Consider a $<100>$ Si wafer with no native oxide. It is exposed to dry oxidation at 1000 °C for 2 hours and then wet oxidation at 1200 °C for four hours. What is its final oxide thickness? (50 points)

Rate constants for Dry Oxidation
$<100>$ Si

<table>
<thead>
<tr>
<th>Oxidation Temp (°C)</th>
<th>B (μm^3/hr)</th>
<th>B/A (μm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>0.045</td>
<td>0.667</td>
</tr>
<tr>
<td>1100</td>
<td>0.027</td>
<td>0.178</td>
</tr>
<tr>
<td>1000</td>
<td>0.0117</td>
<td>0.042</td>
</tr>
</tbody>
</table>

Ans:
Graphically:

Dry oxidation for 2 hours at 1000 °C yields ~ 0.085 μm oxide
Wet oxidation for 4 hours at 1200 °C yields ~1.8-1.8.5 μm oxide
In wet oxidation at 1200 °C, 0.085 μm will be achieved in less than 0.1 hours (~6 minutes), so there will be negligible effect of dry oxidation.

The answer is ~ 1.85-1.9 μm
2. P-type Si is doped with \( N_A = 10^{17} \text{ cm}^{-3} \) boron (B) atoms. \((E_A-E_v=0.045 \text{ eV})\) Determine the fraction of the acceptors that are ionized and the location of the Fermi energy with respect to the valence band at \( T=100 \text{ K} \) given \( m_n^* = 1.062m_0, m_p^* = 0.590m_0 \), and \( E_G=1.12 \text{ eV} \).

\[
m_o := 9.1 \cdot 10^{-31} \text{ kg} \quad k_B := 1.3806 \cdot 10^{-23} \cdot \frac{J}{K} \quad h := 6.626 \cdot 10^{-34} \cdot J \cdot s
\]

\[
T_1 := 100 \cdot K \quad \text{eV} := 1.602 \cdot 10^{-19} \cdot J
\]

\[
N_A := 10^{17} \text{ cm}^{-3} \quad g_A := 4
\]

\[
m_n := 1.062m_o \quad m_p := 0.590m_o
\]

\[
N_v := 2 \left( \frac{2 \cdot \pi \cdot k_B \cdot T_1 \cdot m_p}{h^2} \right)^{\frac{3}{2}} \quad N_v = \left(2.19 \cdot 10^{18}\right) \text{ cm}^{-3}
\]

for boron \( E_A-E_v = \quad E_A-E_v := 0.045 \cdot \text{eV} \)

\[
N_z := \frac{N_v}{g_A} \cdot \exp \left( \frac{-E_A-E_v}{k_B \cdot T_1} \right) \quad N_z = (2.949 \cdot 10^{15}) \text{ cm}^{-3}
\]

\[
p := \frac{N_z}{2} \cdot \left(1 + \frac{4 \cdot N_A}{N_z}\right)^{\frac{1}{2}} - 1 \quad p = (1.576 \cdot 10^{16}) \text{ cm}^{-3}
\]

\[
\frac{p}{N_A} = 0.158
\]

\[
E_F := -k_B \cdot T_1 \cdot \ln \left( \frac{p}{N_v} \right) \quad \frac{E_F}{k_B \cdot T_1} = 4.932 \quad E_F = 0.043 \text{ eV}
\]
3. (50 pts)

Describe the photolithography process below. Write name of the processing step under each picture. Is this a positive or negative photoresist? Why?