PLASMA METHODS IN DEPOSITION AND EVALUATION OF NANO-SIZED CARBON FILMS

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Abstract. For the deposition of ultrathin carbon overcoat with thicknesses below 2 nm the carbon precursors from the gas phase have advantages over the solid carbon targets. The surface carbon marks (micro and nano sized dust) that are part of deposition process can be minimized by the gas plasma composition. Introduction of ion and plasma sources over the traditional sputtering and cathodic arc solid carbon sources can improve the surface smoothness and continuous coverage of the disk. Optical emission spectroscopy from the gas excited species as well as micro Raman spectroscopy of deposited carbon film can be used to track the carbon dust formation on the surface.

1. INTRODUCTION

For the deposition of ultrathin diamond like carbon films with thicknesses below 5 nm a uniform surface deposition, carbon micro and nano dust-free coverage and controlled protective film properties are essential for the magnetic recording discs [1-3]. Cyclic incorporation of atomic and ionized oxygen or hydrogen in the process gas mixture, (e.g. C_2H_4 with noble and reactive gases), as well as effective pump-out time for the produced long living oxygen metastables and hydrogen atoms, can minimize deposition and adherence of carbon nano dust particles. DC sputtering technology is particularly vulnerable to creation of carbon dust and target poisoning. Improvements on the sputtering targets (better heat removal from the target surface, small grain size of the hot-pressed carbon particles during the target production, bipolar self-bias, controlled gas channel supply) are some of the measures in improving the carbon film properties [4,5].

Deposition of DLC film with a thickness below 2 nm is extremely challenging. Also, to prevent cross-contamination it is necessary for the sources to operate in separate vacuum chambers. Number of surface marks and defects, along with other protective properties, is a key parameter in the effectiveness of

the plasma method used. Introduction of the Plasma Beam Source (PBS) in carbon film deposition opens a door for the further optimization of the disk smoothness (e.g. by ion beam polishing, milling, disk buffing under vacuum for subsequent vacuum lubrication) with variable incident angle ion beam deposition and minimization the magnetic dead layer thickness.

2. RESULTS AND DISCUSSION

In Fig.1is shown how a disk surface may look like after the carbon film deposition with sputtering or filtered cathodic arc deposition method. The optical surface analyzer and a standard Nomarsky polarization interference type optical microscope have been used.

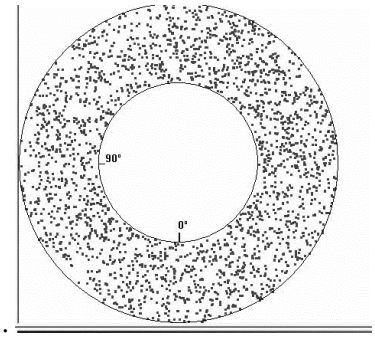

Figure 1. Pits and surface marks on the magnetic substrate (deposition conditions: 3 mTorr, V_b= -120 V; N(at%)=11.2 in Ar+C_2H_4+N_2 gas).

The surface marks (hills) were not evenly distributed. Almost all surface marks in size over 1 micron were located close to the inner diameter. Majority of observed surface marks have a lateral size around 6 μm.

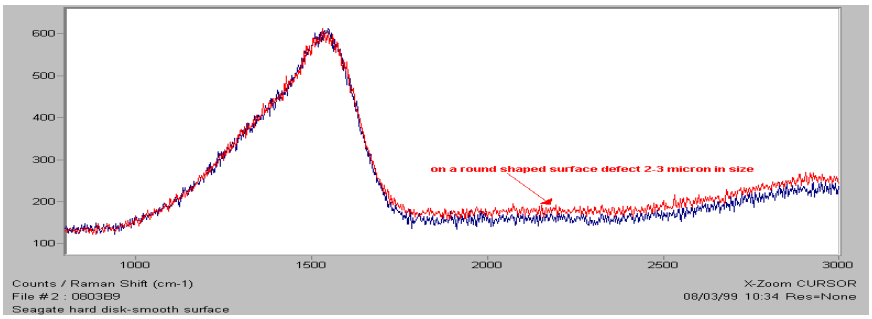

Figure 2. Micro Raman spectra of carbon films and the surface marks. Bottom curve: aside from the surface mark, on matrix. Upper curve: on a surface defect.

