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Humidity and Temperature Dependences of the Adsorption and Desorption Rates for Acetone and Xylene on Silicon Wafer

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Acetone and xylene can be easily found in clean rooms during various cleaning processes. A recently developed experimental setup was applied to study humidity and temperature dependences of adsorption and desorption rates of acetone and xylene on silicon wafers. The humidity dependence is somewhat stronger for acetone compared with xylene at ambient temperature, which can be attributed to the physical–chemical properties of both compounds. Adsorption and desorption rate constants of acetone and xylene are temperature dependent in the range of 273–333 and 273–343 K, respectively. The temperature dependence of the Langmuir constant (K) for acetone is given by $K(T) = 1.80 \times 10^{-3} \exp(615.90/T)$ at a gas-phase concentration of $c_g = 1450\ \mu g\ C\ m^{-3}$ at relative humidity (RH) = 0%, and that for xylene is given by $K(T) = 2.57 \times 10^{-4} \exp(1065.80/T)$ at a gas-phase concentration of $c_g = 1250\ \mu g\ C\ m^{-3}$ at RH = 0%. From this data set, the adsorption enthalpies $\Delta H_{ads} = -(5.1 \pm 0.02)$ kJ mol^{-1} and $\Delta H_{ads} = -(8.9 \pm 0.01)$ kJ mol^{-1} were obtained for acetone and xylene, respectively.
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Trace levels of organic compounds may arise in clean room environments, wafer storage boxes, and process chambers. Organic contamination includes an extensive list of polar and nonpolar compounds such as hydrocarbons, amines, organosilicon, and organophosphate compounds.[1]

When silicon wafers are exposed to the ambient atmosphere, even in a regulated clean room, volatile organic compounds (VOCs) can be easily adsorbed on the wafer surfaces in a short period of time. To avoid the adsorption of such organic compounds, silicon wafers are stored in plastic boxes, which are usually made of polypropylene or polycarbonate materials.

To date, the control of volatile organic contamination in clean rooms remains an extremely difficult task. Even in storage boxes, submonolayer organic coverage on wafer surfaces can take place.[2,3] VOC adsorption on silicon surfaces is supposed to have an increasingly detrimental impact on the performance, yield, and reliability of semiconductor devices.[4]

In the literature, there are several studies devoted to examining the adsorption and desorption phenomena of organic molecules on wafer surfaces.[5-8] Some of them have applied a thermodesorption–gas chromatography–mass spectrometry (MS) technique[5,6] where silicon wafers were subjected to desorption at a very high temperature (400°C). Recently, the surface of silicon wafer has been characterized by X-ray photoemission spectroscopy, atomic force microscopy, and static and dynamic water contact angle measurements.[7] Attenuated total reflection–Fourier transformed infrared spectroscopy has also been used as a detection tool. But, it is a qualitative technique that gives poor identification in a complex molecular structure.[8]

In contrast to all the above-mentioned studies, we applied an alternative experimental approach to determine the adsorption and desorption rates of acetone and xylene on wafer surfaces. It consists of three main components, i.e., a stable gas-phase generator serially connected to a flow tube reactor and proton transfer reaction mass spectrometry (PTR-MS) .[9] This experimental setup allows one to work with extremely low gas-phase concentrations, which correspond to concentration levels of organic contaminants in clean rooms during fabrication processes.

In this research, we address the significance of the humidity and temperature dependences of the adsorption and desorption rates for two VOCs, acetone and xylene, on a silicon wafer. These two compounds were chosen due to their presence in a semiconductor fabrication environment and their physical–chemical properties. The overarching purpose of this research is to examine the mechanism of sorption kinetics to gain deeper molecular and bonding information on the surface of silicon wafers during contamination episodes.

Experimental

The experimental approach used here has been previously explained in detail;[9] therefore, only a brief description is given here (Fig. 1).

The setup consisted of a gas generator (PUL 200, Saint Chamas, France) serially coupled to a dilution system (DGM 100, Saint Chamas, France), a horizontal flow tube reactor, a humidification system, and a PTR-MS at the end as a detection tool.

