Increasing the number of wells increases the randomization (different pumping of wells, interface roughness), leading to a more symmetric gain curve and therefore low antiguiding.

- 4 samples – each with a 2 μm waveguide.
  - 14 QW spaced 146 nm apart
  - 10 QW spaced 210 nm
  - 5 QW spaced 475 nm
  - 5 QW spaced 100 nm, packed at center

Compare antiguiding, threshold, and intensity of each laser

For practical applications, want devices with good BQ (low α), low threshold, and high output power.

Measuring the antiguiding parameter of Quantum Well (QW) OPSLs

**QW Lasers**
- Precisely grown with Molecular Beam Epitaxy (MBE)
- InGaAsSb layers absorb pump radiation (λ ~ 1.8 μm)
- Thickness of InAs regions determines output λ (~3.9 μm)
- Dimensions: 2 mm L x 3 mm W x 150 μm T

**Antiguiding Parameter (α)**
- Describes coupling between refractive index (n) and gain (g) as pumping is varied (N).
  \[ \alpha = \frac{4n}{\lambda} \frac{\partial n}{\partial N} = -\frac{\Delta\delta}{\partial R \partial G} \]
  (where \( \delta = \frac{4mL}{\lambda} \), L is cavity length, R is the reflectivity, and G is the single pass gain.)
- Has large effect on laser beam quality (BQ), where a large α causes filament formation and poor BQ. Ideal value is 0.
- Small shifts in refractive index and large gain shifts produce small α (≤1) and good BQ.
- Symmetrical gain curve indicates a very low α.

**Measuring α**
- Use Fourier Transform Infrared (FTIR) Spectrometer to take Hakki-Paoli spectrum measurements (intensity vs. wavelength)
- Cryo-cooled and temperature controlled (~79K) for acquisitions
- Take multiple sub-threshold spectra at different pumping levels and directly measure phase shift (φ) and reflectivity x gain (RG) using a full fit equation and optimizing parameter values.
- α is the negative slope of the line fitted to ln(RG) vs. phase points

**Experiment**
- Increasing the number of wells increases the randomization (different pumping of wells, interface roughness), leading to a more symmetric gain curve and therefore low antiguiding.
- 4 samples – each with a 2 μm waveguide.
  - 14 QW spaced 146 nm apart
  - 10 QW spaced 210 nm
  - 5 QW spaced 475 nm
  - 5 QW spaced 100 nm, packed at center
- Compare antiguiding, threshold, and intensity of each laser
- For practical applications, want devices with good BQ (low α), low threshold, and high output power.

**Results**

<table>
<thead>
<tr>
<th>Device</th>
<th>Threshold (Pump current)</th>
<th>Power with pump @ 60A</th>
<th>Antiguiding Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 QW</td>
<td>12.2 amps</td>
<td>2.8 W</td>
<td>1.12</td>
</tr>
<tr>
<td>10 QW</td>
<td>11.2 amps</td>
<td>4.1 W</td>
<td>1.19</td>
</tr>
<tr>
<td>5 QW</td>
<td>12.6 amps</td>
<td>2.7 W</td>
<td>?</td>
</tr>
<tr>
<td>5 QW (Packed)</td>
<td>15.4 amps</td>
<td>0.3 W</td>
<td>?</td>
</tr>
</tbody>
</table>

- The 5 QW samples produce non-linear curves with negative antiguiding values. It is to be determined whether this strange result is real or a systematic error.
- The antiguiding values for the 10 and 14 QW samples are each very small, and not drastically different. Interestingly, the 10QW sample has the lowest threshold and highest output power.
- Future samples with 28 QWs will be created and analyzed to add further data to the comparison.
- Different structures in the 28 QW samples will also be interesting to compare.