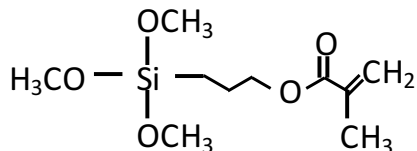


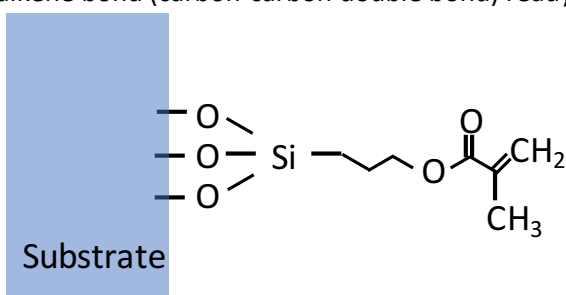
III. Frequently Asked Questions on Silanization

1. How does silanization work to promote hydrogel adhesion?

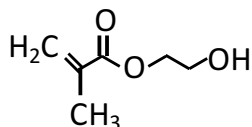
Silane A174 can be used to covalently bond hydrogel and wafers. Silane A-174 has the following chemical structure:



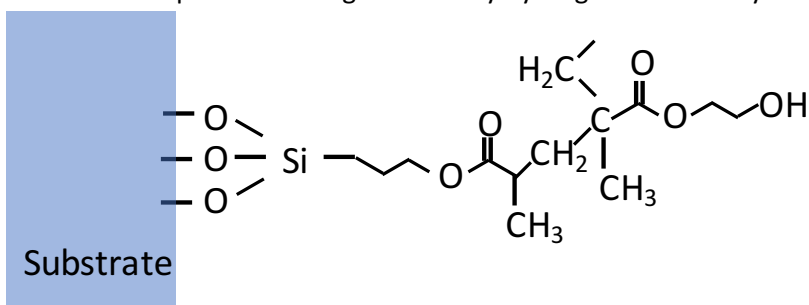
The hydroxyl group (-OH) on wafer surface displaces the alkoxy group on the silane (-O). On one end, silane forms covalent siloxane(Si-O-Si) group with the substrate. On the other end, there's alkene bond (carbon-carbon double bond) ready for hydrogel adhesion.



Hydrogel also comes with alkene bond (see "Hydrogel theory section"). Take HEMA for instance:



Then the alkene bonds on hydrogel and silane can be polymerized when mixed with photo-initiator and exposed to UV light. This way hydrogel is covalently bonded to the wafer surface.



2. Can I use Yes Oven to silanize the wafer for hydrogel adhesion?

No, you cannot. Indeed yes oven uses HMDS (hexamethyldisilane) to silanize the wafer for photoresist spin coating. However, the key point of silanization to anchor hydrogel is actually introducing alkene group on the wafer to covalently bond hydrogel. Since HMDS only comes with single carbon bond, it cannot be used to adhere hydrogel.

3. How do I tell if my wafer is silanized?

The wafer doesn't look different after being silanized. However, the surface chemistry has been modified and the most visual detection method is water contact angle. When wafer is fully silanized by silane A174, the contact angle is around 55 degrees. Clean wafer has a contact angle of less than 10 degrees.

4. My hydrogel prepolymer doesn't coat on silanized wafer?

You need the right amount of silanization. Silane makes the wafer hydrophobic as indicated by the high contact angle. This is difficult for hydrogel to wet the surface so you need to reduce the amount of silanization. Reduced silanization can improve uniformity significantly without compromising hydrogel adhesion.

Liquid silanization process can have large run-to-run variations, and it is recommended to do a test wafer first. I have had wafers fully silanized to 55 degrees in 3 minutes or as long as 25 minutes.

Some paper suggests use IPA as solvent instead of DI water to increase surface wettability [6].

Another paper recommends pre-soaking the substrate in the pre-polymer for 24 hours [7].



Figure. Hydrogel spin coating on thermal oxide on silicon wafers.

5. How do I improve silanization efficacy?

Similar to all silanization process, abundant hydroxyl group (-OH) on wafer surface improves silanization. Therefore, you can first thermally oxidize the wafer. Immediately prior to silanization, perform a 5 minute oxygen plasma in the plasma-etch in nSIL. This not only cleans the wafer but also activates more -OH groups.

Although Matrix also does oxygen plasma, I do not recommend the tool. It has particle issue which requires SRD clean. After SRD, the wafer has a thin layer of water molecule adsorbed on the surface, so the water molecule instead of the wafer are reacted with the silane agent[8].

6. Any other silanization method and recipes?

For liquid silanization, I have tried the following two recipes:

- A. 45 minutes soaking in 0.25% silane A174 in toluene [3]
- B. 45 minutes soaking in 2% silane A174 in equal parts of water and IPA [10]

Although recipe B is recommended pre-treatment for parylene coater at some facilities, it didn't give a uniform coating even under visual inspection.

Some other variations for recipe A can be found in [3]: such as replacing toluene with ethanol or acetic acid water solution. Ethanol recipe gives poor adhesion between hydrogel and thermal oxide. Acetic acid attacks many metal. Therefore these 2 recipes are not used. Some people also recommended heating up toluene [6]. Please contact exfab-wbsolv bench staff to get qualified for heating solvents.

For ALD silanization, please contact InSurfTech in Menlo park.

For vapor silanization, please contact Michelle for more details. You are expected to bring your own dessicator.

7. Your process is performed on thermal oxide, does it work on other surfaces?
Liquid silanization is experimentally verified to work on PDMS surface in SNF. However, it gives poor adhesion on ALD silicon dioxide (plasma), even when fully silanized to 55 degrees contact angle. Future work can be done to compare ALD, PECVD and thermal oxide. It is claimed to work with nitride surface [6].