To the best of the author's knowledge, several methods exist for the continuous generation of the VOC gas standard: (*i*) continuous syringe pump injection, (*ii*) diffusion methods, (*iii*) evaporation methods, (*iv*) electrolytic methods, (*v*) chemical methods, and (*vi*) permeation methods.[10] Among all those methods, permeation methods are considered one of the best and have been used since the 1960s.[11] These methods use a sealed polymeric container (typically, tube) filled with organics of interest, which in turn dissolve and permeate through the container walls at a constant rate for a given temperature. Permeation works extremely well for the organics that are able to maintain a gas–liquid equilibrium inside the container.[9,11]

The gas generation system used here delivers a stable continuous flow of VOC over the broad range concentrations comprised between 15 ppt and 10 ppm in a long period of time (few weeks).

The thermostatted quartz tube reactor (30 cm length and 1.7 cm diameter) was maintained at the laminar flow regime. It contained six glass supports at both ends where silicon wafer strips (L = 30 cm, w = 0.7 cm) were mounted. The flow reactor was purged with nitrogen before placing the silicon wafer strips. Gas-phase acetone and xylene were introduced into the reactor via a movable injector equipped with a fritted end. While varying the position of the injector inside the reactor, we could control the contact surface between the gaseous molecules and the wafer surface, which in turn allowed us to elucidate the kinetics. The flow tube reactor was thermostatted by an ethylene glycol bath through an outer jacket.

The concentration of acetone and xylene in the gas phase was continuously monitored by state-of-the-art PTR-MS. Relative humidity (RH) was regulated by dilution as follows: Dry carrier gas (N_2) was divided into two fluxes. One flux was kept dry, and the other one was humidified by bubbling in deionized water (UHQ, Millipore MilliQ system). Mixing these two flows at various ratios allowed us to obtain a controlled RH, which was measured online by

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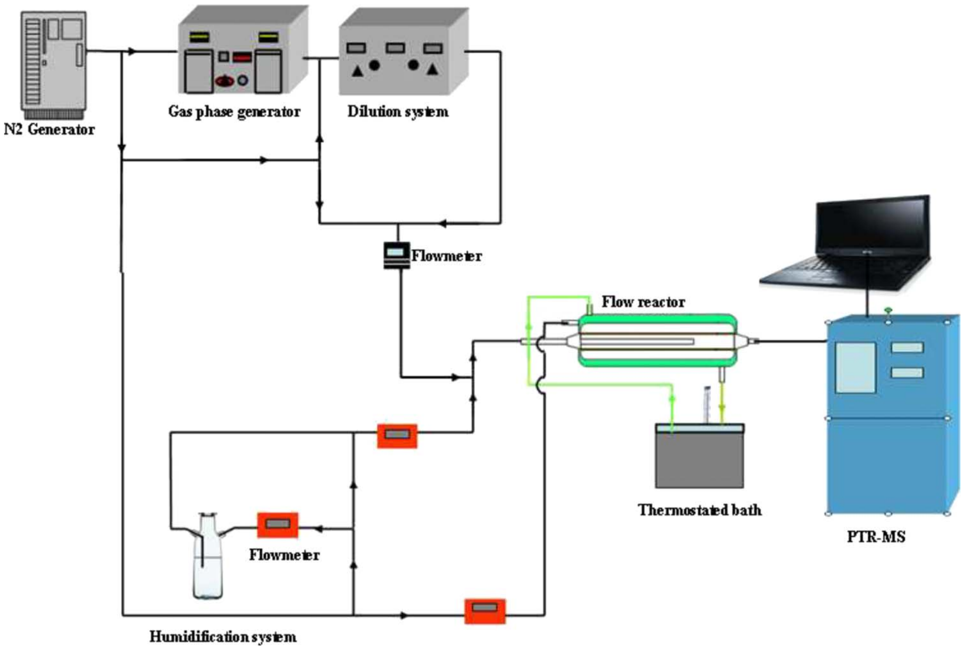


Figure 1. (Color online) Experimental setup for the measurements of the adsorption and desorption rate constants of organic contaminants on silicon wafers.

a hygrometer (Hygrolog NT2, Rotronic, France) with ±1.5% accuracy. In the present study, the gas-phase organic compound concentration was not influenced by the RH variation; i.e., the gas-phase concentration was kept constant during the experiments.

Results and Discussion

Acetone and xylene mixing ratios have been previously measured in clean rooms, and the reported values lie in the range of 39–2970 and 15–36 ppb for acetone and xylene, respectively.[12]

These two compounds have been chosen due to their presence in clean rooms and to their different physical–chemical properties. The dipole moments and the vapor pressures of acetone and xylene are summarized in Table I.

