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Solid State GMR Memory

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Abstract

We found that in weakly-coupled giant magnetoresistive (GMR) sandwich the small-field response's slope is dependent on its past magnetic history. Based on this storage mechanism, we designed a binary solid state memory element. It operates on the general principle of storing a biary digit in hard component and sensing nondestructively its remanent state by switching the soft component in such a way that the magnetic state of the hard component unaltered and thereby causing a dramatic GMR polar readout. So far one-bit experimental apparatus has been realized.

1. Introduction

Magnetoresistive Random Access Memory(MRAM) [1] [2] is a magnetic memory technology which has two functions: magnetic storage and magnetoresistive reading. GMR materials can be used [3] [4] [5] as reading to improve read access time as the result of the higher signals of GMR elements. It is because that twice the signal decreases the time necessary to resolve a signal by about a factor of four.

In weakly-coupled GMR sandwiches, we found a storage mechanism: the slope of the resistance vs field curve R(H) depends on its magnetization history. Based on this mechanism, we develop a binary memory which uses spin-valve sandwich for both storing and reading data. It is expected that its signal level and read access time will be improved sufficiently to compete with any solid state integrated memory, and potentially with magnetic disks in some application.

2. Experimental results

The structure which we used is Co(50A)/NiFe(5A)/Cu(30A)/Co(5A)/NiFe(50A), namely comprised of two ferromagnetic components: the hard component Co(50A)/NiFe(5A) and the soft component Co(5A)/NiFe(50A). To prepare these samples, a RF sputtering system are employed. Uniaxial anisotropy, important both for memory storage and for the way that a bit is selected, is induced by a magnetic field of 15.5 Oe applied during sputtering. We investigated the R(H) transfer curves of the above samples under AC excitating field with various strength. As well known the switching of the double ferromagnetic layers with different coercivities give rise to the "double-clock" shaped curve depicted in Figure 1, where the applied field between ±15 Oe. From Figure 1 there are obviously two switching thresholds at point A and point B, corresponding with the magnetization reversals of the soft and the hard component respectively. Figure 2 illustrates the R(H) response for the same sample operating in the mode in which only the soft component is switched by applying a field between ± 7.5 Oe. In Figure 2(a) the element is initially DC saturated to the "negative" direction by field of −15 Oe while in Figure 2(b) initially saturated to the "plus" direction by +15 Oe.

We have fabricated a one−bit solid state GMR memory, as shown in Fig. 3. The storage/sense line is made of the above sandwich whose size is 10 μ m × 20 μ m. Two lead pads and word line are Cr/Cu/Cr multilayer. A combination of a sense current flowing along the GMR line and a exciting current floing along the word line can realize a 2D selection storge/sense function. When an plus pulse word current Iw passes through the word line, a plus (corresponding to "1") or minus (corresponding to "0") voltage Vs should appears across that GMR storage/sense line. It proved to be true by the pulse sequence of Fig. 4.

3. Conclusions

In weakly−coupled sandwiches Co (50A)/NiFe(5A)/Cu(30A)/Co(5A)/NiFe(50 A), we found a storage mechanism: the slope of the minor loop of the resistance vs field curve R(H) depends on its magnetization history. That is to say, after being polarized to negative direction the response's slope will be plus whereas after being polarized to plus direction the slope will be minus. Based on the above mechanism, we develop a memory which uses weakly−coupled sandwich for both storing and reading data.

References

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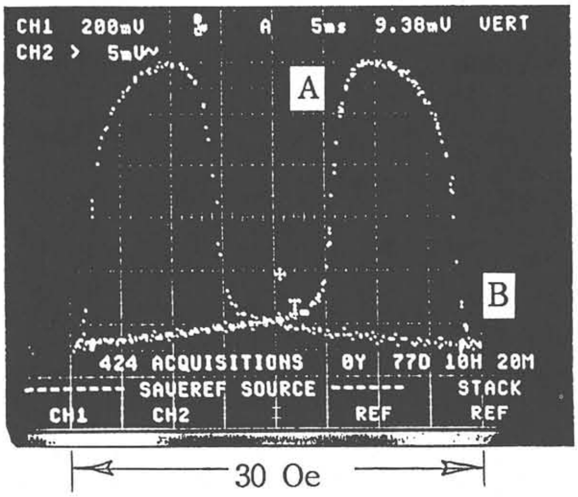


Figure 1. The resistance vs field curve R(H) with applied field between ±15 Oe.

