Proposed project title: Evaluating thermal stability of near-field transducer materials

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Background

The persistent demand for cost-effective storage solutions, particularly in data-centric industries, sustains the relevance of Hard Disk Drives (HDDs) alongside emerging technologies like artificial intelligence, big data analytics, and the Internet of Things (IoT). Heat-Assisted Magnetic Recording (HAMR) represents a key advancement in HDD technology, enabling an escalating need for increased storage density while maintaining cost-effectiveness, achieving areal bit densities as large as 2.6 Tb/in^2.

At the core of HAMR's success lies the near-field transducer (NFT), a critical component enabling precise data writing. The NFT breaks the diffraction limit, concentrating optical energy into spots smaller than the laser wavelength, allowing for intense localized heating of the magnetic medium above its Curie temperature. This process, harnessed through surface plasmon resonance, facilitates stable data recording within small grains.

The harsh operating conditions of HAMR technology requires consistent and reliable performance throughout the operational life of the HDD. As the optical energy in the HAMR system is increased, the resulting increase in the temperature of the head and the media significantly reduces the NFT lifetime. Gold (Au) has been the material of choice for NFTs due to its superior plasmonic properties and high thermal conductivity. However, Au is soft and has a high surface diffusivity leading to a tendency for the NFT to deform when heated, accelerating its degradation. This has led to the investigation of alternative protective coatings, designs and materials to enhance the longevity and stability of NFTs.

While some understanding of potential degradation processes exists, the exact mechanisms and their contributions vary based on factors like material composition, operating conditions, and design specifics. Proposed degradation mechanisms include thermal diffusion, oxidation, morphological changes, recrystallization, and mechanical wear and stress due to device cycling. However, most of the work investigating the thermal effects on the NFT are from simulations, with very few experimental evidence.

This research project aims to investigate the degradation effects induced by heating as a function of NFT design and material using novel in-situ heating and gas transmission electron microscopy (TEM) techniques under different environments. In-situ TEM provides real-time, high-resolution imaging and spectroscopic analysis under environments that mimic operational conditions. Thus, making it the ideal characterization tool for studying degradation effects at the micro and nanoscale.

Samples will be provided directly by Seagate with also potential collaboration with SmartNano.

Moreover, the student will be expected to conduct high-resolution state-of-the-art TEM techniques at advanced facilities such as the SuperSTEM (UK) and ER-C (Germany).