in either the serial or parallel mode, that larger bubbles are easier to detect and that orthoferrite crystals are better than garnet crystals for these purposes. An "orthoferrite" as used herein is deemed to mean a ferromagnetic oxide of the general formula $MFeO_3$, where M is yttrium or a rare earth iron. By "domain" is herein meant a region in a solid within which elementary atomic or molecular magnetic or electric moments are aligned along a common axis. By "easy axis" is meant the crystallographic axis of a single ferromagnetic crystal body which requires minimum saturation magnetization energy and the axis along which spontaneous magnetization occurs.

SUMMARY OF THE INVENTION

The devices disclosed herein use orthoferrite crystals to achieve such bubble devices as a subtractive comparator or a random access memory both of which afford nondestructive readout and fast operation in either the serial or parallel mode. In both devices bubble domain locations are defined by a pattern of conductors deposited on the crystal or on a glass plate which is positioned adjacent to an associated crystal in which the bubble domains are established and controlled by magnetic fields generated by magnets and/or current flow in the conductors on the glass plate. Depending upon the particular nature of the device, one or more of such plate-crystal pairs is positioned axially along the path of a beam of polarized light which may simultaneously illuminate the entire crystal surface of any subdivisions thereof for parallel readout, or which may comprise a flying spot scan for serial readout. Means are provided on the other side of the plate-crystal pair or pairs to analyze or detect a change or changes in the state of polarization of the light transmitted and a photodetector converts such detected change or changes into electrical readout signals. Where two plate-crystal pairs are used in connection with a suitably perforated mask and are fully illuminated throughout the array thereon, it is possible to interrogate one plate (the memory) by electronic signals applied to other (the interrogator) with the same logic pattern as is commonly used in ferrite core memories to define and query an array position but without destroying the contents of the memory.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood from the detailed description below taken in conjunction with the drawings attached hereto in which like reference characters refer to like parts throughout and wherein;

FIGS. 1*a*, 1*b*, 1*c*, 1*d*, 1*e*, and 1*f* are plan views of a typical orthoferrite crystal platelet as seen under a microscope wherein polarized light is alternatively trans-