A significant factor governing the adsorption phenomena of organics on surfaces is the polarity of the compound (molecules with higher dipole moments are more attracted to the wafer surfaces).[1] However, this factor is not necessarily a single parameter that describes the adsorption process; other phenomena can also play a role, such as the reorientation of the molecules, the size, and the configuration of the molecules (see below).

Solid surfaces such as silicon wafer represent an asymmetric boundary capable of attracting the gas-phase molecules due to the imbalance of the existing Madelung force field. Attraction also occurs due to the dispersion and London forces. Adsorption occurs when a solid surface is exposed to gas-phase molecules, and such interactions are classified as physisorption.[13]

Table I. Dipole moments, vapor pressures, and boiling points of the compounds under study.

Compound	μ/D	Vapor pressure[13]	Boiling point[13] (K)
Acetone	2.88 ± 0.03 [13]	184 mm Hg (293 K)	329
p-xylene	0.00 [14,15]	6.8 mm Hg (293 K)	411
m-xylene	0.37 [14] 0.31 [15]	6.0 mm Hg (293 K)	412
o-xylene	0.64 [13] 0.52 [14] 0.54 [15]	5.2 mm Hg (293 K)	417

Organic compounds interact with the wafer surface by a dynamic equilibrium process. The amount of organics on the surface depends on the relative rates of adsorption and desorption.

In the present study, the adsorption and desorption rate constants were estimated, assuming a Langmuir-type adsorption, which means that the surface is saturated at a monolayer coverage beyond which no more adsorption takes place. Due to the limited number of adsorption sites, saturation effects may occur during adsorption. The model proposed by Zhu[14,15] (Eq. 1) was adopted to determine the adsorption and desorption rates of acetone and xylene

$$c_s(t) = c_g\left(\frac{k_{ads}}{k_{des}}\right)[1 - \exp(-k_{des}t)] \qquad [1]$$

where k_{ads} and k_{des} are the adsorption and desorption rate constants, respectively; the ratio between the adsorption and desorption rate constants is assigned as the Langmuir equilibrium constant (K_L), where c_s is the surface density (ng m^{-2}), c_g is the gaseous concentration (ng m^{-3}), and t is the time. This model fits very well with the experimental data under the assumption that the adsorbed quantity of the organic compounds is proportional to its gas-phase concentration.

Calculation of surface adsorption capacity.— To apply Eq. 1 properly and to avoid the overestimation of the surface density, it is crucial to prove that physisorption occurs exclusively on a monolayer organic coverage. In this context, the surface adsorption capacities of acetone and xylene were calculated to verify that the achieved surface density at the equilibrium was lower than the monolayer adsorption capacity.

Assuming that both acetone and xylene molecules have a spherical geometry, their radii were calculated as follows[16,17]

$$r_i = \sqrt[3]{\frac{3V_m}{4\pi N_A}} \qquad [2]$$

where V_m is the molar volume (cm^3) of the reactant and N_A is the Avogadro number.

The molar volume can be estimated with a method developed by Biltz,[17] applying a group contribution of the atoms and considering different kinds of chemical bonds forming the organic molecule of interest. The values of radii obtained for acetone and xylene were 2.82×10^{-10} and 3.38×10^{-10} m, respectively.

The maximum surface adsorption capacity was calculated for each molecule by the following equation

$$c_{\mathrm{s\,max}} = \frac{M_w}{AN_A} \qquad [3]$$

where $c_{\mathrm{s\,max}}$ is the highest surface concentration of the adsorbed organics on the silicon surface ($\mathrm{g\ cm^{-2}}$), M_w is the molecular weight ($\mathrm{g\ mol^{-1}}$) of the organic molecules, and A is the area occupied by a single molecule ($\mathrm{cm^2\ molecule^{-1}}$).

According to Eq. 3, the estimated values of $c_{\mathrm{s\,max}}$ correspond to 38.88 and 49.18 $\mathrm{ng\ cm^{-2}}$ for acetone and xylene, respectively, which fall in the range of the available data (2.5–$54\ \mathrm{ng\ cm^{-2}}$).[18]

In all our experiments, the maximum values of surface concentrations at equilibrium were 4.2 and 2.2 $\mathrm{ng\ cm^{-2}}$ for acetone and xylene, respectively. These values are about 9 and 22 times lower than the estimated $c_{\mathrm{s\,max}}$ values. Following the latter results, we can reasonably apply Eq. 1 for the calculation of adsorption and desorption rate constants.

