Stat 235

Lab 1

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Lab EL12

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# 1 Histograms

## 1.a Histograms of Thickness: 400°C, 600°C, and 800°C

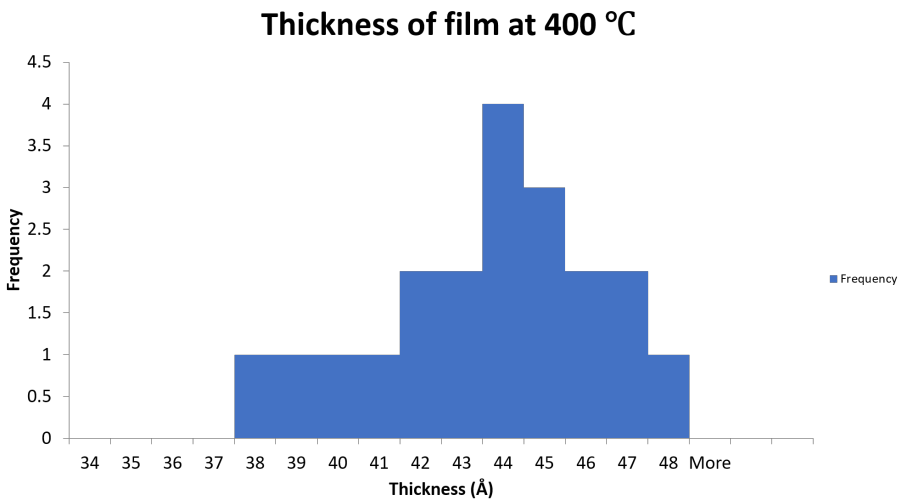


Figure 1: INSERT CAPTION HERE

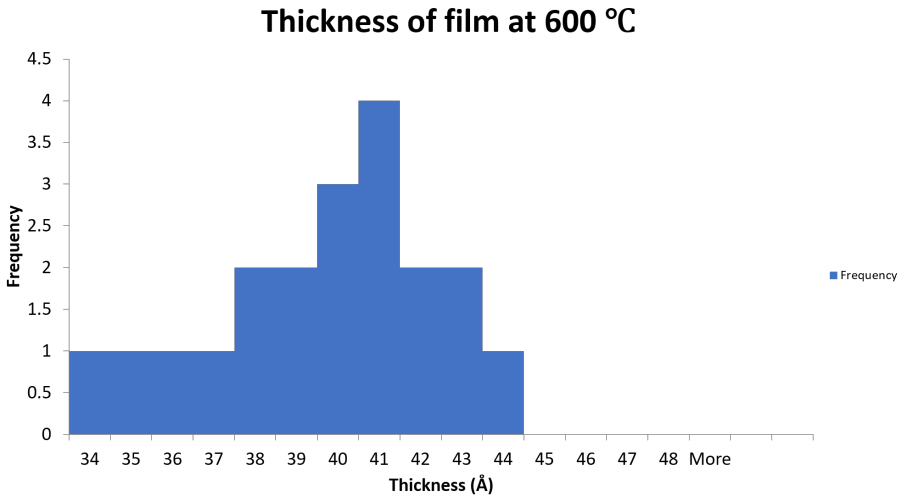


Figure 2: INSERT CAPTION HERE

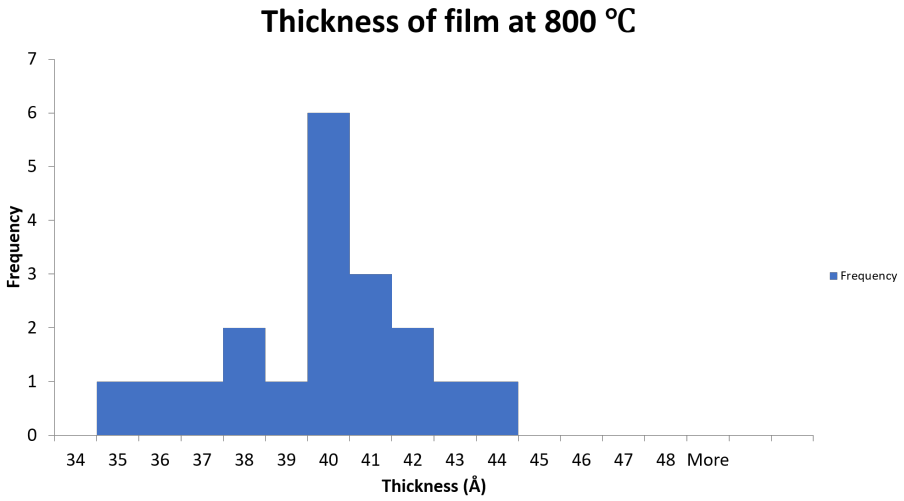


Figure 3: INSERT CAPTION HERE

## 1.b Shapes

All the histograms above appear to be slightly left-skewed. Figure 1 appears to be very slightly left-skewed, while Figure 2 appears to be a little more left-skewed. Figure 3 also visually looks left-skewed as well. All histograms have one obvious peak, but at first glance, Figure 3 might seem to have a second smaller peak in bin 38, but upon further inspection, the frequency count only has a difference of 1 compared to its surroundings, which does not seem significant enough to count as a second peak. So, each histogram above is single-peaked. There don't seem to be any obvious outliers judging from the 3 histograms above. When taking a step back and squinting, nothing seems to be visually away from the bulk of the data.

## 1.c Centers and Spreads

The first histogram (Figure 1) has a center at bin 44, and a spread (range) of 10. The second histogram (Figure 2) has a center at bin 41 and a spread of 10 as well. The third histogram (Figure 3) has a center around 40, and has a spread of 9. For all 3 histograms, the means are slightly less than their respective medians, or visually, the means are slightly to the left of the medians, which seems to partially confirm the left skewness of the histograms. (Although the difference betweem the medians and their respective means is not huge.) The mean and median for each distribution can be found in Tables 1 and 2 on page 3.

