# INFLUENCE OF PROTECTION LAYERS ON LOCAL HEATING IN HEAT ASSISTED MAGNETIC RECORDING

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## I. INTRODUCTION

Heat assisted magnetic recording (HAMR) is studied to realize high recording density over 4 Tbit/inch$^2$. A near-field transducer (NFT) is used to heat a local area by surface plasmon effect. We have studied structures of the NFT and a plasmonic waveguide (PWG) without protection layers, such as a lubricant layer and overcoat layers of diamond-like carbon, to keep temperature which is lower than 150 °C at the NFT tip, when a recording medium is heated up to 277 °C [1]. It is, however, not clear about the effect of the protection layers on the heating of the medium and the temperature rise of the NFT. Therefore, we analyzed energy convergence and temperature rise of the NFT with the protection layers by computational simulation.

## II. SIMULATION MODEL

Calculations of electromagnetic wave and heat conduction are performed by a Finite-Difference Time-Domain (FDTD) method and an Alternating Direction Implicit (ADI) method. A model of a structure of a HAMR head for thermal calculation is shown in Fig. 1. A PWG is constructed by a $Ta_2O_5$ core, an $Al_2O_3$ clad and a gold sheet along the $Ta_2O_5$ core. A thickness of the gold sheet is 100 nm, and a distance between the $Ta_2O_5$ core and the gold sheet is 190 nm, as an efficient condition for delivering surface plasmon polaritons [2]. Diamond-like carbon (DLC) layers with 1 nm-thick are put on the NFT and a recording medium. A lubricant of 1 nm is placed on the DLC layer of the recording medium side. The light source is located in the $Ta_2O_5$ core and the incident light angle to the surface between the $Ta_2O_5$ core and $Al_2O_3$ clad is 60°. The recording medium is a granular structure of the FePt grains covered with $SiO_2$. Optical and thermal constants are shown in Table 1.

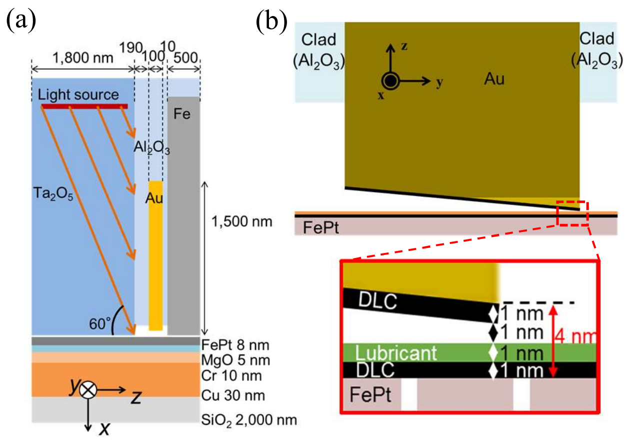


Fig. 1 The structure of HAMR head when covering a DLC and a lubricant for thermal calculation. Side view (a), NFT enlarged view (b).

Table 1 Optical and thermal constants

| Material | Refractive index $n$ | Extinction coefficient $\kappa$ | Specific heat $C$ [J/kg/K] | Thermal Conductivity $K$ [W/m/K] | Density $D$ [kg/m$^3$] |
|---|---|---|---|---|---|
| Fe | 2.8 | 3.8 | 453 | 28 | $7.86\times10^3$ |
| Au | 0.174 | 4.86 | 453 | 28 | $1.928\times10^4$ |
| Cu | 0.242 | 4.85 | 440 | 400 | $9\times10^3$ |
| FePt | 3 | 4 | 200 | 100 | $15\times10^3$ |
| MgO | 1.73 | 0 | 500 | 4 | $4\times10^3$ |
| Cr | 4.11 | 4.35 | 360 | 100 | $7\times10^3$ |
| $Ta_2O_5$ | 2.17 | 0 | 207 | 2 | $8.73\times10^3$ |
| $Al_2O_3$ | 1.76 | 0 | 779 | 2 | $8.73\times10^3$ |
| $SiO_2$ | 1.47 | 0 | 740 | 1.38 | $2.19\times10^3$ |
| Head Overcoat | 2.5 | 0.2 | 570 | 1.3 | $1.9\times10^3$ |
| Lubricant | 1 | 0 | $2.0\times10^3$ | 0.2 | 900 |
| Medium Overcoat | 2.3 | 0.2 | 570 | 1.3 | $1.9\times10^3$ |

## III. CALCULATION RESULTS

Normalized power density distributions along to a cross truck direction with and without the protection layers are evaluated. The calculation model and observation line are shown in Fig. 2 (a). The power density distributions are observed in the DLC or vacuum layers on the surface of the FePt layer. In Fig. 2 (b), it is found that a full width at a half maximum (FWHM) of the normalized power density distribution without the protection layers is less than 10 nm, which is the required value to achieve 4 Tbit/inch$^2$ in density. Even if the case of with protection layers, FWHM is also the same value. The result shows that such protection layers do not affect the energy convergence from the NFT tip to the recording

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medium.