Humidity Dependence

One of the most intriguing properties of a water–solid interaction is the high probability with which the water molecules can be attached at most surfaces, including the wafer surface. High humidity levels may dramatically alter the adsorption phenomena of organic compounds on silicon wafers. At increased RH, several layers of water molecules can be adsorbed on the native oxide of silicon wafers. For instance, Takahagi et al.[19] reported the presence of three layers of water on a silicon wafer surface. Habuka et al.[20] considered that the outmost layer on silicon wafers is quickly produced in a clean room because after cleaning, silicon wafers are exposed to ambient air, which usually consists of about 40–50% RH.

In such case, organic molecules mainly interact with the –OH functional group of water molecules by hydrogen bonding. The latter occurs due to the strong decay of intermolecular interactions with distance. Therefore, it is the outermost molecular layer of the surface that controls the adsorption.[21]

Water adsorption on a solid surface usually proceeds by preferential orientations of water molecule on the surface. Usually, the oxygen end is placed closer to the surface with one or both O–H bonds oriented away from the surface. Both the surface and water–water interactions play a major role in dictating the orientation of adsorbed water.

Hugenschmidt et al.[22] showed that water dipoles were oriented away from a solid surface composed of TiO_2. The estimated dipole moment of the water molecule exhibited a value of 0.5 D, which is significantly smaller in comparison with the dipole moment of the gas-phase water molecule (1.88 D).[23] This could be due to some tilting possibly via the interaction with bridging oxygen atoms, which are present on the surface.[22] The latter suggests that we could reasonably assume the same behavior of water molecules on the SiO_2 surface.

The adsorption/desorption processes depend on the compound's physicochemical properties and, therefore, the electrostatic interactions that are involved. Figure 2 shows the adsorption and desorption rate constants of acetone as a function of RH. Figure 2 reveals that the adsorption and desorption rate constants of acetone increase by factors of 1.7 and 1.6, respectively, at RH up to 50% and at 298 K.

Notice the strong linear dependence of the adsorption and desorption constants with humidity. Arguably, this linear dependence can lead to the plateau at extremely high humidity levels, e.g., 90%, due to the saturation effect on the silicon surface. However, we did not perform such measurements because humidities higher than 50% are not relevant for the clean rooms.

Rana et al.[24] showed that very low mixing ratios (in the range of parts per billion) of preadsorbed water vapor on silicon oxide can increase the adsorption of polar molecules such as isopropanol. This agrees well with the behavior of acetone adsorption at higher humidity levels observed here. Although both adsorption and desorption rate constants of acetone increase with RH, the reason for this behavior is different in both phenomena.

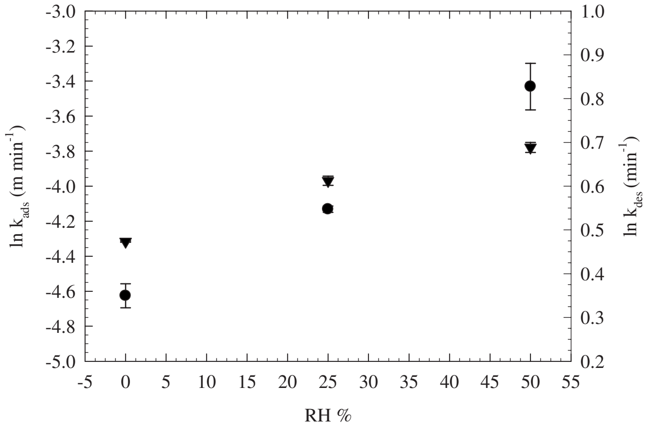


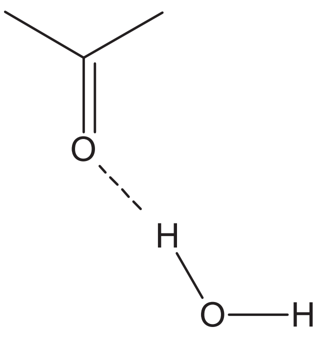
Figure 2. Humidity dependences of (▼) adsorption and (●) desorption rate constants of acetone on silicon wafer for gas-phase concentrations of acetone $c_g = 640\ \mu\mathrm{g\ C\ m^{-3}}$ at 298 K.

