Diamond-base data storage

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Problem Description

Starting with the paper data media, computer-generated data storage has made great progress in its development. To date, magnetic and optical media are the most common (see the book [1]). However, they have some physical limitations due to which further increase of the recording density and reliability of information storage is hindered. One solution to go beyond the limits of conventional magnetic and optical recordings, to high density storage, is the use of the micro-tips to write and read data. Many works on SPM-based storage processes (see reviews [2-4]) show that these effective tools for nanometer-scale surface observation are applicable to data storage devices.

One of the limitations of SPM-based storage is the low read/write rate. To solve this problem multi-probe systems have been developed [5], which brings this method to the industrial use. Such systems are often called Probe Data Storage (PDS), a term which will be used below. For successful PDS industrial use high wear resistance of the tip has to be provided. This requirement can be implemented using a diamond tip (an approach used by one of the members of the consortium [6-9]).

Polymers, which are being actively developed to obtain new information carriers, are materials that can be easily destroyed by external influences, and can remain effective for a relatively limited time. This fact creates enormous risks for the data contained in polymer-based storage technology. As we know from history, the vast amount of information stored on relatively easily destroyable organic materials (papyrus, paper, etc.) has been lost in fires, during natural disasters, wars, etc. At the same time, the information that was recorded on inorganic materials (clay tablets, rock inscriptions and so on) is preserved for millennia. To date, enormous human, energy and material resources are being spent for the digitization of information from various fields of human activity, which was previously stored in analog form. Almost all the new information is recorded in digital form. A lot of this information from the fields of science, genetics, medicine, etc. can be claimed by many centuries or millennia.

Since the polymer-containing media are not resistant to adverse storage conditions, and require rewriting after a few decades, there are huge risks associated with the loss of this information. It is difficult to expect that the support of an inorganic material can get cheaper than that of an organic. However, if we take into account the life expectancy of the media and the objective is to keep the information in the course of 500 years, a single carrier, made of an inorganic material or 10 organic carriers that have to be rewritten every 50 years are required. Recently a DVD made from an inorganic material by the American company Millenniata [10] appeared on the market displaying the economic attractiveness of such materials.

The way of problem solving

The way of problem solving is the development of the methods of fabrication and preparation of inorganic materials, originated from three groups, to their utilization in next-generation carriers of information. Single-crystal, phase-changed, and MAX-phase materials will be used to overcome the limitations of the lifetime of the existing and developed data storage. Modeling of a nano-interaction between the diamond scanning probe of microscope and the surface of inorganic materials during the formation of binary pattern will at the core the theoretical part of the project. Significant theoretical effort will also require to characterization of the developed materials obtained under different process parameters in terms of their suitability for PDS. Experimental investigations of the project will include the study of nano-manipulations with the surface to establish parameters of the maximum data density to determine the durability of probe nano-modified surfaces, the wear resistance of diamond tip and number of probes to ensure the highest possible information recording rate. The final part of the project will contain prototyping of inorganic materials for industrial-oriented PDS and comparative analysis of physical and mechanical characteristics of each material for different applications (regular media, archival data carriers for specific environmental conditions for the storage of data).

Thus, the concept of the project is to perform works on the creation/preparation, research and testing of the properties of materials that meet three basic criteria:

- the materials should be inorganic to be used to ensure long-term storage;
- the mechanical properties of these materials must comply with PDS to provide high data density;

- the materials for the carrier of information will interact with a diamond tip, which is needed for the industrial application, which requires high wear resistant SPM- tip.

The physical and mechanical properties of the material suitable for use as a data storage medium, the reading and writing of which will be performed by the probe methods must meet several requirements:

1. The material for the carrier of information should be easily treatable, which is important for the industrial orientation of the project. . Such materials are the machinable ternary carbides and nitrides with the general formula: Mn+1AXn , where M is an early transition metal, A is an A-group element, and X is C or N represent a class of solids with an unusual combinations of properties. Two independent basal slip systems render them exceedingly damage tolerant, thermal shock resistant, and relatively tough. Their most characteristic attribute has to be the ease by which most materials within this family can be machined.

2. Uniformity of nano-scale material properties, which is important for the write/read operations. Random variations of these characteristics on the carrier's surface can be erroneously treated by the reader as binary data and can lead to their distortion. Single crystals are the most suitable materials in terms of uniformity of physical and mechanical characteristics.

