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TPD Workstation

Analysis of Coated Silicon Surfaces by TPD/TPS

Hiden TPD Workstation

Introduction

Amorphous and crystalline silicon, a-Si and c-Si, respectively, are widely used in thin film solar cells. For the successful thin film technology development, a well-known microstructure of these materials is extremely important. Differences in microstructures can depend, e.g., on the deposition method, the substrate temperature, the annealing state, doping and alloying [1]. When implemented in solar cells, the thermal stability at higher temperatures [2] and the surface passivation of novel thin film materials are essential [3].

A successful method for investigating the microstructure of thin films by thermal effusion measurements is Temperature Programmed Desorption (TPD), also known as Thermal Desorption Spectrometry (TDS) or Thermal Desorption Analysis (TDA). Analysis by TPD involves positioning the sample in an Ultra High Vacuum (UHV) chamber and heating the sample at different linear temperature ramp rates while collecting the desorption spectra using a quadrupole mass spectrometer. The Hiden TPD Workstation is a complete experimental setup designed for this and many other applications and is optimised to obtain maximum sensitivity for desorption species ranged from 1 – 300 amu.

[1] phys. stat. sol. (c) **1**, 5, 1144–1153 (2004)
[2] J. Appl. Phys. **111**, 093713 (2012)
[3] J. Appl. Phys. **125**, 105305 (2019)

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TPD sample under analysis

Example Data

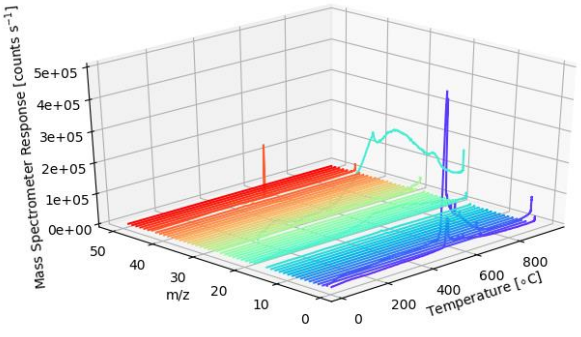
Optimisation of Sensitivity

The Hiden TPD Workstation has several features to optimise the sensitivity of the system for low level desorption products. These include:

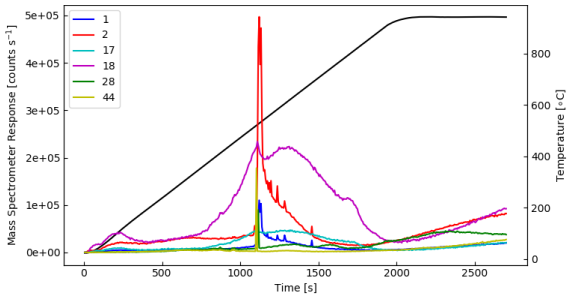
- No sample holder – only the sample enters the UHV chamber meaning no outgassing components other than the sample.
- High sensitivity triple filter PIC quadrupole mass spectrometer.
- Close coupling between the sample and mass spectrometer for maximum sensitivity and optimum desorption profile.
- Cooled mass spectrometer shroud to minimise background contributions.

Silicon Surface Analysis

In this example a Si wafer coated with Al_2O_3 was investigated using the TPD Workstation. The sample was heated at a constant rate of 30 °C/min to 1000 °C. During the temperature ramping, a 1-50 amu bar scan was performed to detect the desorbing species. The complete mass range analysed is depicted in the 3D plot below.

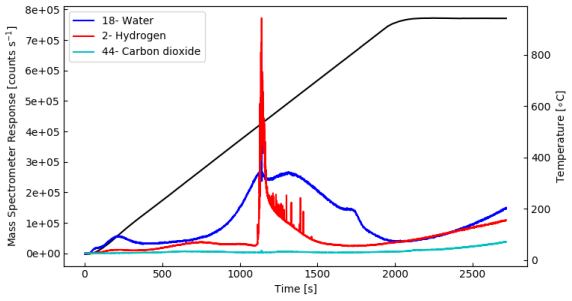


The main desorbing species observed, namely 1 – H, 2 – H_2, 17 – HO, 18 – H_2O, 28 – CO, 44 – CO_2, are shown in the plot below which is derived from the 1 – 50 amu bar scan data (3D plot).



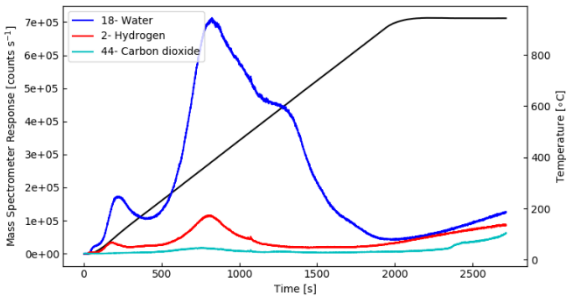
High Resolution Analysis

In a second TPD run with a fresh sample of the same material, the desorbing species of interest, here hydrogen, water and carbon dioxide, were measured again with a multiple ion detection (mid) scan which yields a higher time, i.e. temperature resolution for the desorbed species of interest. The result is shown in the plot below.



As expected, the mid scan results are in agreement with the spectra obtained from the 1 – 50 amu bar scan. The advantage of the mid scan is its faster data acquisition and the therefore higher resolution in time, i.e. temperature. Noticeably, the data for hydrogen show several spikes at temperatures above 500 °C which probably occur from blistering of the sample surface giving rise to a sharp evolution of gas.

Surface Sample Comparison



In order to demonstrate the differences in these effusion measurements to other samples, the plot above shows data acquired from a similar Al_2O_3 coated Si sample produced at a different deposition temperature of the substrate. Here, the carbon dioxide and water signal behave similarly to the first sample, but almost no hydrogen desorption is observed.

Conclusions

The Hiden TPD Workstation is ideal for examining the microstructure of differently coated silicon surfaces and other thin film materials. Additionally, any other gases can be detected simultaneously with the species of interest. The Hiden TPD Workstation is easy to use and offers high sensitivity and repeatability.