Increased background signal on the right side of the carbon peak with respect to the left side indicates higher hydrogen content in the surface mark.

Micro Raman analysis of the surface marks on a non-textured disk deposited with a new graphite target at different hydrocarbon concentration is shown in Fig.2 and Fig.3. Poisoning of the sputtering targets takes place very quickly, even after 15 minutes of operation.

The hydrogen can originate also from the water vapor occluded on the chamber wall as well as from the residual hydrogen of the target surface.

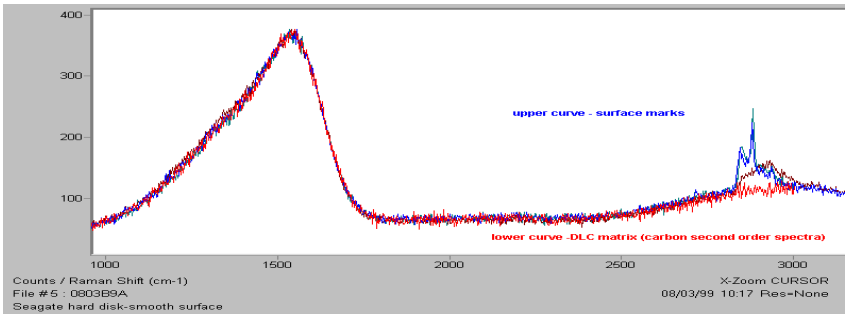

Figure 3. Several micro Raman spectra on different surface marks on a same substrate. An origin of the maximum at 2847 cm^{-1} and at 2880 cm^{-1} is not yet clarified. Both feature a sudden rise of a signal at 2840 cm^{-1} surpassing the carbon second order spectrum. Surface marks have a linear dimension ~ 5 micrometers.

Surface marks observed on the substrate as well as white and black appearing nodulus formation on the target are “rich” in hydrogen. Instead of introducing a gas mixture close to the target surface it is worth to consider a separate gas channel for hydrogen/hydrocarbon and nitrogen gas channel close to the disc. In order to estimate how long a target should be exposed to the cleaning process in pure Ar, a hydrogen H_β-line (486.1 nm) was acquired during the removal of the hydrogenated DLC formation on the target. A new target was “contaminated” by a gas mixture containing Ar (33 sccm), C_2H_4 (1.5 sccm) and N_2 (3 sccm) at a DC discharge power of 760 W (3.4 W/cm^2) for 20 minutes. This measurement may bring us to conclusion that even after 11 minutes of discharge cleaning, a leveled off hydrogen signal coming from the target surface can not be achieved. Because of numerous parameters that influence the emission intensity (e.g. electron energy distribution function, local electron density, energy of sputtered hydrogen atoms), that may change simultaneosly, this time interval is only a rough prediction. Obviously, a solution for the carbon dust particle contamination should be searched in the gas phase carbon precursor deposition methods.

3. CONCLUSIONS

Ultrathin DLC carbon overcoat with a small number of surface defects-marks can be obtained in plasma discharges using hydrocarbon gas as a carbon precursor, rather than a solid, and in a controlled gas mixture. By adding a pure hydrogen or oxygen in a cyclic gas operation on dedicated deposition chambers the amount of carbon nano-dust and micro particles deposited on the substrate surface can be controlled. Non contact methods such an optical emission spectroscopy should be used for optimizing the carbon film deposition process. Additional tube with the holes of proper size looking at the substrate should be mounted in the vicinity of protective shields. In that way a reaction of hydrogen with the target surface can be minimized. On all micro Raman spectra due to the small defect size and low instrumental lateral resolution (~3 μm) the influence of the matrix is predominant.

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