### 1.d Effect of Temperature on Thickness

It would appear that increased temperature tends to result in overall lower thickness of the films deposited. It can be noted that increasing the temperature from 400 °C to 600 °C seems to result in a more significant decrease in thickness overall, compared to the difference between the process happening at 600 °C and 800 °C.

## 2 Summary Statistics

### 2.a Mean, Std. Deviation, Variance for each Temperature Level

| Statistics | Temperature Levels (°C) | | |
|---|---|---|---|
| | 400 | 600 | 800 |
| Mean | 43.65 | 39.7 | 39.7 |
| Std. Deviation | 2.700389 | 2.716421 | 2.704771 |
| Variance | 7.292105 | 7.378947 | 7.315789 |

Table 1: My caption

### 2.b Quartiles

| Statistics | Temperature Levels (°C) | | |
|---|---|---|---|
| | 400 | 600 | 800 |
| Lower Quartile | 42 | 38 | 38 |
| Median | 44 | 40 | 40 |
| Upper Quartile | 45.25 | 41.25 | 41 |
| IQR | 3.25 | 3.25 | 3 |

Table 2: My caption

Wait check this The 400 one doesn't seem to match, but for 600 and 800 , the positions of the quartiles seem to support the conclusion that these histograms are left-skewed, since Q1 is further from the median than Q3 is.

## 2.c Mean & Std. Deviation of Thickness at Each Pressure Value

| Pressure | Mean | Std. Deviation | Mean Change |
|---|---|---|---|
| 0.25 | 45.33333 | 2.309401 | |
| 0.3 | 44 | 1.732051 | -0.57735 |
| 0.35 | 43.33333 | 1.527525 | -0.20453 |
| 0.4 | 43.66667 | 2.886751 | 1.359226 |
| 0.45 | 42.66667 | 2.886751 | 0 |
| 0.5 | 43.33333 | 3.21455 | 0.327799 |
| 0.55 | 42 | 1.732051 | -1.4825 |
| 0.6 | 42 | 2.645751 | 0.913701 |
| 0.65 | 41.33333 | 2.309401 | -0.33635 |
| 0.7 | 42 | 2.645751 | 0.33635 |
| 0.75 | 41.33333 | 2.309401 | -0.33635 |
| 0.8 | 40.66667 | 1.154701 | -1.1547 |
| 0.85 | 40.66667 | 2.081666 | 0.926965 |
| 0.9 | 40.66667 | 2.886751 | 0.805085 |
| 0.95 | 39.66667 | 2.886751 | 0 |
| 1 | 38.66667 | 1.154701 | -1.73205 |
| 1.05 | 38.33333 | 2.309401 | 1.154701 |
| 1.1 | 38 | 3.464102 | 1.154701 |
| 1.15 | 36 | 1.732051 | -1.73205 |
| 1.2 | 35.33333 | 3.21455 | 1.482499 |
| Average | | | 0.047639 |

