

Nanoindentation of Silica Colloid Thin Films



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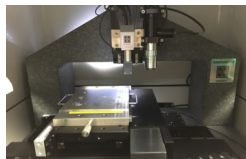
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Introduction

Silica colloid films are technologically important as they can serve as the matrix to hold nanoparticles for the fabrication of thin film sensors. Thin film sensors need to be durable to function in a variety of environments. A Hysitron nanoindenter was used to test the hardness of three sets of silica colloid thin films. The first set was slip casted and sintered at temperatures varying by 100 C (700C-1100C). The second set was spin coated using various layer thicknesses (1-20 coats). The third set consisted of various layer thickness and gold nanoparticles with a silica matrix of various layers. Of the sintered samples our findings indicated samples sintered at higher temperatures had a higher hardness. Of the spin coated samples it was found that the third layer, from the second set, had the highest hardness, but that could be due to an uneven spread of silica. The thickness of the first two sets were also found to observe the difference between the slip casted and spin coated samples. The spin coated samples had a thinner film. As for the samples with the gold nanoparticles we found that adding gold nanoparticles do not compromise the silica matrix.

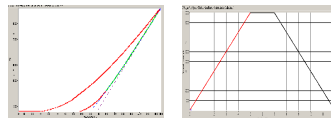
Methods

Using the Hysitron Nanoindenter, a load function of five second approach, two second hold, and five second unload was used for each of the samples.



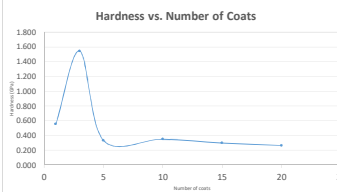
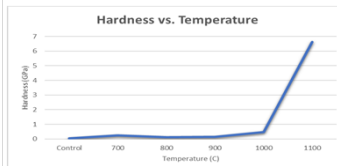
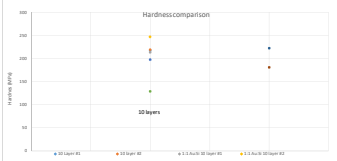
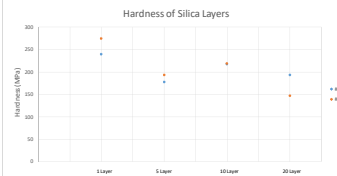
On each sample, we tested 15 points in a concentrated area. We then tested five to eight points on various spots around the sample, making sure to stay over the area of the magnet to ensure a stable surface for the diamond tip to approach.

Sample	Force
1100 C	10,000 uN
1000 C	10,000 uN
900 C	10,000 uN
800 C	10,000 uN
700 C	2,500 uN
Control	1,000 uN
Spin Coated	1,000 uN



1100 C

Layer Comparison



Results

1st set

1100 C

Average
Hardness: 6.619 GPa
Modulus: 53.894 GPa

1000 C

Average
Hardness: 0.467 GPa
Modulus: 21.325 GPa

900 C

Average
Hardness: 0.147 GPa
Modulus: 19.039 GPa

800 C

Average
Hardness: 0.124 GPa
Modulus: 13.535 GPa

700 C

Average
Hardness: 0.245 GPa
Modulus: 7.579 GPa

Control

Average
Hardness: 0.035 GPa
Modulus: 4.168 GPa

With the first three sets it is seen that there is no significant trend between the layers of silica, they are all similar to one another. For sintering there is a large significance in the 1100 C hardness, however spin coating is a faster and more effective method for an even coat.

4th set

Sample A

Average
Hardness: 4.5343
Modulus: 56.2838

Sample B

Average
Hardness: 2.6914
Modulus: 50.6276

Sample C

Average
Hardness: 2.6419
Modulus: 49.7267

Sample preparation for the fourth set involved a more thorough cleaning process of the substrate before deposition of the thin film.

2nd set

20 Layer

Average
Hardness: 0.261667 GPa
Modulus: 6.691429 GPa

15 Layer

Average
Hardness: 0.294952 GPa
Modulus: 9.517619 GPa

10 Layer

Average
Hardness: 0.346857 GPa
Modulus: 12.91429 GPa

5 Layer

Average
Hardness: 0.330714 GPa
Modulus: 17.19143 GPa

3 Layer

Average
Hardness: 1.545 GPa
Modulus: 36.66429 GPa

1 Layer

Average
Hardness: 0.555 GPa
Modulus: 31.32714 GPa

3rd set

20 Layer

Average
Hardness: 0.16950 GPa
Modulus: 2.40639 GPa

10 Layer

Average
Hardness: 0.21797 GPa
Modulus: 3.99119 GPa

5 Layer

Average
Hardness: 0.18492 GPa
Modulus: 4.73408 GPa

1 Layer

Average
Hardness: 0.25659 GPa
Modulus: 18.7679 GPa

1:20 Ratio

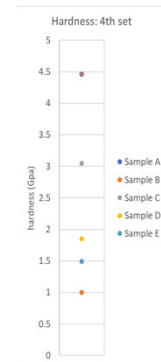
Average
Hardness: 0.16287 GPa
Modulus: 3.5017 GPa

1:1 Ratio

Average
Hardness: 0.22984 GPa
Modulus: 8.79178 GPa

Alternating Layer

Average
Hardness: 0.20112 GPa
Modulus: 4.8123 GPa

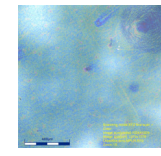


On the Surface:

Surface images were taken from samples of each set.



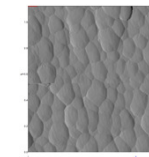
Sintered Sample that was slip casted at 800 C



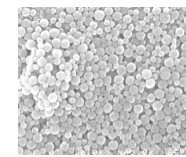
Confocal Microscope: 1 coat spin coated

Silica Particle Packing:

The silica particles measure 150 nm in diameter. These images will be used to compare to difference in packing arrangement when gold nanoparticles are added.



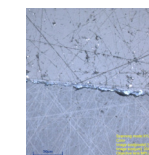
AFM at 1.13um
Silica Particle Packing



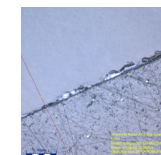
SEM: Silica particles at 667 um

Thickness of thin film:

The thickness of the thin films were taken via cross section analysis. Measurements were taken in two areas on each sample with 7-8 points measured at each area.



900 C
Average thickness: 6.77 um



20 coat
Average thickness: 3.93 um

Next Steps

The next step is to correlate the elastic modulus and hardness data, along with SEM images with the sample preparation procedures for a journal article.

Acknowledgments

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