As mentioned above, Hugenschmidt et al.[22] claimed that the adsorbed water molecules exhibit a much smaller dipole moment (0.5 D) than that of gas-phase water molecules (1.88 D).[23] Although there is an important decrease in the dipole moment, the water–acetone complex formation via hydrogen bonding is highly probable. We propose (Scheme 1) a formation of a complex between the top layer of adsorbed water molecules and acetone. The existence of such complexes between the molecules of water and acetone was already reported.[25,26]

Hence, the enhancement of the adsorption rate constants at higher humidity levels can be attributed to dipole–dipole interactions between the gas-phase molecules of acetone and the top layer of adsorbed water molecules on the wafer surface.

The desorption of acetone also increases at higher humidities, suggesting that water molecules do not attract acetone during the desorption process. These results agree well with those obtained by Rana et al.[24] for isopropanol. Such phenomenon was also observed by Ruiz et al.[27] for the adsorption of VOCs onto soil minerals. They[27] exhibited that the increase in the air humidity accelerated the removal of VOCs from the minerals.

In a stable system consisting of water–water interactions (minimum potential energy) on a wafer surface, the presence of acetone molecules induces a less stable system. Clearly, in such a configuration (water–acetone–water), the molecule of acetone leaves the surface more easily than a water molecule. This can be ascribed to the differences in the physical–chemical properties of acetone (bp = 329 K, Table I)[23] and water.



Scheme 1.

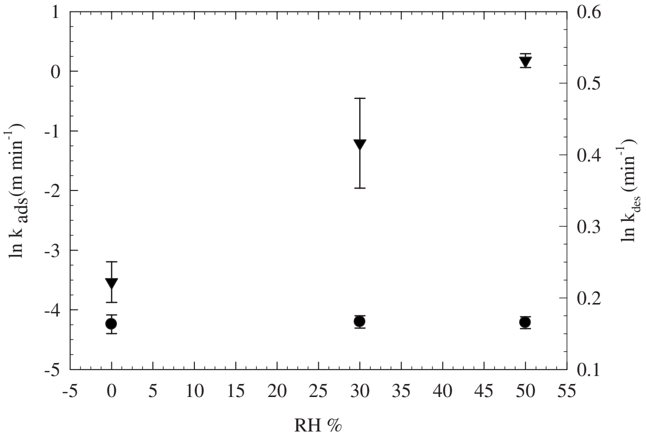


Figure 3. Humidity dependence of (●) adsorption and (▼) desorption rate constants of xylene on silicon wafer for gas-phase concentrations of xylene $c_g = 1500\ \mu g\ C\ m^{-3}$ at 298 K.

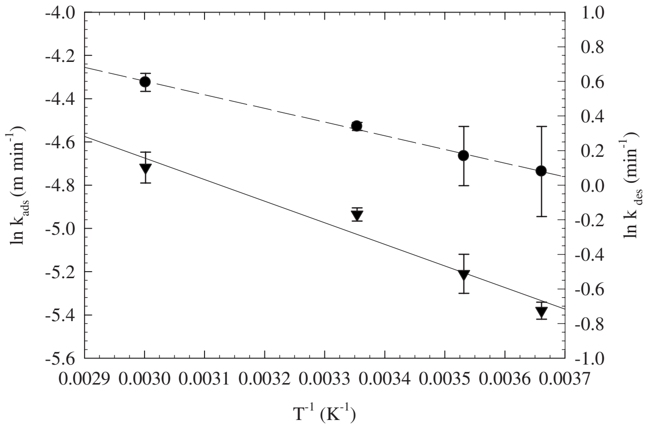


Figure 4. Temperature dependence of (●) adsorption and (▼) desorption rate constants for gas-phase concentrations of acetone $c_g = 1450\ \mu g\ C\ m^{-3}$ at RH = 0%. Long dashed line represents regression line for *T*-dependence of adsorption rate constants, and solid line represents regression line for *T*-dependence of desorption rate constants.

As in acetone, by increasing humidity levels, the adsorption behavior is governed by the interaction between xylene and water molecules already adsorbed on the surface. Figure 3 shows the adsorption and desorption rate constants of xylene as a function of RH.

