

## Adsorption properties of MgO protective layer in AC PDP

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### Abstract

We have studied the adsorption of contaminations on the MgO protective layer by Thermal Desorption Spectrometry (TDS). The result shows that the increase in exposure time, MgO thickness and humidity multiply the quantity of adsorbed contaminations. It is also found that the desorption activation energy and contamination quantity is decreased by the additional firing process of MgO layer under oxygen environment.

### 1. Introduction

MgO layer has two important roles, the extension of lifetime by lowering the sputtering rate and the decrease of driving voltage by increasing the secondary electron emission coefficient. However, these good properties of MgO disappear by presence of contamination [1, 2].

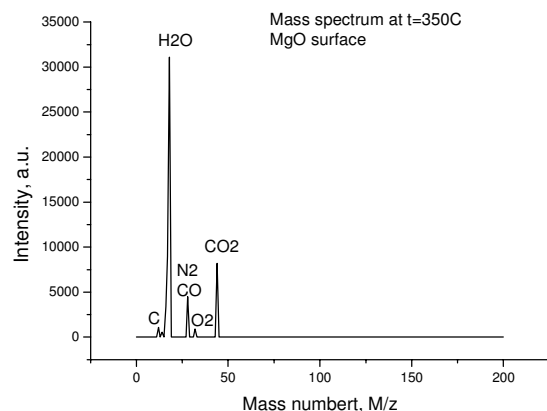
This work has been carried out to understand the adsorption mechanism of contaminations on MgO surface. Moreover, the method to decrease the level of contaminations is proposed using the experimental results.

### 2. Experimental

The adsorption process of contaminations on MgO protective layer is investigated using Thermal Desorption Spectrometry (TDS). This method is based on the mass spectrometric analysis of desorption gases inside ultra-high vacuum chamber under the heating condition. The sample of MgO layer is inserted on the stage inside an ultrahigh vacuum chamber, working under pressure  $10^{-6}$  Pa. While the temperature controller heats a sample, desorbed gases are analyzed by Quadrupole Mass Spectrometer. In the final we have a dependence of intensities of mass-ions on the temperature of sample stage, which is controlled by the thermocouple installed under the stage. Its procedure is well described in other work [3]. TDS helps to derive the values of adsorbed contaminations and thus to derive the activation energy of desorption.

### 3. Results and discussion

In order to investigate the species of desorbed contamination, the mass spectrum is scanned in the range of 1 to 200 M/z. It is seen in Fig. 1 that the spectra for H<sub>2</sub>O and CO<sub>2</sub> have the highest intensities. The spectrum for H<sub>2</sub>O has two peaks as given in Fig. 2. The first peak is formed by the physical adsorption, whereas the second one is generated by the chemical adsorption. On the other hand, only one peak via chemical adsorption is found for CO<sub>2</sub>, which is in good agreement with the result in other work [4].

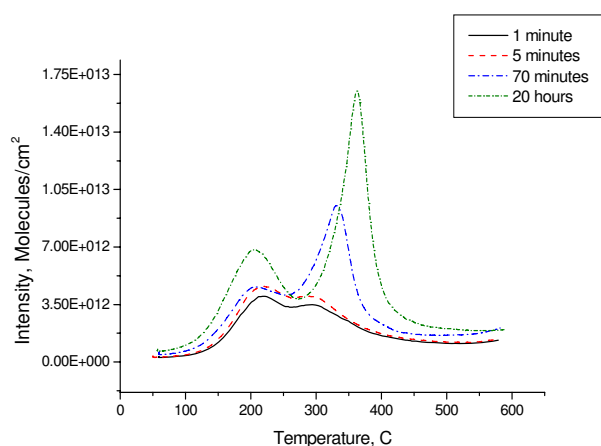


**Fig.1 Mass spectrum of desorbed gases from MgO protective layer.**

*Influence of MgO thickness on adsorption of contaminations.*

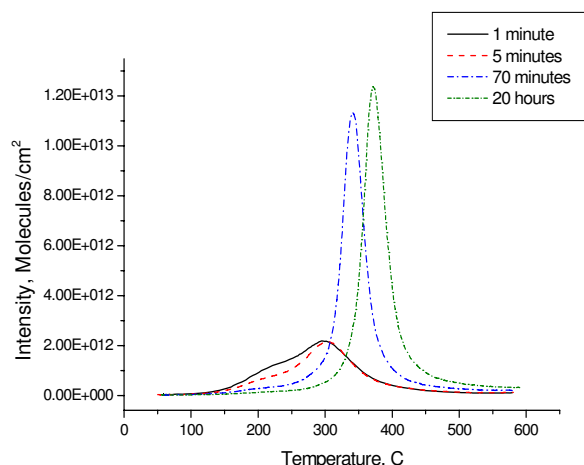
The TDS spectra are measured at the same exposure time in air for the samples with the MgO thickness in a range from 650 to 900 nm. It is found that the contamination quantity is in proportion to the MgO thickness.

