The Low-Pressure, Chemical Vapor Deposition of SiO_2 Layers Using CO_2 as the Oxygen Source

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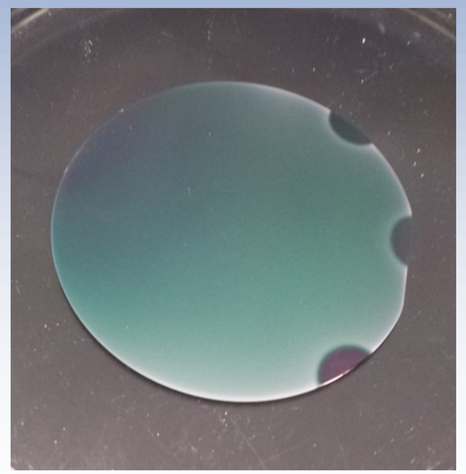
Introduction:

Silicon dioxide (SiO_2), useful in microelectronics and microfabrication, is often deposited via low pressure CVD (LPCVD). One method is to use dichlorosilane (DCS) and an oxidizer such as N_2O: $SiH_2Cl_2 + 2\ N_2O \rightarrow SiO_2 + 2\ N_2 + 2\ HCl$.

Carbon dioxide (CO_2) is isoelectric and should be able to replace N_2O as an oxidizer. Little work has been done with CO_2 and DCS at low pressure. We deposited silicon rich SiO_2 on silicon wafers using CO_2 and DCS over the ranges 0.6 to 5 Torr and 800 to 950 °C. We used ellipsometry and SEM-EDX to measure the thickness, refractive index, and chemical composition of each sample. We found that most of the films were hazy, i.e. light scattering off the surface was obvious to the eye. So little SiO_2 formed at 0.6 Torr and 800 °C that we concluded substrate oxidation rather than deposition occurred. It was the least silicon rich and least hazy. Around 5 Torr we achieved SiO_2 deposition with a refractive index of 1.6, atomic ratio of Si to O of 40:60, and the haziest surface.

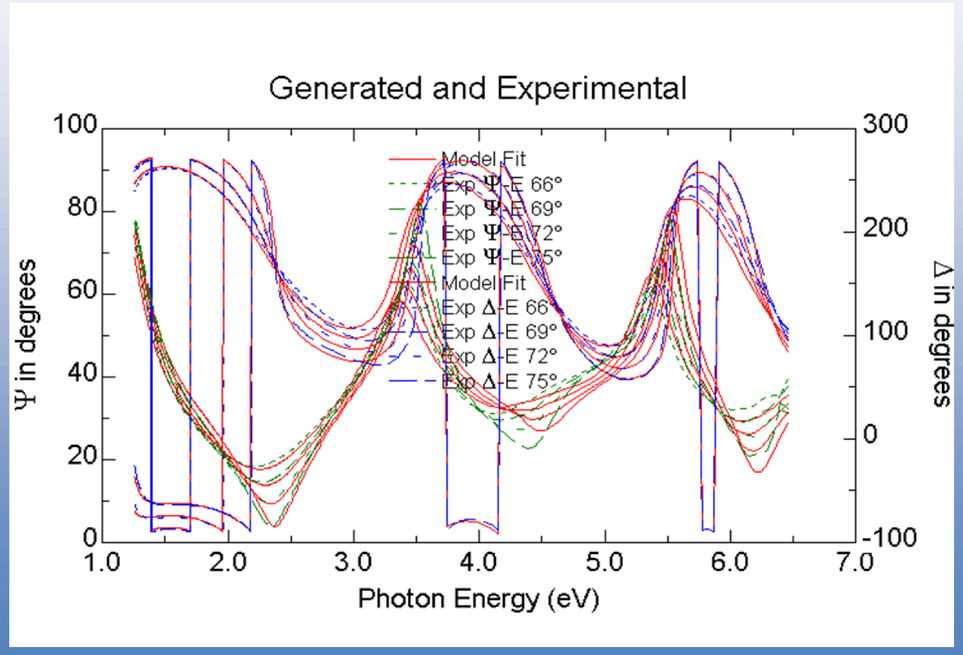


	Final
MSE	32.79
Thick.3	125.312 ± 0.428
An.3	1.4211 ± 0.00151
Bn.3	-0.0054343 ± 0.000484
Cn.3	0.00025142 ± 2.41e-005
Ak.3	0.0053689 ± 0.000555
Thick.5	363.319 ± 18.2

Thickness of silicon dioxide thin film (nm)

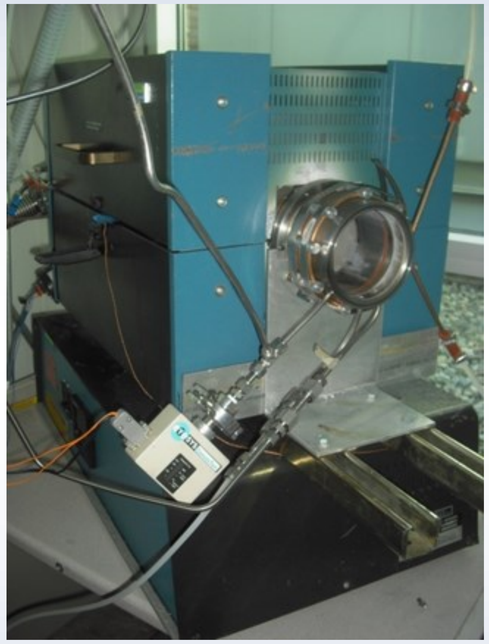
Optical Constants

Thickness of roughness (nm)



Low-Pressure, Chemical Vapor Deposition:

Chemical vapor deposition is a process which builds layers of a material on top of a substrate through chemically reacting other materials. This varies from physical vapor deposition in which a material is deposited without reacting with anything. Using chemical vapor deposition does not require a line-of-sight path from the source of the reactants to the deposition surface. This allows us to deposit on multiple substrates simultaneously, stacked one behind the other,.



Rough Surface:

We expected our SiO_2 thin films to be smooth at least to the order of visible light wavelengths. Upon removing our samples from the CVD system it was clear that our samples did not have this level of smoothness. They did not reflect light specularly, or have a mirror-like surface, but rather seemed somewhat hazy. We checked to see how rough the surface really was by getting an image of the surface with a scanning electron microscope. We found that the surface had distinguishable features hundreds of nanometers in diameter. Literature on the subject of roughness in SiO_2 thin films has led us to believe that our roughness is caused by the DCS condensing. We hope to avoid this in the future by heating the line that delivers DCS to the CVD system.

Ellipsometric Data:

After deposition, we use an ellipsometer to measure the thickness and optical constants of the thin film. The raw data is actually a measure of the change in polarization angle and phase of light reflected off the sample surface. We then fit this data to optical models to find thickness and optical properties. Using data like that shown, we found that the SiO_2 we deposited has optical constants similar to that which we would expect, but that our samples are not smooth to the order of visible light as we had expected. This roughness also makes getting accurate and reliable data on the ellipsometer more difficult.