Xylene exhibited much weaker RH dependences of the adsorption and desorption rate constants. Even when RH was raised up to 50%, the adsorption rate remained practically constant, and the desorption rate increases by a factor of 1.3 at 298 K, (Fig. 3). Considering a dipole moment of gas-phase xylene (0.5 D, Table I), it could be anticipated that weak electrostatic interactions between adsorbed water molecules and gas-phase xylene molecules are taking place. However, the low vapor pressure of xylene compared to that of acetone allows it to stay longer on the surface after its deposition. Moreover, the strong tendency of water molecules to form hydrogen bonds with each other influences their interactions with nonpolar molecules such as xylene. The main effect of bridging water molecules and the molecules of xylene is the reorientation of the water molecules. In addition, the size and the configuration of the nonpolar molecules are fairly critical in determining their interactions with water molecules. Both theoretical and experimental studies indicate that the reorientation of water around the nonpolar molecules is entropically very unfavorable.[27] Hence, it is not surprising to observe very weak humidity dependences of both adsorption and desorption rate constants of nonpolar molecules, such as xylene (Fig. 3).

Temperature Dependence

The adsorption rate constants of acetone and xylene as a function of temperature at RH = 0% are shown in Fig. 4 and 5, respectively. The kinetic measurements at different temperatures revealed that for acetone, when the temperature increases, k_{ads} increases (Fig. 4).

However, the adsorption rate constant of xylene remained practically unchanged as a function of temperature (Fig. 5). In fact, as the temperature increases, the probability of collision is more important, and thus, the probability of adsorption on the silicon surface increases. The latter can also be attributed to the fact that higher temperatures would increase the unoccupied surface sites. This tendency, however, was less significant for xylene. This could be partially ascribed to the physical–chemical properties (polarity and molecular weight) of xylene, which make its adsorption rate less affected by the temperature (in the range under study, i.e., 273–333 K).

The desorption rates exhibit a strong temperature dependence for both compounds, i.e., acetone (Fig. 4) and xylene (Fig. 5). The temperature influences the partitioning process between the gas and solid phases, and thus, higher temperatures would favor the xylene and acetone desorption from silicon wafers. Correspondingly, the occupied site concentrations decrease at higher temperatures.

Figures 6 and 7 display the dependence of the Langmuir constant (K_L) as a function of temperature for acetone and xylene, respectively. The plots clearly demonstrate that an increase in temperature leads to a decrease in surface density in the range of temperatures studied for both compounds. The adsorbed amount of organic compound diminishes, and consequently, the equilibrium constant (K_L) values followed the same behavior.

The observation that a less organic compound adsorbs at higher temperatures is consistent with an exothermic adsorption process, in which increasing thermal energy favors its desorbed state. Such phenomenon was observed by Schmidt et al.[28] who studied the interaction of acetone with the surface of TiO_2. Similar results were reported by Behr et al.,[29] who studied the interaction of acetone with ice surface. They[29] demonstrated that the augmentation of temperature in the range of 190–220 K leads to an increase in k_{ads} and k_{des} and a decrease in K_L.

Assuming the Arrhenius forms for the adsorption and desorption rate constants

$$k_{ads} = A_a \exp(-E_{ads}/RT) \qquad [4]$$

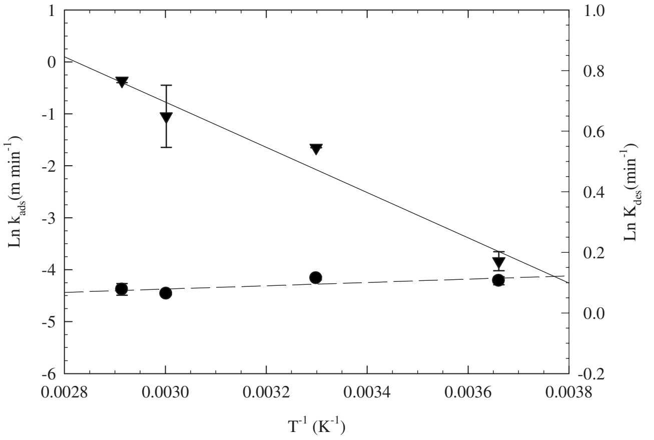


Figure 5. Temperature dependence of (●) adsorption and (▼) desorption rate constants for gas-phase concentrations of xylene $c_g = 1250\ \mu g\ C\ m^{-3}$ at RH = 0%. Long dashed line represents regression line for *T*-dependence of adsorption rate constants, and solid line represents regression line for *T*-dependence of desorption rate constants.

