Development of User-Friendly High-Resolution Magnetic Scanning Microscope using a Needle MR Probe

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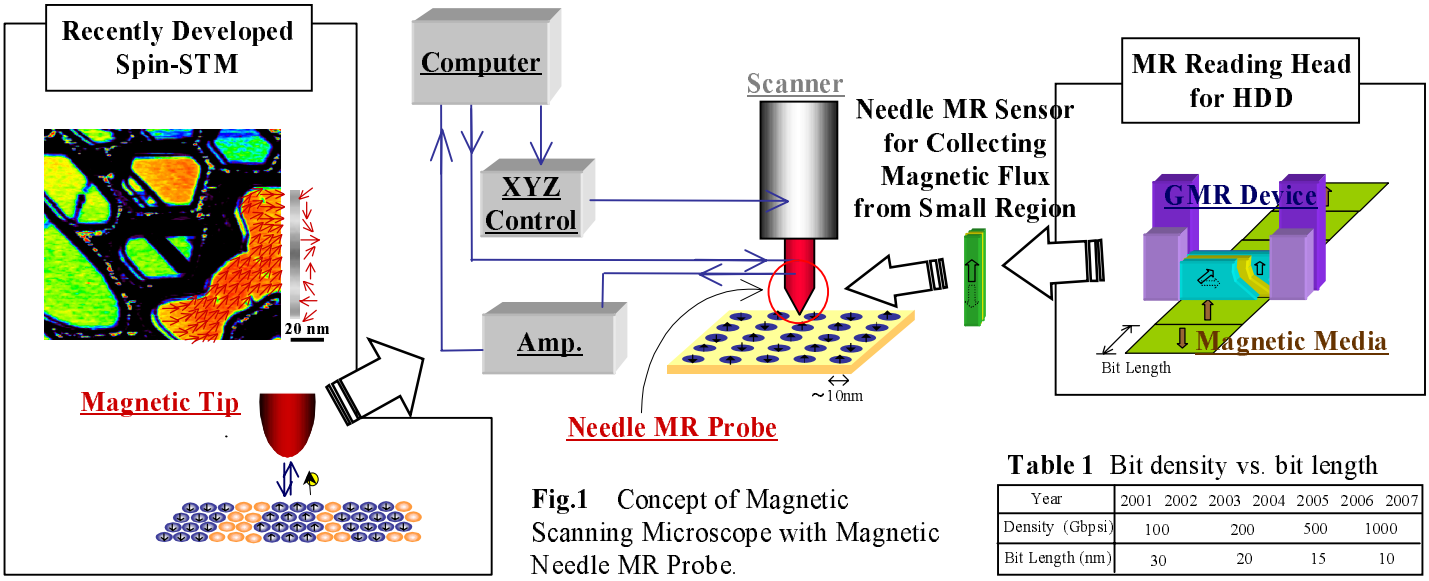

Fig.1 Concept of Magnetic Scanning Microscope with Magnetic Needle MR Probe.

Table 1 Bit density vs. bit length

Year	2001	2002	2003	2004	2005	2006	2007
Density (Gbpsi)	100		200		500		1000
Bit Length (nm)	30		20		15		10

1. Introduction

Magnetic data storage is one of the key technologies for the contemporary information-oriented society. With miniaturizing and improving the functionality of the various high-technology info tools, bit density stored in storage media increases rapidly, resulting in the shrinking of each magnetic bit. A magnetic analysis method with high resolution and high sensitivity is needed in order to characterize the fundamental properties of such small bits.

Generally, high-resolution analysis methods tend to sacrifice usability. Conversely, methods with high usability have low resolution. Regarding magnetic imaging techniques, spin-polarized STM developed recently has the highest resolution, sub-nm level, making it possible to observe the magnetization direction distribution inside small magnetic elements [1,2]. However, since the measurement is limited in UHV, at present, application to actual HDD media is difficult. From a practical point of view, an analysis method which has high user-friendliness and modest high resolution is needed.

In this poster presentation, we propose a user-friendly magnetic scanning microscope, which can analyze magnetic bits with the size of ~10 nm in ambient atmosphere.

Table 2 Comparison of magnetic imaging techniques

	Spin-STM	Spin-SEM	MFM	Kerr	Proposal
Resolution (nm)	sub nm	5nm	20nm	500nm	<10nm
Usability	× (UHV)	× (UHV)	○	○	○

2. System Structure

In order to obtain magnetic information from a small area in air, the system proposed uses a needle-shaped MR device as the magnetic sensor. It is constructed inside the probe. The basic principle of operation and functions are as follows.

1) Collection of magnetic flux by needle shaped soft-magnet.
2) Detection of the flux direction by using MR effect.
3) Scanning using piezo-device.
4) Contact mode operation. Probe height sensing by detecting force or current.
5) Support of perpendicular magnetic media.

3. Goal

Our goal is to establish a user-friendly magnetic scanning microscope with a new probe structure enabling measurement of magnetic bits corresponding to Tera-bpsi class bit density.

4. Technical Challenge

The important technical challenge concerns the spatial resolution. A similar magnetic microscope developed previously has a resolution of higher than 100 nm [3]. There are two principal issues. First, the shape, structure, and size of the magnetic needle sensor have an important bearing on the ability to achieve high resolution. We propose a needle shaped sensor with a width of 10 nm. The second issue is how to fabricate the sensor. For that purpose, we intend to use a highly advanced micro-fabrication technique.

References

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