ISSUES IN VAPOR PHASE LUBRICATION OF MAGNETIC DATA STORAGE MEDIA

Andrew J. Gellman and Yang Yun
Department of Chemical Engineering
Carnegie Mellon University
Pittsburgh, PA 15213

ABSTRACT
Vapor phase lubrication (VPL) integrates media lubrication with the vacuum processing steps used throughout most of the hard disk media fabrication process. This avoids exposure of the unlubricated a-CH₄ overcoat surface to the ambient air and airborne contamination. In vapor lubrication the a-CH₄ surface can be oxidized under controlled conditions immediately prior to lubricant adsorption. The kinetics of a-CH₄ oxidation have been studied using X-ray photoemission spectroscopy in an apparatus that allows oxidation of freshly deposited a-CH₄ films. The dissociative sticking coefficient of oxygen is $\sim 10^{-6}$ and the initial oxidation kinetics can be described by a Langmuir-Hinshelwood mechanism.

INTRODUCTION
The final steps in the production of magnetic data storage hard disks include the deposition of an a-CH₄ overcoat, removal of the disk from the vacuum deposition system in which it is fabricated and the application of the lubricant via dip-coating. Removal of the disk from vacuum and exposure to ambient air results in the immediate oxidation of the exposed surface of the a-CH₄ overcoat, as has been documented by a number of studies using X-ray photoemission spectroscopy [1, 2]. The kinetics of this process are so rapid, however, that they have not been studied carefully.

Exposure of the a-CH₄ overcoat to ambient air is arguably the least well controlled step in the process of disk fabrication. The disk surface is subject to oxidation under ambient humidity and exposure to air-borne contaminants. One approach to circumventing this step would be the integration of the lubrication process with the vacuum processing steps through the use of vapor phase lubrication. This would improve process control but at the same time raises a number of issues. Does the oxidation of the a-CH₄ overcoat prior to lubricant influence its interaction with the lubricant and the subsequent properties of the lubricant film? Will it be necessary to oxidize the a-CH₄ overcoat under controlled conditions by exposure to O₂ prior to vapor deposition of lubricant? What are the kinetics of the a-CH₄ overcoat oxidation process? These questions have been addressed in a controlled study of the oxidation of freshly deposited a-CH₄ overcoats.

EXPERIMENTAL
The experiments were performed in an ultra-high vacuum chamber that allowed the deposition of a-CH₄ overcoats and the subsequent exposure of these films to O₂ at pressures ranging from $10^{-9}$ to $10^{-3}$ Torr and at temperatures ranging from 100 to 600 K. Following exposure of the fresh a-CH₄ overcoat to O₂ for a controlled period of time the surface of the film was analyzed using x-ray photoemission. All the deposition, oxidation and analysis processes were performed without removing the sample from the UHV chamber. Oxidation of the a-CH₄ overcoat is readily detectable by monitoring photoemission from the O 1s core level and by the appearance of high binding energy features in the photoemission spectrum of the C 1s core level.

RESULTS AND DISCUSSION
Exposure of the fresh a-CH₄ film to O₂ results in oxidation of the surface and the uptake of oxygen. Figure 1 shows the uptake of oxygen on the surface of a fresh a-CH₄ film during exposure of the surface to O₂ at a pressure of $P_{O₂} = 2 \times 10^{-4}$ Torr at a temperature of 300 K. The oxygen concentration (●) initially increases rapidly and then saturates at a concentration of roughly $\sim 18\%$ oxygen in the film. If one assume that this represents complete coverage of the oxygen adsorption sites or in other words a coverage of $\theta = 1$, then the data can be plotted in the form $ln(1-\theta)$ versus time, as shown in Fig. 1 (●). This representation of the oxygen uptake data reveals a roughly straight line and is indicative of a first-order uptake of oxygen on the a-CH₄ film. The rate constant for oxidation, given by the slope of $ln(1-\theta)$ versus time deviates slightly from linearity. Initially, or at low oxygen coverages the rate constant is slightly higher than at long times. This reveals that the surface of the a-CH₄ film is somewhat heterogeneous and that some sites are more readily oxidized than others.

The slope of the $ln(1-\theta)$ versus time curve in Fig. 1 is the rate constant for oxidation of the a-CH₄ film in the presence of a partial pressure of O₂, $k\cdot P_{O₂} = 1.2 \times 10^{-4}$ sec⁻¹. Since the flux of O₂ to the surface at $2 \times 10^{-4}$ Torr is $F = 10^{16}$ site⁻¹•sec⁻¹ this indicates that the sticking coefficient for oxygen is $S \approx 10^{-6}$.
CONCLUSIONS

Although the surfaces of a-CHₓ films are heterogeneous in nature, it appears that the description of their oxidation kinetics is quite simple. Oxidation in O₂ can be described as a Langmuir-Hinshelwood reaction with a relatively low rate constant for oxidation. If it were necessary in a vapor lubrication process to accelerate oxidation of the surface, this might require a stronger oxidant.

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REFERENCES