

## Model studies of the photocatalytic removal of carbon from titanium dioxide

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Multilayer Mo/Si mirrors used for EUV lithography are rapidly contaminated with carbon through light-induced reactions with residual gas molecules present in manufacturing vacuum. This severely reduces the mirror's reflectivity and usable lifetime. To prevent this contamination capping layers of catalytically active Ru have previously been studied. In this work we have investigated the carbon remediation properties of UV illuminated  $\text{TiO}_2$ . Photons with energies larger than the rutile  $\text{TiO}_2$  band gap (3.2 eV) create electron-hole pairs which react strongly with adsorbates such as carbon in the presence of an oxidizing gas background.

The substituted benzene catechol ( $\text{C}_6\text{O}_2\text{H}_6$ ) was chosen as a model contaminant on the  $\text{TiO}_2$  (110) surface, and our focus is on studying molecular-level interactions. The bonding configuration of catechol was investigated with Scanning Tunneling Microscopy (STM) and ultraviolet and x-ray photoelectron spectroscopy (UPS, XPS). UV exposure in ultrahigh vacuum (UHV) does not alter the XPS C1s signal, but UPS measurements indicate the removal of H from the surface. Under UV exposure in an oxygen background, catechol is observed to degrade via oxidation of the catechol molecule.

This oxidation process results in removal of roughly 10% of the initial monolayer, after which the photocatalytic reaction slows considerably. By changing the background gas to nitric oxide (NO) the rate of catechol oxidation is greatly increased. The incident wavelength of the excimer UV source, XeF (351 nm) and KrF (248 nm), did not affect the removal rate in oxygen.

The photocatalytic reaction of catechol is shown to differ from the thermal reaction pathway. These different reaction paths allowed us create a carbonaceous contamination layer by annealing the catechol monolayer to 600 C. This carbon layer is more difficult to remove by photocatalytic oxidation than a pristine catechol monolayer.

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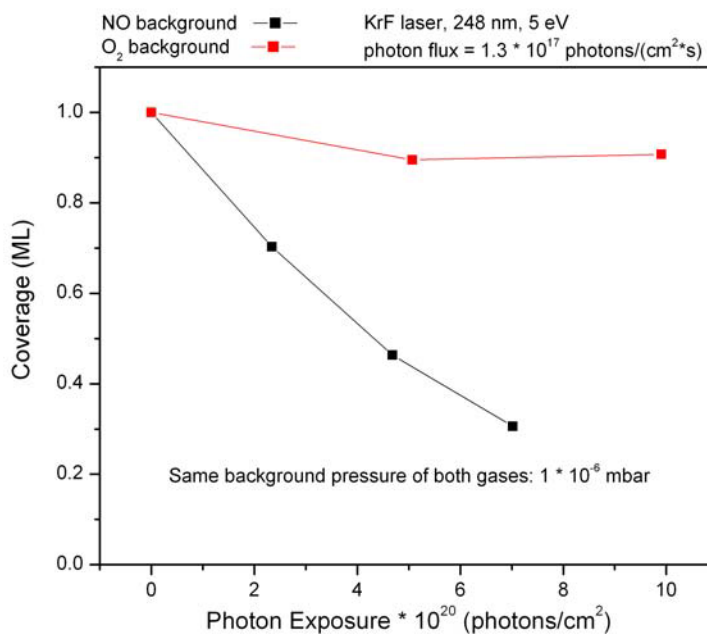


Fig. 1: Coverage of catechol on  $\text{TiO}_2(110)$ , measured with XPS, as a function of photon exposure in a background of  $1 \times 10^{-6}$  mbar  $\text{O}_2$  and NO.