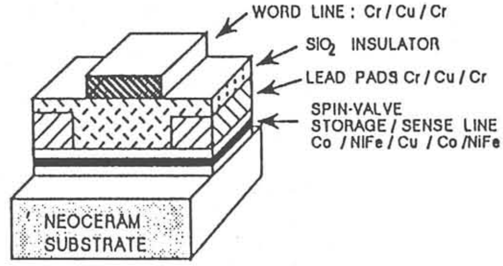
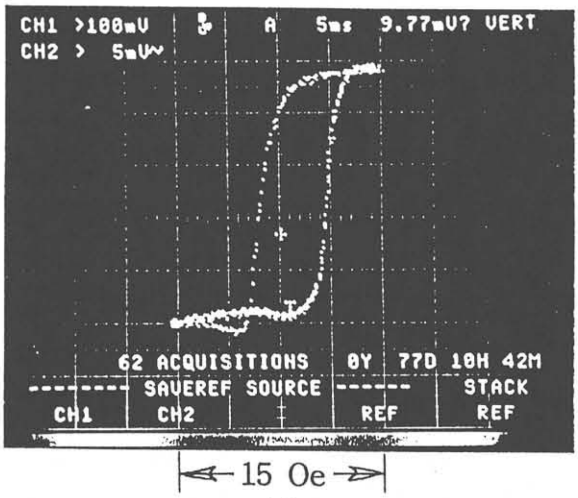
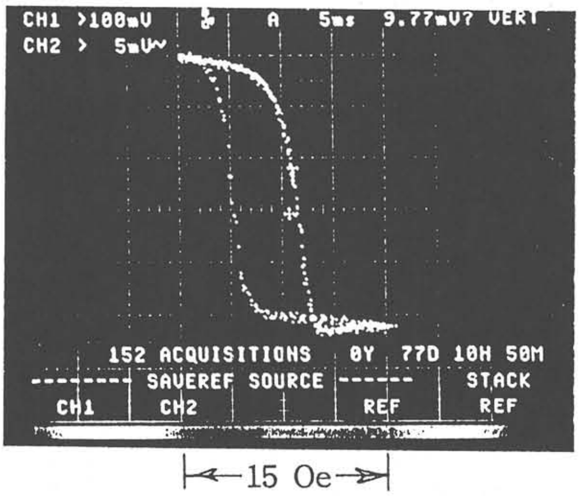


Figure 3. Experimental apparatus.



(a)



(b)

Figure 2. The resistance vs field curve R(H) with applied field between ±7.5 Oe.

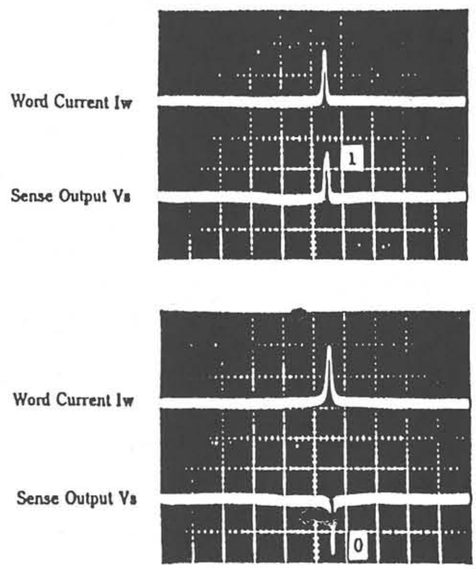


Figure 4. Pulse sequence of reading process.