3. Ability to predictably change certain physical and mechanical characteristics under the influence of SPM-probe in the very localized to the tip space. Among such materials are phase-change materials.

Thus, the study of MAX-phase materials, Single crystals sapphire and Phase-change materials will be performed in order to develop methods of obtaining, preparation, and characterization these materials for PDS.

Basic publications

1. High density data storage. Principle, Technology, and Materials. Edited by Y. Song and D. Zhu, World Scientific Publishing, 2009, 363 p.
2. H. Masrtin, D Terris, L.Fa Proximal probe microscopies, 39, 1995, 681-699.
3.H.Peng, Z. Liu. Coordination Chemistry Reviews 254 (2010) 1151–1168.
4. Y. Ma, Y.Wen and Y. Song J. Mater. Chem., 2011, 21, 3522-3533.
5. E. Eleftheriou, T. Antonakopoulos, G. K. Binnig, et al. IEEE Transactions on Magnetics, vol. 39, no.2, pp. 938-945, March 2003.
6. O.Lysenko, N.Novikov, V. Grushko, et al. "High-density data storage using diamond probe technique" 2008 J. Phys.: Conf. Ser. 100 052032 (4pp).
7. O. Lysenko, A. Mamalis, V. Andruschenko et al. Nanotechnology Perceptions. 2010, 6, P.41-50.
8.O. Lysenko, V. Grushko, E. Mitskevich and A. Mamalis, Mater. Res. Soc. Symp. Proc. Vol. 1318, 2011, 179-183.
9. O.Lysenko, N.Novikov, V.Grushko et al. Diamond & Related Materials 17 (2008) 1316-1319.
10. http://en.wikipedia.org/wiki/Millenniata

Innovative Aspects of the solution / development/ methodology, tool, prototype

The main innovative difference between the project from the state of the art technology is its focusing on technologies that will solve the problem of extremely low lifetime of the existing data storages, as well as emerging media, which contain polymers.

The novelty of the project is to develop three promising groups of materials, with the specified physical and mechanical properties obtained at different technological parameters of synthesis, assess the stability of physical and mechanical properties of these materials and conduct experiments on the surface nanomodification to obtain ultra-dense binary digital data.

Main advantages of the solution / development/ methodology, tool, prototype

We will obtain knowledge about the properties of materials that will be useful in the development of innovative information technologies to all spheres of human activities.

Having long-term memory devices has several significant advantages. First of all, it reduces risks of information loss as a result of failure of the existing storage media caused by the degradation of properties or physical destruction initiated by the natural disasters, terrorist acts, accidents, etc. The introduction of new materials in the PDS will ensure the transfer of currently available information from various areas of human activity for future generations.

New memory devices based on materials developed in this project will have significantly reduced consumption of energy, materials and other resources, while PDS does not contain any rolling elements with accompanying motors, drives, etc.

The emphasis on inorganic materials will lead to the development of long-term storages of information, which is important for reduction of the costs of utilization of used carriers of information and the prevention of environmental pollution.

Financial and Economic Parameters

The data given here should correspond to the technical and economic assessment or business plan and have a full documentation (for negotiations with potential investors).

Investment Offer *(is not obligatory)*

The goal of this section is to give a potential investor a notion of the required investment volume and proposed level of investor's involvement in implementation and exploitation of the project.

Current stage of development of the offered solution / development/ methodology, tool, prototype *(please, select)*

○ Development phase – laboratory tested
○Available for demonstration – field tested
○Already on the market
Comments:

Intellectual Property Rights *(please, select)*

○ patent applied for (name countries in which you have applied for patents in)
○patents granted (enter the countries that have granted the patents; where the initial patent was granted and say a few words about the company)
○copyright
○exclusive rights
○secret know-how
○others (registered design, plant variety right, etc.)
Comments

Collaboration Details (Type of collaboration sought; *more than one option can be selected*)

○ Technical co-operation
○ Commercial agreement with technical assistance
○ Joint Venture agreement
○ License agreement
○ Manufacturing agreement
○ Financial resources
Comments:

Technology Key words

Diamond, Data storage, Nanotechnology