

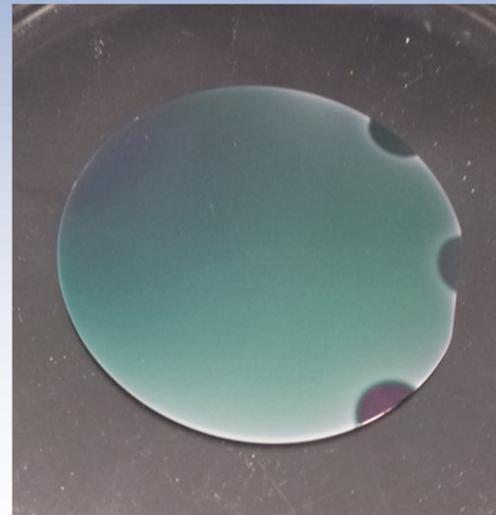
# The Low-Pressure, Chemical Vapor Deposition of SiO<sub>2</sub> Layers Using CO<sub>2</sub> as the Oxygen Source

Brandon McKeon, David Allred, Kenneth Hinton—Department of Physics and Astronomy, Brigham Young University

## Introduction:

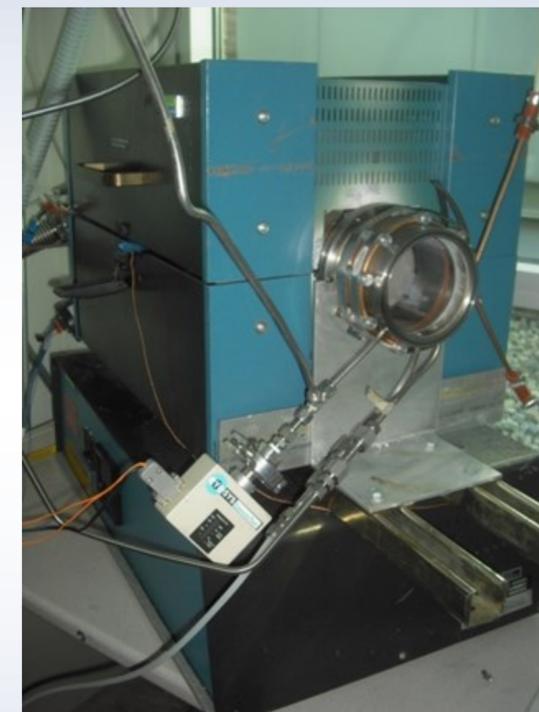
Silicon dioxide (SiO<sub>2</sub>), useful in microelectronics and microfabrication, is often deposited via low pressure CVD (LPCVD). One method is to use dichlorosilane (DCS) and an oxidizer such as N<sub>2</sub>O:  $\text{SiH}_2\text{Cl}_2 + 2 \text{N}_2\text{O} \rightarrow \text{SiO}_2 + 2 \text{N}_2 + 2 \text{HCl}$ .

Carbon dioxide (CO<sub>2</sub>) is isoelectric and should be able to replace N<sub>2</sub>O as an oxidizer. Little work has been done with CO<sub>2</sub> and DCS at low pressure. We deposited silicon rich SiO<sub>2</sub> on silicon wafers using CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> deposition with a refractive index of 1.6, atomic ratio of Si to O of 40:60, and the haziest surface.



## Low-Pressure, Chemical Vapor Deposition:

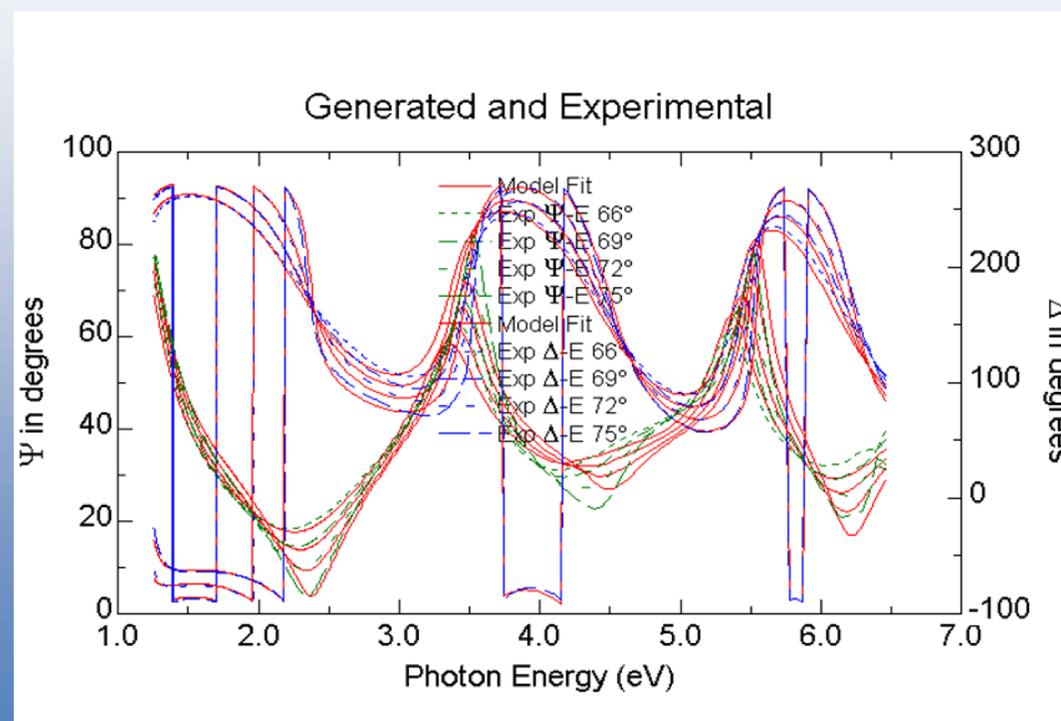
Chemical vapor deposition is a process which builds layers of a material on top of a substrate through chemically reacting other materials. This varies from physical vapor deposition in which a material is deposited without reacting with anything. Using chemical vapor deposition does not require a line-of-sight 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<sub>2</sub> 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<sub>2</sub> 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.

MSE	Final	
Thick.3	125.312 ± 0.428	← Thickness of silicon dioxide thin film (nm)
An.3	1.4211 ± 0.00151	
Bn.3	-0.0054343 ± 0.000484	} Optical Constants
Cn.3	0.00025142 ± 2.41e-005	
Ak.3	0.0053689 ± 0.000555	
Thick.5	363.319 ± 18.2	← Thickness of roughness (nm)



## 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<sub>2</sub> 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.

