ME Seminar

Advancing the Mechanical Design, Development and Reliability of Next-Generation Hard Disk Drives

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ABSTRACT

In the hard disk drive (HDD) industry, Heat-Assisted Magnetic Recording (HAMR) has emerged as a critical, next-generation technology to maximize the areal data density and keep up with the exponential pace of data generation. During data writing in HAMR, the read/write head uses a ~20 nm FWHM laser to heat the storage disk to ~500℃, making head overheating a major reliability concern. Moreover, HAMR laser heating causes the ~1 nm thick lubricant film on the disk to deform, evaporate and transfer to the head, leading to head contamination. In the first part of this talk, I will present numerical models to predict the deformation, disk-to-head transfer, and recovery of the lubricant during HAMR laser heating, under the influence of thermocapillary (Marangoni) stress and disjoining pressure. To account for the viscoelastic nature of the lubricant, I introduce a modification to the traditional (viscous) thin-film lubrication equation using the linear Maxwell (viscoelastic) constitutive equation. I will also present numerical models to simulate the head/disk temperature profiles and the head-disk spacing due to nanoscale heat transfer in the head-disk interface (HDI) for two configurations – a stationary disk and a rotating disk. These models consider the effects of traditional air conduction, wave-based phonon conduction, and HDI interfacial forces, ensuring a good match with experiments.

An HDD is also equipped with a servo-control system for precise head positioning on the desired data track, while retaining robustness against device-to-device Frequency Response Function (FRF) variation during high-volume manufacturing. Developing methodologies to accurately predict FRF variation is critical to create realistic population boundary FRF datasets to optimize servo-control design and ensure robustness. In the second part of this talk, I will present a methodology that combines statistical analysis of measured population FRFs of an existing Product A with the numerically simulated FRF of a future Product B to predict the device-to-device FRF variation of Product B. This methodology involves four stages: modal parameter estimation, unsupervised clustering, boundary FRFs selection and boundary FRFs prediction. I utilize this methodology to predict population boundary FRFs for an HDD product and demonstrate good agreement with the real variation in the measured population FRFs of that product.

ABOUT THE SPEAKER

Dr. Siddhesh Sakhalkar has a B.Tech. in Mechanical Engineering from Indian Institute of Technology Bombay (2010-2014) and a Ph.D. in Mechanical Engineering from University of California, Berkeley (2016-2020). He is currently working as a Principal Engineer at Western Digital in San Jose, USA (2020- present). Dr. Sakhalkar's doctoral research focused on developing numerical models to study nanoscale lubricant flow, air bearing flow, interfacial forces and heat transfer at the head-disk interface in hard disk drives (HDDs). Currently, at Western Digital, he works on improving the structural dynamics and robustness of HDD actuators to meet nanoscale positioning accuracy targets for the recording head in next-generation technologies. His research interests include developing theoretical frameworks, numerical models and machine learning tools to advance the mechanical design, development and reliability of micro and nano scale systems such as HDDs, lubricated bearings with surface microtexturing, microfluidic devices and Micro-Electro-Mechanical Systems. Dr. Sakhalkar is a recipient of the John and Janet McMurtry Fellowship, The Otto and Herta F. Kornei Endowment Fund Fellowship and the ASME 28th Conference on Information Storage and Processing Systems Best Paper Award.

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