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PROBE-BASED DATA STORAGE TECHNOLOGY: THERMOMECHANICAL STORAGE –STATE OF THE ART

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Abstract

Ultra high density data storage imposes an ever increasing demand on the capacity and speed of data storage systems becoming an essential issue in this digital age. Secondary storage has been indispensable constituent of any computer system for storing data at high speed with ultra-high density. AFM (Atomic Force Microscopy) based data storage is a promising alternative to conventional magnetic data storage because it offers great potential for considerable storage density improvements, which has become very popular. Significant challenges, salient features and associated benefits of the nano tip based data storage devices were discussed briefly in this case study. This study addresses the following: (i) a brief discussion on emerging research directions broadly in the areas of thermomechanical data storage and storage intersecting low-dimensional polymer materials; (ii) advancing experimental methods to fabricate microcantilever with nano tip that can sustain with pulse gradient, thermo mechanically stable under large thermal cycles which can be electrically interrogated with negligible parasitic loss.

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1. INTRODUCTION:

Secondary storage is an indispensable constituent of any computer system, from the mobile PC to the server system. For several decades hard disks have been serving the secondary storage. The information storage imposes an ever increasing demand on the capacity and speed of data storage systems and has been becoming an issue in this digital age and in order to meet this demand, nanotechnology offers an alternative for present magnetic storage. In

Magnetic storage, bit is represented by magnetized part on the recording medium. Magnetized part is represented as 1 and the Non-Magnetized part is represented as 0. But when the size of magnetic domain decreases below a certain value, the probability of the bit undergoing thermal demagnetization at room temperature becomes unacceptably large, and effects the magnetic domain and hence storage. The size of magnetic domain has a limiting value where it is not affected by thermal demagnetization at room temperature (i.e. magnetic domains become small to be stable at room temperature, called Paramagnetic Limits) (E.Grochowski et al., IBM). Within the paramagnetic limits, areal densities are 100Gbit/inch^2(E.Grochowski et al., IBM). The searches for digital storage technologies which have to meet the demand for data storage with more storage capacity offered ever increasing data densities. Several ideas have been proposed on how to overcome this limit such as holographic storage, electron beam based storage, optical storage, and the tip based storage. One of such a proposal is AFM (Atomic Force Microscopy) tip method. AFM method employs a microcantilever with a sharp tip to image a nonconductive surface on the atomic scale.

The available tool known that is simple and providing long term perspectives is cantilever with nano tip. AFM based data storage is a promising alternative to conventional magnetic data storage. With the invention of STM it became possible to image atoms and a few years later manipulation at atomic scale was demonstrated by Eigler and Schweizer (1990) (D.M.Eigler et al., 1990). Probe storage resembles AFM. The main difference between AFM based data storage and Probe based data storage is the number of probes used. It offers great potential for considerable storage density improvements, which has become very popular.

THERMO MECHANICAL DATA STORAGE is a method that uses AFM tip heated by electric pulses, which in contact with a storage medium is used to store data. The MILLIPEDE concept introduced by IBM is a new approach for storing data at high speed and with ultra-high density. Locality of a bit is given by a tip, and results in high data rates due to parallel operation of such tips. Areal densities of 4 Tbit/inch^2 (G.Schmid et al., 2008) have been achieved by parallel operation of large 2D (32x32) AFM cantilever arrays with tips and write/read storage functionality. It is very attractive since bit size is not determined by maximum resolution of lithography processes. Cantilever probes are chemically etched and have the potential to be automatically sharp without expensive manufacturing step.

THERMO MECHANICAL DATA STORAGE:

This method uses a cantilever to write, read and erase of data bits (or simply bits). This is a probe based storage mechanism.In 1994 Gimzewski et al. Constructed first micro cantilever which was used as a chemical reaction sensor. A cantilever with a tip is used to indent bits on polymer medium. Writing is done by heating of the cantilever tip with a laser beam, and reading was achieved by measuring deflection of another laser beam. Piezo-resistive cantilevers were used in this recording type. A major disadvantage of this method is that lasers are bulky and require precise alignment. So, cantilevers with integrated heaters or writing elements that do not rely on lasers can be a solution to make it simple (Benjamin W.Chui, 1999).

AFM thermo mechanical recording in polymer storage medium has undergone many modifications mainly with respect to integration of sensors and heaters designed to increase simplicity and to increase data rate and storage density. Using these heater cantilevers instead of piezoresistive cantilevers, high storage density and data rates have been achieved (Seongsoo Jang et al., 2006).

It is developed by IBM under a project named MILLIPEDE (Vettiger et al., 2000). In this method, topographical changes are created on a polymer medium by making indentations representing 1. Absence of indentations is used both as spacer between neighboring 1's and also for 0's.