Journal of Magnetism and Magnetic Materials 156 (1996) 405–406

ELSEVIER

journal of magnetism and magnetic materials

Spin-valve multilayers of [H/Cu/S] (H = Co, Co–Pt, or Co–Fe, S = NiFeCo) and memory cells

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Abstract

Spin-valve memory elements composed of hard and soft magnetic layers separated with non-magnetic layers have been developed. Non-destructive read out (NDRO) is possible with this memory device as the hard magnetic layer is used for the data storage and the magnetization switching of the soft magnetic layer is used for the data readout. Spin-valve multilayers having small saturation fields have been studied for the memory elements.

1. Introduction

MRAM devices have been studied using conventional AMR films, resulting in small outputs because of their small MR ratios. Since the discovery of GMR materials, GMR memory devices have been proposed [1] and micromagnetic analysis [2] has been performed for the ultra dense GMR memory cells.

Spin-valve sandwiches using an antiferromagnetic layer (AF spin-valve) such as FeMn/NiFe/Cu/NiFe [3] are used for a new type of MRAM device [4]. In this case, a free NiFe layer is used for the data storage, as the magnetization switching of the NiFe layer blocked with the FeMn layer is quite difficult. Hence this memory device could not have non-destructive readout (NDRO) characteristics.

We have studied spin-valve multilayers using a hard magnetic layer (HM spin-valve) [5], instead of an antiferromagnetic layer, and proposed a new type of MRAM [6] using the HM spin-valve, which shows NDRO characteristics. This memory device requires HM spin-valves having sharply peaked MR curves with small saturation fields, as the magnetic fields generated by word lines are small. In this paper, we report on the HM spin-valve memory and the spin-valve multilayers developed for the memory device.

2. Experimental

HM spin-valve multilayers of [HM/Cu/SM(/Cu)] were prepared by rf sputtering [5] or by UHV evaporation [7], where HM and SM indicate semi-hard and soft magnetic layers, respectively. CoPt, CoFe, and Co were used for the HM layer and NiFe, NiFeCo is used for the SM layer.

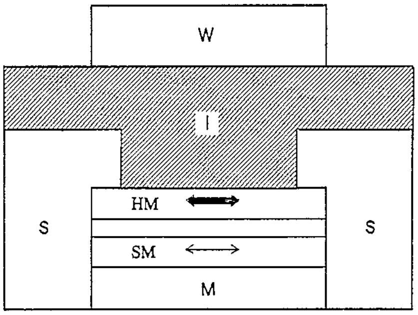

Fig. 1. Structure of the memory cell, where W, I, M, S denote word line, insulator, MR element, and shunt line, respectively.

The memory cells were fabricated with optical lithography and ion milling techniques. Fig. 1 shows the structure of the memory cell. The magnetoresistive element, M, is composed of [HM/Cu/SM(/Cu)] multilayers. The fabricated memory cell is composed of a 133 nm thick M having an active area of 20×40 μm, connected to 300 nm thick Au shunt films to form the sense line. The Au word line is 80 μm wide and 200 nm thick, separated from the memory element by 1 μm thick insulating photoresist.

3. Spin-valve memory

In our spin-valve memory, the data are stored by magnetizing the HM layer in the magnetoresistive (MR) element along the easy axis in one direction or the opposite direction according to the memory state ‘1’ or ‘0’. The magnetizing field generated by word (and sense) current is, therefore, required to be larger than the threshold of the HM layer, H_s. Data readout is performed by applying a

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