AA Light Sources
HCL Operation

Electrical Discharge

Ne\(^{+}\) + e\(^{-}\)

Photon Specific to Excited Atom

Excitation

Relaxation

E\(_{n}\) → E\(_{o}\)

E\(_{n}\) → E\(_{o}\)
Self-Reversal

Cloud of Ground State Atoms

Normal Output  Output after Reversal
Choosing an Analytical Wavelength

Sample Concentration
Precision
Dilution Factors
Wavelength
  • Calibration Curvature
Relative Sensitivity
  • Concentration & Dilution
Relative Intensity
  • Signal to noise
<table>
<thead>
<tr>
<th>Element</th>
<th>Maximum Current mA</th>
<th>Recommended Current mA</th>
<th>Wavelength</th>
<th>Slit nm</th>
<th>Relative Sensitivity</th>
<th>Relative Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni</td>
<td>10</td>
<td>4</td>
<td>232.0</td>
<td>0.2</td>
<td>1</td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>352.5</td>
<td>0.2</td>
<td>5</td>
<td>100</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>351.5</td>
<td>0.2</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>362.5</td>
<td>0.2</td>
<td>500</td>
<td>10</td>
</tr>
<tr>
<td>Cu</td>
<td>10</td>
<td>4</td>
<td>324.8</td>
<td>0.5</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>327.4</td>
<td>0.5</td>
<td>2</td>
<td>50</td>
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<tr>
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<td></td>
<td></td>
<td>217.9</td>
<td>0.2</td>
<td>8</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>218.2</td>
<td>0.2</td>
<td>10</td>
<td>2</td>
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<tr>
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<td></td>
<td>222.6</td>
<td>0.2</td>
<td>40</td>
<td>5</td>
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<td></td>
<td></td>
<td>244.2</td>
<td>1</td>
<td>270</td>
<td>15</td>
</tr>
</tbody>
</table>
Multi Element Lamps

Available for:

Ag-Cd-Pb-Zn
Ag-Cr-Cu-Fe-Ni
Ca-Mg
Ca-Mg-Al
Co-Mo-Pb-Zn
Cu-Fe-Mn-Zn
Cu-Fe-Si-Zn
Cu-Zn
Fe-Co-Ni-Mn-Cu-Cr
Na,K
Using Multi Element Lamps

Use all normal recommended wavelengths

Refer to Data Sheet for recommended slit width

Refer to Data Sheet for recommended lamp current
The SAME current is used for ALL elements in the lamp – may need to change in the method
Multi Element Lamps

Advantages

More elements can be run without changing lamps
Lower initial cost

Disadvantages

More complex emission profile
Some secondary lines cannot be used
Some changes in sensitivity observed
Operating current may be higher
Line intensities may be lower
How Can We Make Lamps More Intense?

We could increase the lamp current - but this results in the following undesirable changes:

- The atom cloud extends beyond excitation region and cools down
- Atoms in the atom cloud may absorb light from the lamp (self-reversal)
- This causes broadening of the emission line and increased calibration curvature
The High Intensity UltrAA Lamp
The Varian UltrAA Lamp

- Anode
- Boost Anode
- Shields
- Glass Envelope
- Quartz Window
- Glass Shield
- Cathode
- Discharge Guide
- Boost Filament
2 anodes are fitted inside the UltrAA lamp:
- one for the normal HCL discharge
- the second for a separate boost discharge which is directed across the cathode

Electrons emitted by a heated filament are passed through the atom plume to re-excite the atoms by collision

This increases the emission intensity of the lamp
## UltrAA Lamps - Elements Available

### Single Element UltrAA Lamps

<table>
<thead>
<tr>
<th>Element</th>
<th>Element</th>
<th>Element</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sb</td>
<td>Cu</td>
<td>Mn</td>
<td>Si</td>
</tr>
<tr>
<td>As</td>
<td>Ge</td>
<td>Ni</td>
<td>Te</td>
</tr>
<tr>
<td>Bi</td>
<td>Au</td>
<td>Pd</td>
<td>Ti</td>
</tr>
<tr>
<td>B</td>
<td>Fe</td>
<td>Pt</td>
<td>Sn</td>
</tr>
<tr>
<td>Co</td>
<td>Pb</td>
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</tbody>
</table>

### Multi Element UltrAA Lamps

<table>
<thead>
<tr>
<th>Multi Element</th>
<th>Multi Element</th>
<th>Multi Element</th>
<th>Multi Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag-Cr-Cu-Fe-Ni</td>
<td>Cu-Fe-Mn-Zn</td>
<td>Cu-Fe-Si-Zn</td>
<td>Cu-Zn</td>
</tr>
<tr>
<td>Ag-Cd-Pb-Zn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As-Cu-Fe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca-Mg-Al</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-Mo-Pb-Zn</td>
<td></td>
<td></td>
<td>Ni-Se</td>
</tr>
</tbody>
</table>
UltrAA Lamps

Varian's boosted discharge lamps provide:

- Improvements in intensity
- Extended lifetime
- Improved sensitivity
- Improved calibration linearity
Lead Lamp Comparison

**Graph:**
- **X-axis:** Concentration
- **Y-axis:** Absorbance
- Two curves:
  - UltrAA Lamp
  - Normal HCl Lamp
Advantages of UltrAA Lamps

Reduced baseline noise

Peak to peak baseline noise for Se is 0.013 Abs. for the conventional HCL compared with 0.008 Abs. for the UltrAA Lamp.
Increased sensitivity

- Typical signals for 75 µg/L Se are illustrated
Enhanced calibration linearity

- Typical calibrations for Se using standards of 25, 50 and 75 ug/L Se are illustrated
Advantages of UltrAA Lamps

Improved Characteristic Concentrations and Detection Limits

<table>
<thead>
<tr>
<th>Element</th>
<th>Wavelength (nm)</th>
<th>UltrAA Lamp</th>
<th>Conventional HCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>193.7</td>
<td>0.25 - 0.3</td>
<td>0.31</td>
</tr>
<tr>
<td>Pb</td>
<td>283.3</td>
<td>0.15 - 0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Se</td>
<td>196.0</td>
<td>0.49 - 0.5</td>
<td>0.85 - 2.2</td>
</tr>
</tbody>
</table>

Characteristic Concentration (in µg/L with 20µL sample)

Detection Limits (3 sigma in µg/L with 20µL sample)

<table>
<thead>
<tr>
<th>Element</th>
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<th>Conventional HCL</th>
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<tbody>
<tr>
<td>As</td>
<td>193.7</td>
<td>0.35 - 0.7</td>
<td>0.3 - 1.4</td>
</tr>
<tr>
<td>Pb</td>
<td>283.3</td>
<td>0.18 - 0.23</td>
<td>0.8</td>
</tr>
<tr>
<td>Se</td>
<td>196.0</td>
<td>0.28 - 0.57</td>
<td>1.1 - 3.1</td>
</tr>
</tbody>
</table>
Gold Lamp Comparison

Absorbance vs. Concentration

- Boosted Lamp
- Normal Lamp
Comparison of Gold UltrAA and Normal Lamps at Detection Limit Levels

![Graph showing precision percentage against concentration for different lamps at various detection limits.](image-url)
Lifetime of UltrAA Lamps

- Arsenic
- Selenium
- Lead

Photomultiplier Volts vs. Operating Time Hours in mA-Hours
Key Benefits of the UltrAA Lamp

Improved analytical performance
  • Lower baseline noise levels
  • Increased sensitivity
  • Lower detection limits
  • Enhanced calibration linearity

Greater reliability
Longer lamp lifetimes