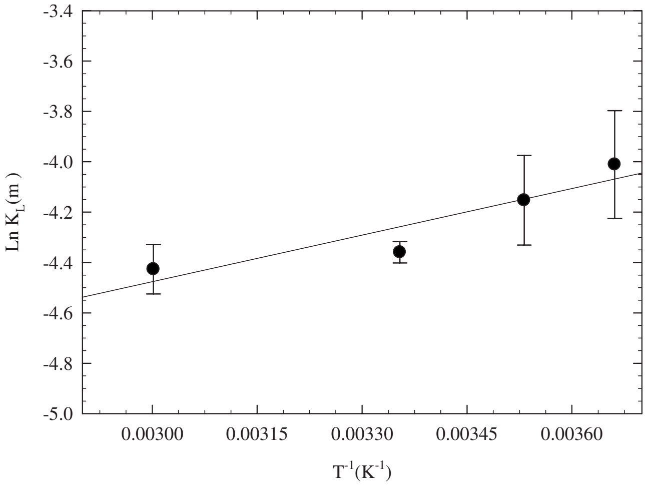


Figure 6. van't Hoff plot for acetone in the temperature range of 273–333 K at RH = 0%.

$$k_{des} = A_d \exp(-E_{des}/RT) \qquad [5]$$

where k_{ads} and k_{des} are the adsorption and desorption constants, respectively, E_{ads} and E_{des} are the adsorption and desorption energies, respectively, and A_a and A_d are the pre-exponential factors for the adsorption and desorption processes, respectively.

Supposing that a microscopic reversibility works, as it does in this case, the temperature dependence of the Langmuir constant can be obtained by a combination of Eq. 4 and 5 as follows

$$K_L(T) = A_K \exp\left(-\frac{\Delta H_{ads}}{RT}\right) \qquad [6]$$

Equation 6 represents the well-known van't Hoff low,[30] where $K_L(T)$ is the Langmuir constant (m), A_K is the pre-exponential factor, R is the ideal gas constant equal to 8.314 J mol^{-1}, and T is the temperature (K).

The plots depicted in Fig. 6 and 7 correspond to Eq. 7 and 8, respectively

$$K_L(T) = 1.80 \times 10^{-3} \exp\left(\frac{615.90}{T}\right) \text{ m} \qquad [7]$$

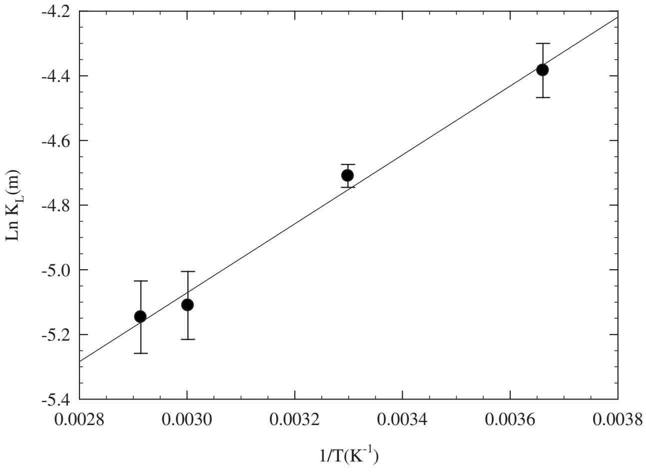
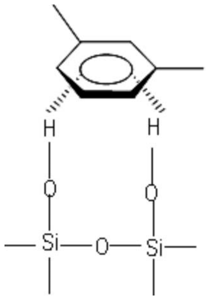


Figure 7. van't Hoff plot for xylene in the temperature range of 273–343 K at RH = 0%.



Scheme 2.

$$K_L(T) = 2.57 \times 10^{-4} \exp\left(\frac{1065.80}{T}\right) \text{ m} \qquad [8]$$

Based on Eq. 4-6, the adsorption enthalpy can be expressed as the difference between the energy of adsorption and the energy of desorption, i.e.

$$\Delta H_{ads} = E_{ads} - E_{des} \qquad [9]$$

Assuming that ΔH_{ads} remains constant in the small range of temperatures studied here, the adsorption enthalpies of acetone and xylene can be derived from the kinetic data.