Table 3: INSERT CAPTION HERE

# 3 Relationships

## 3.a Thickness vs. Temperature

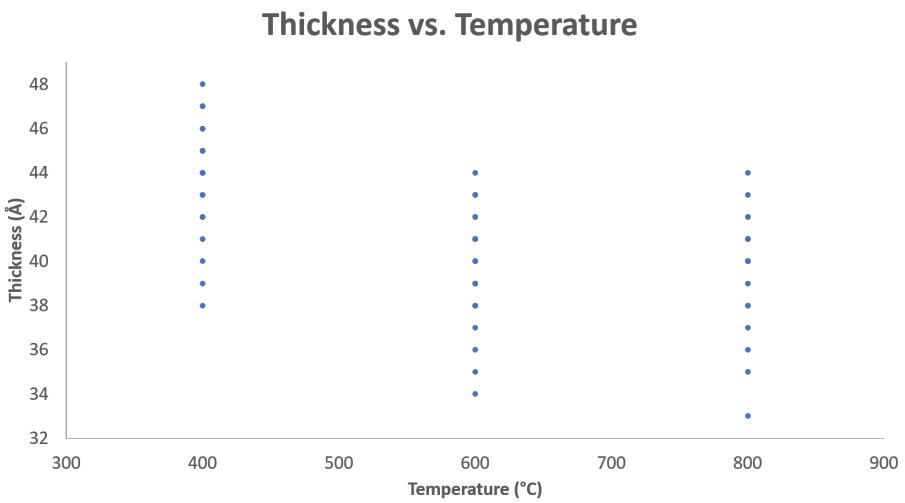


Figure 4: INSERT CAPTION HERE

## 3.b Thickness vs. Pressure by Temperature

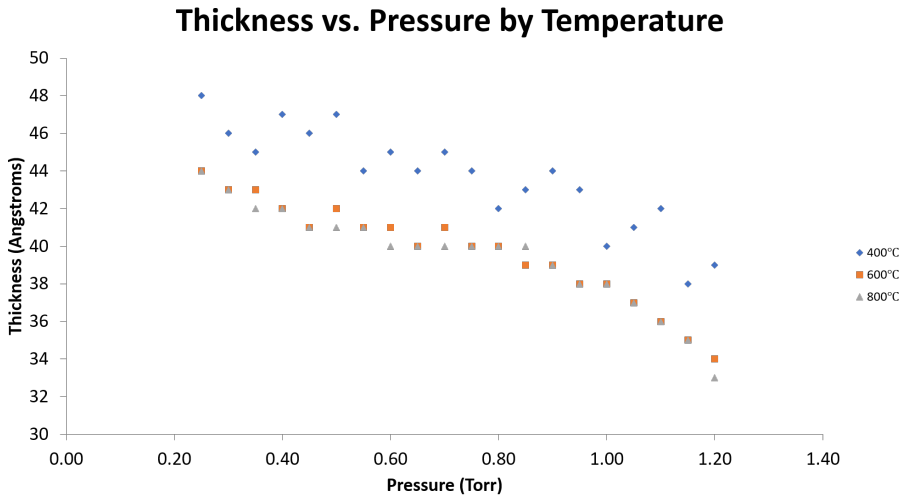


Figure 5: INSERT CAPTION HERE

### 3.c Relationship Between Thickness and Pressure for each Temperature Level

From Figure 5, we can see very clearly that as pressure is increased, the thickness of the film decreases

## 4 How should the temperature and pressure be selected to produce the thinnest possible film for the LPCVD process?

From Figures 1, 2, and 3 we can see that as the temperature is increased, the thickness of the film decreases, evidenced by the bulk of the data shifting left in the histograms as the temperature increases. By observing Tables 1 and 2, we can see that the mean and median averages for thickness also decrease as the temperature is increased. We can also see this effect in Figure 5, where the effect is evidenced by the higher temperature lines (600 °C & 800 °C) being lower than the 400 °C line. Next, when looking at the effect of pressure on the thickness of the film deposited, we can see that in Table 3, the mean thickness decreases when the pressure is increased. This effect is also seen in Figure 5, indicated by the negative slope of each line. Therefore, in order to produce the thinnest possible film for the LPCVD process, high pressure and temperature is desireable. It can be noted however, that there may be diminishing returns as higher temperature and pressure is used. For example, In Figures 1, 2, and 3, there is a more significant decrease in thickness by increasing the temperature from 400 °C to 600 °C compared to the decrease in thickness by increasing the temperature from 600 °C and 800 °C.