FIG. **1** illustrates a diagram depicting a zig-zag shaped magnetoresistive sensing apparatus **100**, which can be implemented in accordance with a preferred embodiment. a range of parameters, which can are generally with the apparatus **100** depicted in FIG. **1**, and can be provided as follows:

$h>100$ nanometers

$4h>w>0$

$2h>p>0.5h$

$L>3p$

$t<0.1w$

In general, the variable "h" generally represents the height of the triangle utilized to construct the zig-zag structure **101** depicted in FIG. **1**. The variable "L" represents the total length of the zig-zag shaped structure depicted in FIG. **1**, which forms the magnetoresistive sensing apparatus **100**. Likewise, the variable "t" represents the thickness of the film **105** depicted in FIG. **1**. Also, the variable "w" represents width of the current path associated with the current **102** in film **105**. The variable "p" represents the periodicity of the zig-zag structure **101** depicted in FIG. **1**. The magnetization direction is generally indicated by arrow **109** in FIG. **1**.

In order for the zig-zag shaped magnetoresistive sensing apparatus **100** to operate as a sensor with an odd transfer function, the magnetization at zero field should be maintained at an angle greater than zero with respect to the current **102**, as depicted in FIG. **1**. In the configuration illustrated in FIG. **1**, parallel jagged edges **104** can be provided, which are similar to a sequence of triangles, thereby forming a "zig-zag" zig-zag due to a dipole effect, as indicated in FIG. **1**. Two types of domains are therefore predominant, with a spatial magnetization at angles $\pm\theta$ with respect to the length **106** (L) of the magnetoresistive sensing apparatus **100**. Note that in the configuration depicted in FIG. **1**, the magnitude of the angle θ is generally greater than the value zero.

When a magnetic field is applied along the length **106** of the magnetoresistive sensing apparatus **100**, the magnetization angle inside the alternating domains increase or decrease in both types of domains, depending upon the sign (i.e., polarity) of the magnetic field (i.e., a scissor mode). Such a scenario can be followed by a corresponding increase or decrease, respectively, in the resistance of each individual domain. Because all elements are in series, the net resistance will increase or decrease.

On the other hand, if the magnetic field is applied perpendicular to the length of the sensor or magnetoresistive sensing apparatus **100**, θ a will increase inside one type of domain and will decrease inside the other type (i.e., rotation mode of the magnetization). This results in opposing resistance changes between the domains. Such changes in series therefore tend to cancel, resulting in a reduced overall response of the sensor. Thus, the magnetoresistive sensing apparatus **100** is relatively insensitive to applied magnetic fields along the axis perpendicular to the length **106** (L) of the magnetoresistive sensing apparatus **100**.

When used as a data storage element, if the magnetoresistive sensing apparatus **100** is saturated by a magnetic field applied along its length, after the magnetic field is removed, the slope of the transfer curve at or near a zero magnetic field possesses the same sign or polarity as the applied magnetic field. The state of the magnetization (i.e., right or left) can be then determined by measuring the slope of the resistance as a function of the magnetic field at a zero magnetic field value. This action constitutes retention of past information and can be referred to as the "memory effect". The amount of magnetic field necessary to erase the previously stored information and record new information can be referred to as a "coercive field".

FIG. **2** illustrates a scanning electron micrograph **200** with polarization analysis, in accordance with one embodiment. In the example illustrated in FIG. **2**, micrograph **200** has been generated with a polarization analysis based on a 3 μm×16 μm, 30 nm thick NiFe film, which can be utilized to implement film **105** depicted in FIG. **1**. The magnetization direction is generally indicated by the circular map **202** depicted to the right of micrograph **200** as depicted in FIG. **2**. Micrograph **200** therefore generally represents a scanning electron micrograph with polarization of the zig-zag shaped magnetic thin film **105** depicted in FIG. **1**.

Additionally, a curve **204** illustrated in FIG. **2** generally represents the actual magnetization angle that occurs toward the center of, for example, element or film **105** depicted in FIG. **1**. a solid blue curve **206** depicted in micrograph **200** can be generated as a simulation based on a modeling program, such as, for example, the Object Oriented Micromagnetic Framework (OOMMF) modeling program.

Note that OOMMF refers generally to a project in the Mathematical and Computational Sciences Division (MCSD) of the Information Technology Laboratory (ITL) and the National Institute of Standards and Technology (NIST) in cooperation with the Micromagnetic Modeling Activity Group (pMAG), aimed at developing portable, extensible public domain programs and tools for micromagnetics. The end product resulting from such an effort is a fully functional micromagnetic code, with a well documented, flexible programmers interface that allows developers outside the OOMMF project to swap their own code in and out as desired. The heart of the code can be written in, for example, C++ with a tool command language interface based on, for example, Tcl/Tk, and possibly OpenGL. Target systems generally include a wide range of Unix platforms and Windows (9x and later). The open source scripting language Tcl/Tk may be required to run OOMMF.

FIG. **3** illustrates graphs **302** and **304** depicting resistance change versus the magnetic field along or perpendicular to the axis of the sensor or magnetoresistive sensing apparatus **100** depicted in FIG. **1**, in accordance with another embodiment. Graphs **302** and **304** therefore illustrate data, which can be utilized to generate transfer curves **305**, **307** and **309**, **311** associated with a NiFe zig-zag element or component depicted in FIG. **1**. FIG. **3** generally illustrates transfer curves of a device that can be constructed with the same dimensions as the apparatus associated with the data depicted in micrograph **200** of FIG. **2**. The only difference between the two devices is that in FIG. **3**, contacts can be made to the ends of such a device utilizing aluminum pads.

The measurements obtained are generally generated by a standard four-probe geometry for current and voltage. The curves **305**, **307** and **309**, **311** depicted in FIG. **3** indicate that in the range of a low magnetic field, $|H|<1000$ A/m, the elements are sensitive to fields along the long axis **312** depicted in graph **302** and insensitive to fields perpendicular as indicated by axis **314** illustrated in graph **304**. Graph **304** also illustrates the two remnant resistances described by their respective slopes at a zero magnetic field. FIG. **3** therefore illustrates transfer curves associated with a 3 μm×16 μm, 30 nm thick NiFe zig-zag element.

It will be appreciated that variations of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.