Deposition and Erosion of Polymer-like Hydrocarbon Layer by Hydrogen Atoms

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P02A

13th PFMC Workshop, Rosenheim, Germany, 10 - 13 May 2011

Abstract

Deposition of polymer-like hydrocarbon layer from vacuum impurities when the sample at RT is exposed to H and D atoms is further studied. A clear transition from hydrocarbon impurity layer deposition to erosion was observed during exposure of the copper sample to D beam during slow sample heating. Observed transition temperature is around 220°C. Measurement also indicates difference of the deposition mechanism at the room temperature and at the temperature around 100°C. Deposition of tungsten from hot capillary is observed and quantified.

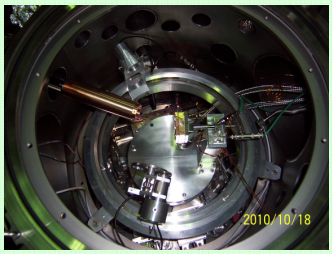
1. Introduction and objectives

We are studying H and D atom interaction with W, Cu and a-C:H by ion beam methods ERDA and RBS. A steady increase of hydrogen concentration on the surface was observed during previous measurements (fall 2008 - January 2009) without any saturation when the sample was exposed to hydrogen atoms at temperatures below 100°C. This increase was identified as deposition of a polymer-like C:H film by incorporating hydrocarbons from the background vacuum [1]. Such impurity film is easily removed by hydrogen atoms if the surface temperature is above 400 K [2]. The goal of the new series of measurements, reported here, was to further rationalize this carbon impurity deposition. This work was undertaken under the EFDA task: "*In-situ* studies of formation of mixed layers under neutral atom/molecule impact on surface" (WP10-PWI-04-04-01/MHES/BS).

2. Experiment

ERDA – HABS experiment for *in-situ* studies of hydrogen interaction with material:

- Samples of Cu, Si and W were exposed to the H and D atom beam from hot W capillary atom source (HABS).
- *In-situ* measurements of impurity layer deposition were performed by ERDA and RBS using 4.2 MeV 7Li2+ probing ion beam.
- Characterization of experimental conditions has been improved by controlling background vacuum with quadrupol residual gas analyzer and by using high purity filter in H_2 feed line.
- RBS edge displacement was used for quantification of carbon deposition.



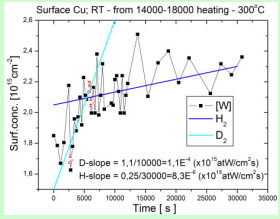
-New experimental cross section for ^{7}Li–D elastic scattering under present conditions is used for determination of surface concentration of D by Li-ERDA.

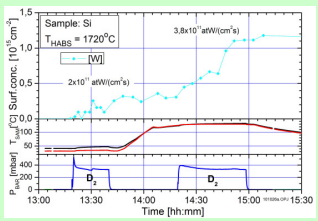
-The distance between capillary exit side to the sample was d = 7.9 cm.

-Central atom flux density at the sample was:
for H 1.6x10^{15} at/cm^{2}s@123 mTorr
for D 1.0x10^{15} at/cm^{2}s @144 mTorr

W deposition from hot capillary of hydrogen atom source, HABS

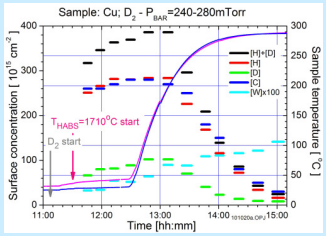
The contamination of the sample by tungsten atoms from hot capillary of the atom source was observed. This was observed and quantified by appearance of the peak in the RBS spectra on Cu and Si sample.

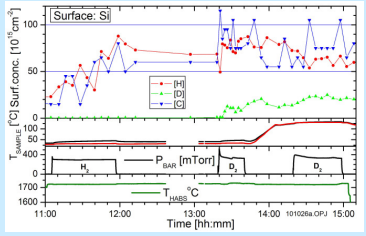




Present findings suggest the use of hot tungsten capillary as possible source of W atoms for studies of tungsten sticking to the surface or possibly for the spectroscopic needs.

3. Results I – Carbon deposition on Cu, W and Si



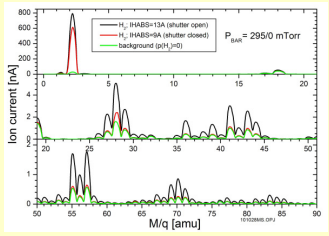


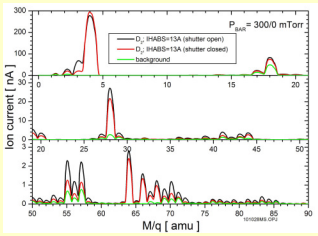
Transition from impurity deposition to erosion is clearly observed. Transition temperature is around 220°C. At lower temperature the layer growth is accompanied by both [H] and [D] increase while at higher one only [D] continues to increase. This indicates temperature dependence of isotope exchange in the growing film which is mainly done by incorporating H-containing hydrocarbons from background vacuum.

Silicon sample used in the present experiment was a piece of Si wafer and no surface treatment was performed before exposure.
- Increase rate of [H] at RT is 1.7x10^{13} cm^{-2} s^{-1} @ 290 mTorr.
Increase rate for [D] at RT is 1.2x10^{13} cm^{-2} s^{-1} @ 330 mTorr and at 125°C it is 8.4x10^{12} cm^{-2} s^{-1} @ 340 mTorr.

4. Results II – environmental conditions (vacuum composition)

In order to rationalize the source of radicals taking part in the observed deposition we have regularly monitored the background vacuum composition by means of a RGA during present series of experiments.





Stronger increase of some M/q peaks and appearance of some new ones is observed when atom beam was on showing important chemical action of particles from HABS on impurities present in the vacuum chamber.

References:
[1] S. Markelj, P. Pelicon, T. Schwarz-Selinger and I. Čadež, in preparation.
[2] T.Schwarz-Selinger, A.von Keudell and W.Jacob, J.Vac.Sci.Technol. A. 18, (2000) 995.
[3] A. von Keudell and W. Jacob, Prog. Surf. Sci. 76 (2004) 21.