13C/2002G292

# Non-destructive XPS depth-profiling of ta:C-films by variable excitation energy

Iris Retzko*[1], Wolfgang E.S. Unger[1], Nobuyuki Matsubayashi[2], Motoyasu Imamura[2], Tomoaki Tanaka[2], Hiromichi Shimada[2]

[1]Federal Institute for Materials Research and Testing (BAM), D-12200 Berlin, Germany

[2]National Institute of Advanced Industrial and Science Technology (AIST), Metrology Institute of Japan, Tsukuba Central 5, 1-1-1, Higashi, Tsukuba, Ibaraki 305-8565, Japan

## Introduction

Since hard coatings such as tetrahedral amorphous carbon (ta:C) are of growing interest for protecting surfaces of industrial machines and high capacity tools against wear and friction or for biomedical applications more information about the structure-to-property relation is required. Therefore core level photo emission and other spectral features in the x-ray photoelectron spectra (XPS) of carbon materials were used to derive "fingerprints" for selected carbon species. Besides the surface properties which can be gained by constant-energy XPS, information of different surface regions is required to receive information on the chemical structure of the material in different depths to understand the deposition process.

Non-destructive depth profiling is possible by using photoelectron spectroscopy exploiting the variation of excitation energy to get information from several mono-layers in depth down to the minimum of monolayer resolution. This is possible because there is a correlation of the effective attenuation length (EAL) of electrons in a solid with their kinetic energy [1]. A variation of the energy of the exciting X-ray radiation provides the possibility to adjust the kinetic energy of the photoelectrons as well as the EAL. The minimum EAL of C 1s photoelectrons should occur at roughly 350 eV X-ray photon energy.

## Experimental

The ta:C samples were deposited on silicon wafers by Laser-Arco® Technology at the "Fraunhofer Institute for Material and Beam Technology" in Dresden/Germany [2, 3, 4].

## Results and Discussion

For all mentioned samples C 1s, O1s (when possible) and valence band spectra were acquired. Excitation energies were used in the range of 760, 600, 450 and 350 eV giving estimated EALs of 2.2, 1.8, 1.4 and 1.2 nm, respectively, for C 1s photoelectrons. As an example here the results obtained with a pure ta:C layer deposited on a silicon wafer (Fig.1) are presented. A more comprehensive presentation of the energy dependent XPS analysis of doped (N, F) and pure ta:C films has been published [5].

The XPS depth profile of a ta:C sample (Fig. 1) indicates that the upper surface region is higher oxidized than the deeper surface regions; this is pointed up by a carbonyl C=O sub-peak around 288 eV binding energy that increases with the surface sensitivity of the XP spectra.

The amount of diamond-like carbon states ($sp^3$) increases towards the deeper layers which is evidenced by a C 1s chemical shift towards a binding of 285.00 eV .The C 1s sub-peak representing the graphite-like species appears around 284.5 eV binding energy.

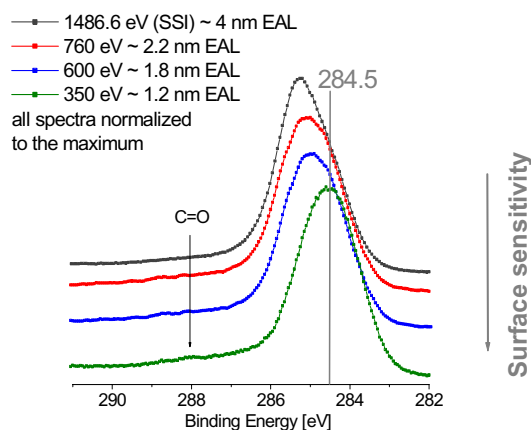In the case of a nitrogen doped ta:C sample the dopant N seems to be depleted towards the outermost layers.



Fig.1 XP C 1s spectra of a ta:C sample obtained at different X-ray radiation energies.

## References

[1] S. Tanuma et al.; SIA *17*, **1991**, 911

[2] P. Siemroth et al.; IEEE Trans. Plasma Sci., *18*, **1990**, 911-916

[3] H.-J. Scheibe et al.; IEEE Trans. Plasma Sci., *18*, **1990**, 917-922

[4] D. Schneider et al.; Diamond and Related Materials *7*, **1998**, 973-980

[5] I. Retzko et al.; Mater. Week Proceed., **2002**, ISBN 3-88355-314-X

*Corresponding author: iris.retzko@bam.de