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Magnetic field measurement for analysis of GHz response in SPT head using electron beam tomography

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Abstract

We measured the main pole field using electron beam tomography to analyze the GHz response of a single-pole-type (SPT) write head. The response of the head to a current was measured up to 1.3 GHz using a head without a recording medium. The magnetic field profiles around the main pole were obtained with 25-nm spacing from the head surface. The head response followed the current switching with a rise time of 0.3 ns, and the frequency response performance did not show any critical degradation up to 1.3 GHz. There was no difference in the head responses between the SPT head and a longitudinal recording head.

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Keywords: Electron beam tomography; Magnetic field; SPT head; Frequency response

1. Introduction

High-frequency recording is important for perpendicular magnetic recording, considered to be the next recording technology. There are a number of factors involved in achieving future data rate requirements. The major practical limitation is the supply of an appropriate write current, which is related to write current electronics such as the write current driver, interconnects, and head impedance. However, the high-frequency response of a write head to the write current and the recording medium response to head field switching are essential limitations that must be clarified.

Experimental studies on high-frequency recording at over 1 GHz have become possible with improvements in wide-band write current drivers. High-frequency recording has been investigated using spin-stand testing, and head response issues have been identified [1,2]. Because the recording performance depends on many parameters, direct measurement of the limiting factors is essential. The subject of this work is to examine the response

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of a single-pole-type (SPT) head to a 1-GHz write current in order to investigate the feasibility of high-frequency perpendicular recording. We also investigated the differences in head responses between an SPT head and a longitudinal recording head. The SPT head has a longer magnetic flux path due to the separation between the main pole and the return pole, and it may affect the head response.

There have been a variety of studies on the factors that determine head response. Eddy currents and magnetization dynamics in the yoke may be limiting factors at over 1 GHz [3,4]. Time-resolved Kerr microscopy had been used to evaluate high-frequency head response [5–7], but the dimensions of the magnetic pole in present write heads are less than the optical diffraction limit.

We have been developing an electron beam tomography (EBT) system for measuring the magnetic fields of a write head [8]. This system can detect electron beam deflections caused by the head field. Magnetic field distributions above the head air-bearing surface (ABS) can be obtained with high spatial resolutions (less than 100 nm). We used our EBT system to measure the response of an SPT head without a medium. When there is no recording medium, the electron beam can be projected onto the SPT head surface to measure the magnetic field. In this article, we describe our experimental analysis of the SPT head response to a high-frequency write current at over 1 GHz and compare the response with that of a longitudinal recording head.

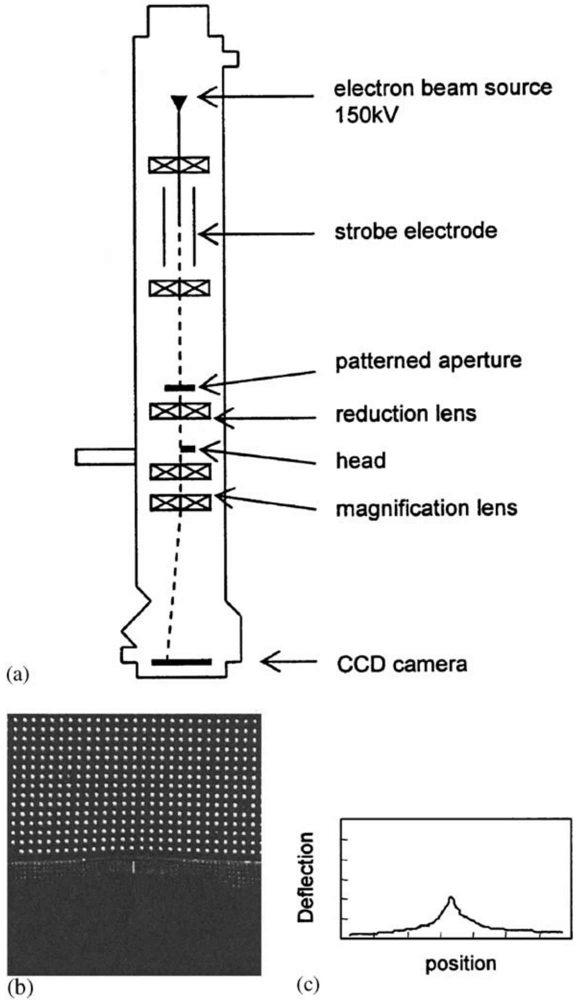

Fig. 1. Electron beam tomography system: (a) electron beam apparatus; (b) CCD image: deflected electron beam pattern; (c) deflection profile.

2. Experiment

A schematic diagram of the EBT system is shown in Fig. 1(a). This system was developed by modifying a transmission electron microscope [8]. A magnetic recording head is located between reduction and magnification lenses. The head surface is parallel to the electron beam. A patterned electron beam, with a pattern period of less than 40 nm, is projected along the head surface. The head field deflects the electron beam, and a CCD detects the deflected pattern, as shown in Fig. 1(b). Deflection profiles, as shown in Fig. 1(c), are obtained from the deflected pattern images. The magnetic field image is reconstructed from the deflection profiles using tomographic calculation.

The head field was observed 25 nm above the head surface. A pulsed electron beam was used to capture the deflection profiles in a 0.1-ns time step. We used the latest write current driver, Hitachi HDL6D301, in the EBT to obtain the 1 GHz write current. The current waveforms were measured using a Tektronix CT6 current probe. An SPT