*The influence of exposure time on the contamination quantity.*

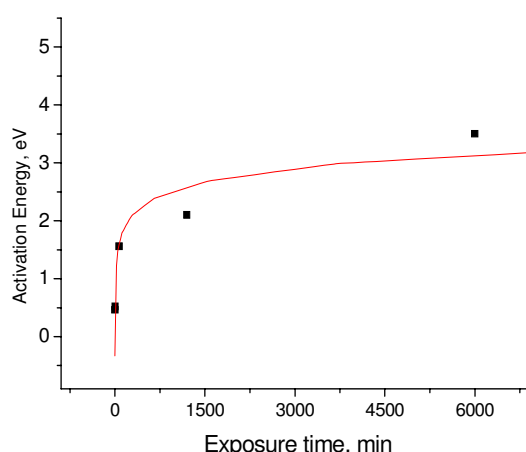


**Fig.2 TDS spectra of H<sub>2</sub>O for different exposure times.**

By varying the exposure time at a constant humidity condition, TDS is carried out for the samples with the MgO thickness of 720 nm. It is found that the quantity of the adsorbed contaminations increases with the exposure time. In addition, with the rise of exposure time, the chemical adsorption peak is shifted toward a high temperature region. The activation energy of desorption is calculated by Redhead formula and Arrhenius equation [3], given in Fig.4. The activation energies calculated by these two methods have different values but their tendency for exposure time is the same.



**Fig.3 TDS spectra of CO<sub>2</sub> for different exposure times.**

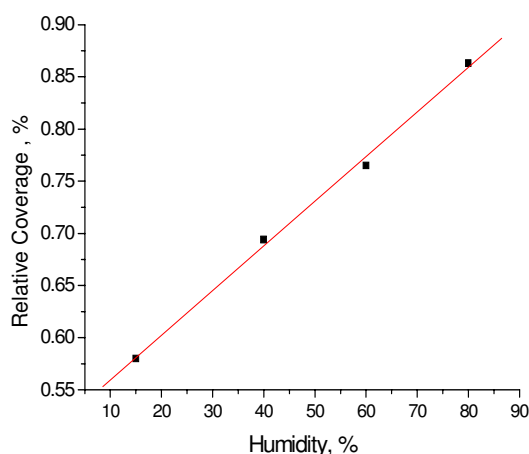


**Fig.4 Dependence of H<sub>2</sub>O desorption activation energy on exposure time at constant humidity of 25%.**

The activation energy for H<sub>2</sub>O equals to about 0.5 eV at the exposure time of 10 minute, which increases to 1.5 eV for the exposure time of 60 minute. It is expected that the activation energy is saturated at very long exposure time (more than 30 days)

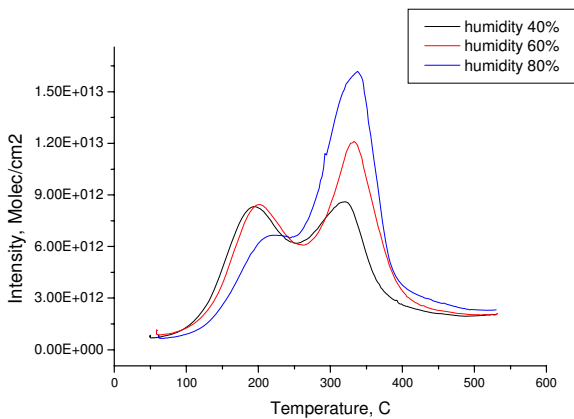
*Influence of humidity*

The influence of humidity on adsorption of H<sub>2</sub>O can be seen in Figs. 5 and 6. The relative coverage in Fig. 5 is defined by the ratio of areas under TDS spectra for current condition to those for saturation condition (after 3 months of exposition).

