SENSING AND MODELING HEAT TRANSFER BETWEEN A RECORDING HEAD AND MEDIUM FOR CLEARANCE SETTING IN HAMR

Neil Zuckerman[1], James D. Kiely[2], Manuel C. Anaya-Dufresne[3], Michael T. Johnson[4], Robert M. Crone[5]

1) Seagate Technology LLC, Bloomington, MN USA, neil.zuckerman@seagate.com

2) Seagate Technology LLC, Bloomington, MN USA, james.d.kiely@seagate.com

3) Seagate Technology LLC, Bloomington, MN USA, manuel.anayadufresne@seagate.com

4) Seagate Technology LLC, Bloomington, MN USA, michael.t.johnson@seagate.com

5) Seagate Technology LLC, Bloomington, MN USA, robert.m.crone@seagate.com

I. INTRODUCTION

Understanding the mechanism and magnitudes of heat transfer throughout the head and media is needed to optimize the reliability of the HAMR recording system. Understanding how laser light heats the head directly and through back-heating is needed to design heads to minimize these effects. In-situ measurements of temperature distributions are extremely difficult because of the small length scales of the design features and the very small head-disc clearance during operation [1]. Because of this measurement challenge, modeling provides the best avenue for understanding thermal effects and for guiding future designs.

Using a coupled air bearing and thermo-mechanical modeling framework [2], protrusions and temperatures can be predicted. The present work used a combination of a HAMR optical Finite Element Model (FEM), a sequential electrical/thermal/mechanical FEM of the head, a thermal model of the media, a head-media contact model (ISBL) [3] and a Computational Fluid Dynamics model, including a simulation of the recording head suspension.

Recording heads use a resistive sensor (called a Dual-Ended Thermal Coefficient of Resistance (DETCR) sensor, an Embedded Contact Sensor (ECS), or a Head-Disk Interface sensor (HDIs)) to measure head-medium proximity and to probe thermal characteristics and events at the head-disc interface. This thermistor-type sensor responds to changes in the cooling of the head by pressurized gas in the air bearing, as well as to frictional heating when the head contacts the disc [4].

By illuminating with a laser the back side of a glass disc coated with metal on only one side, the resistance rise of the DETCR can be used to calibrate models that include a convective heat transfer coefficient at the surface of the head. Previous work identified the potential of using this approach to estimate these heat transfer effects in the HAMR recording system [5,6]. The resulting heat transfer maps also show the effective field of view of thermal events as perceived through a DETCR.

By obtaining a better calibration of the heat transfer coefficient, more confident predictions of head-media temperature distributions are possible. These can be used to predict temperature changes for different operating conditions and different head and media designs. One outcome of this capability is the ability to predict changes in the ability to set head-disk clearance when a resistive sensor is used to determine head-disc contact. Changes in the precision of detecting contact will result in changes in head-media spacing, which directly impact areal density. Thus, improving the predictability of contact sensing improves our ability to forecast areal density improvements through design.

II. RESULTS

Predictions of the resistance change as a function of heater power were generated for several recording

Neil Zuckerman
Seagate Technology LLC
E-mail: neil.zuckerman@seagate.com
tel: +1-952-4025709

head designs, and the derivative of each of these curves was used to compare the ability to detect contact. An example of a predicted resistance slope with respect to power is shown in Fig. 1. In Fig, 1a, the resistance is predicted as function of heater power, corresponding to clearance. In Fig 1b, the slope of the resistance vs. power profile is plotted. As outlined in [7], the sometimes-subtle change in concavity of the *R(P)* curve is due to frictional heating caused by head-disc contact. It is possible to use the inflection point of slope of the resistance vs. power curve as a reference point to determine head-media contact, and then set the head operating clearance to a set distance above this contact condition. As the design changes, the *R(P)* characteristics change, affecting the fidelity of the contact signal. A favorable *R(P)* profile is one that is steep, with high curvature, resulting in a *dR/dP* profile that is steep on both sides of the minimum in *dR/dP*. Such curves are characteristic of designs with high heater efficiency, smooth media, and DETCRs that are well-positioned near the head-disc contact location.

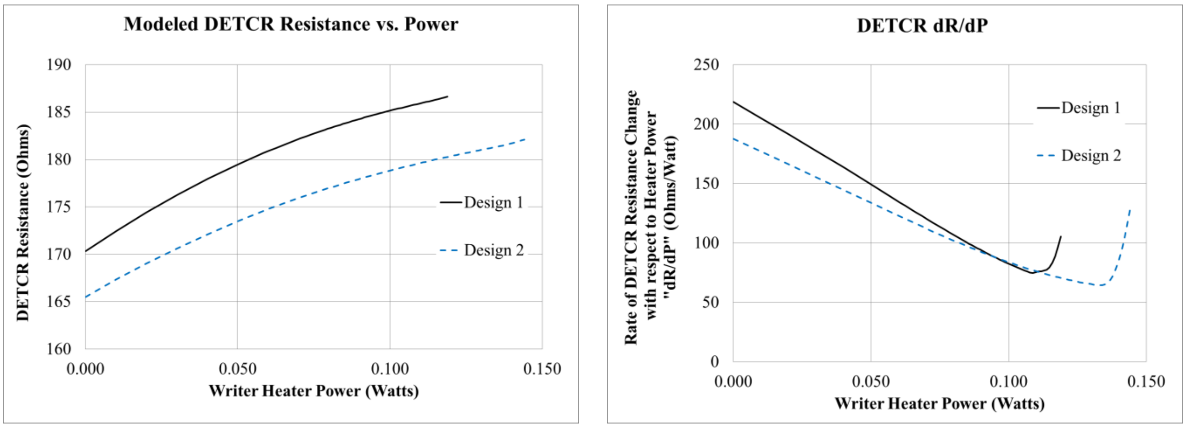

Fig. 1 Modeled resistance vs. heater power (1a) and resulting derivative of the resistance vs. power (1b).

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