ASTC Heads Working Group

Standard Media Stack and Figure of Merits for HAMR NFT Modeling

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The purpose of this document is to provide a standard media stack and figure of merits for modeling HAMR NFTs. You should always show in at least one case how your NFT performs using the reference media stack and the figure of merits included in this document. The ASTC Heads Working group welcomes proposals for new media stacks and figures of merit.

Reference Media Stack:

Table 1 Reference Media Stack

NFT	Thickness (nm)	n	k	Vertical Thermal Conductivity (W/mK)	Lateral Thermal Conductivity (W/mK)	Specific Heat (J/m^3-K)
Head Overcoat	2.5	1.6	0	N/A	N/A	N/A
Air	2.5	1.0	0	N/A	N/A	N/A
Media Overcoat	2.5	1.2	0	N/A	N/A	N/A
Storage Layer	10	2.9	1.5	50	5	$3x10^6$
Interlayer	15	1.7	0	3	3	$2x10^6$
Heat Sink	80	0.26	5.28	200	200	$3x10^6$
Glass Substrate	infinite	1.5	0	1	1	$2x10^6$

Table 2 Reference Media Stack Typical Constant Ranges for NFT Tuning

NFT	Thickness (nm)	n	k	Vertical Thermal Conductivity (W/mK)	Lateral Thermal Conductivity (W/mK)	Specific Heat (J/m^3-K)
Head Overcoat	2.5	1.2-1.6	0	N/A	N/A	N/A
Air	2.5	1.0	0	N/A	N/A	N/A
Media Overcoat	2.5	1.2-1.6	0	N/A	N/A	N/A
Storage Layer	10	2 -3.5	1 -2	10-100	5-1	$2.5\text{-}3.5x10^6$
Interlayer	15	1.5-2.5	0-1	2-20	2-20	$3x10^6$
Heat Sink	80	0.2-0.8	3-6	50-250	50-250	$3x10^6$
Glass Substrate	infinite	1.5	0	1	1	$2x10^6$

Although you should always show at least one example of how your NFT performs on the reference media stack, please do not feel constrained by it. If the media stack requires tuning for your NFT optimization, or additional layers are required, please feel free to change/add the layers. However, please stay within the ranges indicated in table 2. If you introduce new layers, please use realistic constants for the additional layer(s). If your NFT design requires you to move outside these ranges, please consult with one of the ASTC member companies first.

The ASTC welcomes suggestions for improving the reference media stack and experimental verification of the constants for these materials.

In your modeling assume disk velocity of 10 m/s and a Thermal Convection Coefficient at the media ABS surface of $1x10^5$ W/m^2-K

NFT Modeling Figure of Merits:

These figures of merit should be calculated for any NFT modeling work funded by the ASTC.

1. The thermal efficiency measures the peak temperature in the media relative to the peak temperature in the NFT for a given incident power. This metric should be as large as possible since we want the largest increase in media temperature for the smallest increase in NFT temperature. If the NFT gets too hot the overcoats which protect the head will fail or the NFT will melt.

$$Thermal\ Efficiency = \frac{\Delta T_{peak\ \ in\ media}}{\Delta T_{peak\ \ in\ NFT}}$$

2. The thermal spot in the media is characterized by six measurements, the thermal spot size in the media at the full width half max (FWHM), the thermal spot size in the media at 90% of the peak temperature, and the thermal spot size in the media at 10% of the peak temperature in the down track and cross track directions. These parameters allow for the characterization of the "squareness" of the thermal profile. We want to avoid having long thermal tails in the media in both the cross track and down track directions.

$$FWHM\ Down\,Track\ Thermal\ Spot\ Size\ (nm)$$

$$FWHM\ Cross\,Track\ Thermal\ Spot\ Size\ (nm)$$

$$FW@10\%\ Down\,Track\ Thermal\ Spot\ Size\ (nm)$$

$$FW@10\%\ Cross\,Track\ Thermal\ Spot\ Size\ (nm)$$

$$FW@90\%\ Down\,Track\ Thermal\ Spot\ Size\ (nm)$$

$$FW@90\%\ Cross\,Track\ Thermal\ Spot\ Size\ (nm)$$

3. The thermal gradient in the media is characterized by four measurements, the thermal gradient in the media at the full width half max (FWHM) and the thermal gradient in the media at 10% of the peak temperature in the down track and cross track directions. The larger the thermal

gradient the better. Having a sharp thermal gradient allows us to write sharp transitions which are key to high linear densities.

$$FWHM\ Down\ Track\ Thermal\ Gradient\ (K/nm)$$

$$FWHM\ Cross\ Track\ Thermal\ Gradient\ (K/nm)$$

$$FW@10\%\ Down\ Track\ Thermal\ Gradient\ (K/nm)$$

$$FW@10\%\ Cross\ Track\ Thermal\ Gradient\ (K/nm)$$

4. The normalized peak temperature measures the peak temperature in the media normalized by the total power incident on the NFT. This metric is important to teams working on light delivery for HAMR. It tells them how much laser power they need to deliver to the NFT. It is also useful for characterizing the effects of laser intensity noise on the recording system.

$$\text{Normalized Peak Temperature} = \frac{\Delta T_{peak\ in\ media}}{Incident\ Power} (°K/mW)$$

5. The coupling efficiency is defined as the absorbed optical power in a volume defined by a 50 nm by 50 nm square area on the disk and the thickness of the media divided by the total incident power on the NFT. We use a 50 nm by 50 nm square since this is roughly the track pitch we will need for the first HAMR drives. As areal density increases, the area will become smaller.

$$\text{CE}(\%) = 100x\ \frac{Aborbed\ Power(mW)}{Incident\ Power(mW)}$$

6. The optical system coupling efficiency is defined as the absorbed optical power in a volume defined by a 50 nm by 50 nm square area on the disk and the thickness of the media divided by the total power input into the optical system. This metric captures any losses due to the conditioning optics in your system like a mirror, lens, taper, etc. It does not include losses associated with coupling light into your system like grating coupling or laser butt coupling efficiencies. This metric is intended to capture the penalties associated with overly complex beam conditioning optics.

$$\text{OSCE}(\%) = 100x\ \frac{Aborbed\ Power(mW)}{Total\ System\ Power(mW)}$$

Revision History

7/28/2011 – Release of Version 1.0