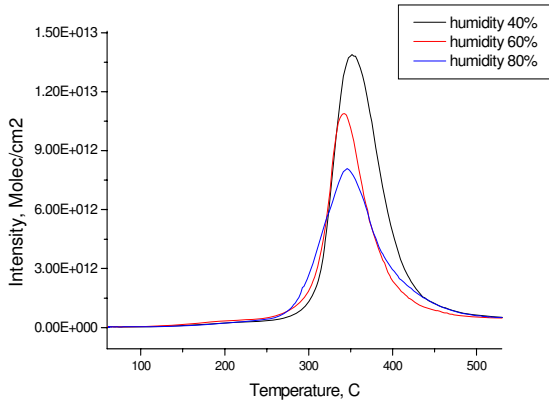


**Fig.5. Influence of humidity on H<sub>2</sub>O adsorption ratio at a constant ambient temperature.**

With the rise of the humidity, the adsorption degree of H<sub>2</sub>O increases, whereas the activation energy of H<sub>2</sub>O desorption decreases. As expected, the saturation of relative coverage is larger at high humidity condition. However, even at humidity of 80% during 70 minute of exposure, the saturation of relative coverage does not occur.



**Fig.6 Influence of humidity on H<sub>2</sub>O adsorption quantity for different temperatures.**



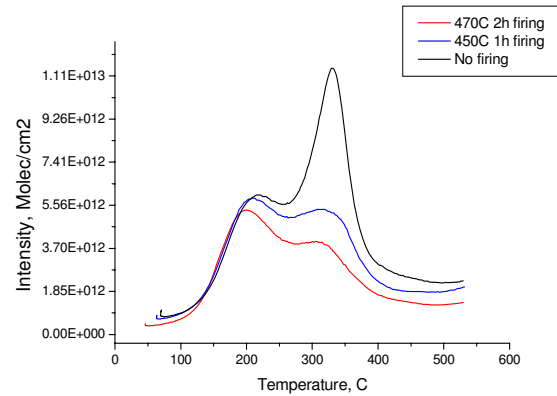
**Fig.7 Influence of humidity on CO<sub>2</sub> adsorption for different temperatures.**

In contrast to the case of H<sub>2</sub>O, the increase in humidity leads to the reduction of CO<sub>2</sub> adsorption degree, as seen in Fig.7. Since the active centers of MgO surface are the same for CO<sub>2</sub> and H<sub>2</sub>O, it can be said that the active centers of MgO are more easily filled with the H<sub>2</sub>O molecules at higher humidity level.

*MgO firing process.*

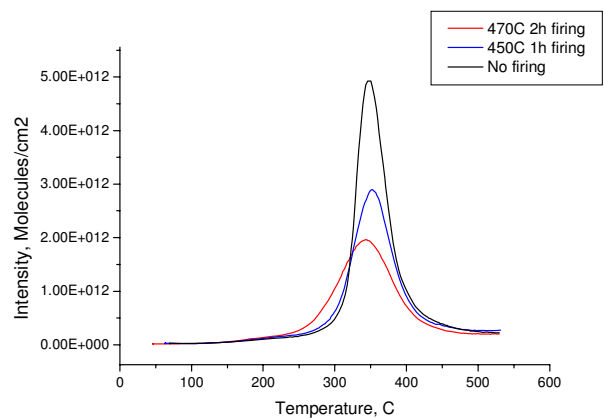
The MgO firing process can be considered as one of

candidates for reducing the contamination level. We have studied several firing processes (vacuum firing and firing in oxygen atmosphere) by varying their temperature and time.



**Fig.8 Comparison of H<sub>2</sub>O spectra measured for different MgO firing temperatures (Humidity and exposure time in air are the same)**

It is found that the vacuum environment gives little influence on adsorption quantity, which remains at almost same levels regardless of firing process. As appearing in Figs. 8 and 9, the effect of firing process is huge in oxygen environment condition. It can be seen that the quantities of H<sub>2</sub>O and CO<sub>2</sub> are reduced with the rise of firing time and temperature



**Fig.9 Comparison of CO<sub>2</sub> spectra measured for different MgO firing temperatures (Humidity and exposure time in air are the same).**

#### 4. Summary

From TDS analysis of adsorption properties of MgO protective layer, it is found that the main contaminations are H<sub>2</sub>O and CO<sub>2</sub>, which diffuse in depth of the MgO layer. This leads to the increase in the desorption activation energy. This means that the baking temperature has to be higher if the panel was exposed for a long time in air during manufacturing processes. The more MgO thickness is deposited, the more contaminations will be adsorbed. It is also found that the decrease in contaminations quantity can be realized by the additional firing process of MgO layer under oxygen environment.

#### 5. References

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