The enthalpy of adsorption for acetone is $\Delta H_{ads} = -(5.1 \pm 0.02)$ kJ mol^{-1}. The negative value implies an exothermic physisorption process, which describes loose binding of adsorbed molecules to the solid surface. In general, negative ΔH_{ads} suggests that the most energetically favorable sites are first occupied. The van der Waals interactions, conformational changes of the molecules, and electrostatic interactions may affect the value of ΔH_{ads}.[30,31]

An adsorption enthalpy of this magnitude (-5.1 kJ mol^{-1}) is consistent with the formation of hydrogen bonds presumably between the acetone carbonyl group and the pre-existing hydroxyl groups on the SiO_2 surface.[32,33] A similar finding was reported by Schmidt et al.,[34] who studied the interaction of acetone with the surface of TiO_2.

From the experimental data, xylene exhibited a slightly more negative ΔH_{ads} than the corresponding value for acetone, i.e., $\Delta H_{ads} = -(8.9 \pm 0.01)$ kJ mol^{-1}.

The more negative ΔH implies greater interaction between xylene and the silicon surface in the absence of humidity. The pre-existing hydroxyl groups linked to the silicon surface act as a weak acid with the partially protonized H atom. The latter implies that silicon can interact by dispersion forces with aromatic molecules such as xylene containing π electrons (Scheme 2).[35,36]

Clearly, the interactions such as dispersion forces cannot explain the rather lower value for adsorption enthalpy of xylene compared with that of acetone. Arguably, this value of ΔH_{ads} for xylene can be attributed to the much lower vapor pressure and higher molecular weight compared with those values of acetone (see Table I). However, this needs to be verified in further experiments.

Finally, the thermodynamic parameters were determined based on the temperature dependence of the adsorption and desorption rate constants performed at zero humidity. Keeping in mind that in the clean rooms the ambient air consists of about 40–50% humidity, it may be expected that the values of adsorption enthalpies would be altered. We revealed that the adsorption and desorption of acetone and xylene increase at higher humidity levels; hence, an enhancement of the adsorption enthalpies is suggested. However, this hypothesis needs to be verified in further laboratory studies.

Conclusion

The equilibrium that may exist between the organics adsorbed on the wafer surface and in the gas phase is a dynamic state; i.e., the equilibrium represents a situation in which the rate of adsorption of molecules onto the surface is exactly balanced by the rate of desorption of molecules back into the gas phase.

The adsorption and desorption rate constants of acetone and xylene on silicon wafers were measured as a function of the RH. For acetone, they exhibited stronger linear dependences than RH dependences observed for xylene. There are strong dipole–dipole interactions between the molecules of acetone and the outermost layer of adsorbed water on the silicon surface. We proposed that such electrostatic interactions may lead to the formation of a hydrogen-bonded complex between the acetone and adsorbed water molecules on the silicon surface. However, xylene exhibits weak dispersion forces with the top layer of adsorbed water molecules on silicon wafer. The latter observation is consistent with the physical–chemical properties of both compounds under study.

The adsorption rate constants for both compounds under study, i.e., acetone and xylene, exhibited a dependence on temperature. However, this effect is more pronounced in acetone than in xylene. However, higher temperatures favor the xylene and acetone desorption from silicon wafers in the range of 273–343 and 273–333 K, respectively, following an exothermic process. From the kinetic data set, adsorption enthalpies of $\Delta H_{\text{ads}} = -(5.1 \pm 0.02)\ \text{kJ}^{-1}$ and $\Delta H_{\text{ads}} = -(8.9 \pm 0.01)\ \text{kJ mol}^{-1}$ were obtained for acetone and xylene, respectively. The slightly stronger dependence of the Langmuir constant on the temperature in xylene compared with acetone was attributed to the lower vapor pressure and higher molecular weight of xylene compared with the corresponding values of acetone.

A more in-depth understanding of the adsorption and desorption phenomena occurring on the silicon surface is highly required. Particularly, the analysis of the mixture of gaseous organic compounds will gain deeper molecular and bonding information on the surface of silicon wafers during contamination episodes.

In this context, measurements of adsorption and desorption rates of mixtures of gas-phase organics on silicon wafers are ongoing in our laboratory, and the obtained results will be published elsewhere.

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