Temperature distributions in the FePt recording layer along to a cross truck direction and down truck direction with and without the protection layers are shown in Fig. 3. Temperature distributions are observed at 0.5 nm under the surface of the FePt layer. When the recording temperature is kept at 277 ºC by adjusting incident light power, the side lobes of temperature is suppressed by using the protection layers. The temperature rise of the NFT tip is also suppressed from 165 ºC to 103 ºC in this condition.

Two effects by using the protection layers were found. 1) the side lobes of temperature in the FePt recording layer were suppressed. 2) the temperature rise of the NFT tip can be lower than 150 °C.

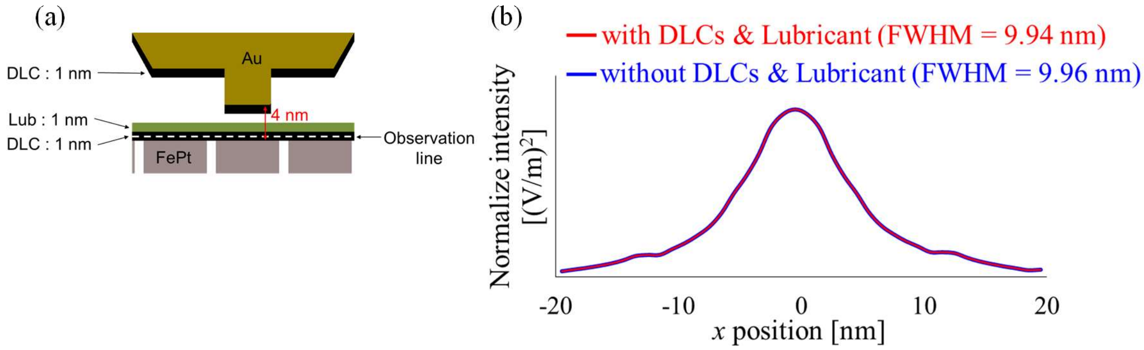


Fig. 2 Calculation model and observation line (a). Power density distributions in DLC or vacuum layer along to a cross truck direction with and without the protection layers (b).

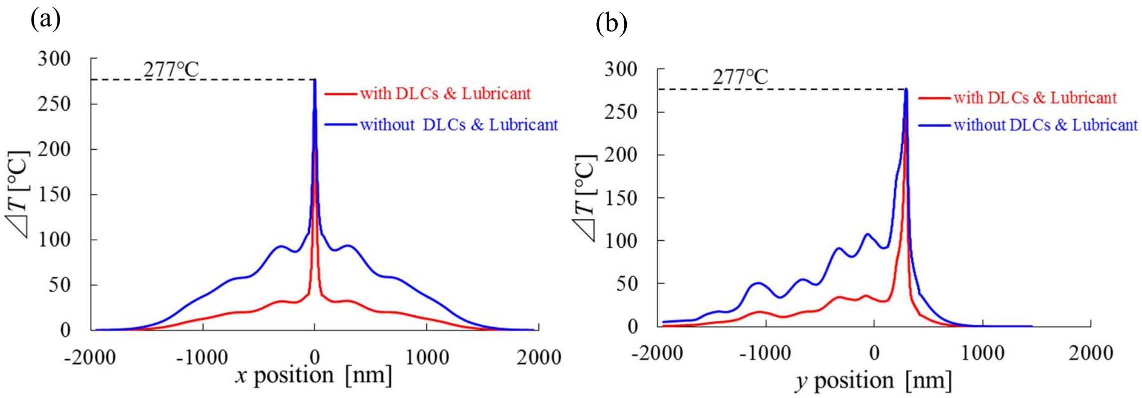


Fig. 3 Temperature distributions in the FePt recording medium along to a cross truck direction (a) and down truck direction (b) with and without the protection layers.

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