Lamp Operation and Handling

Tips for the Effective Use of Spectroscopic Sources

Dale Brabham

How many spectroscopists does it take to change a light bulb? This month's column won't answer that question, but it just may help you select the right type of spectroscopic lamp when it's time to change. Our guest author, Dale Brabham (Imaging and Sensing Technology, 300 Westinghouse Circle, Horseheads, NY 14845) provided this useful overview of common spectroscopic light sources and their proper use.

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Contributing Editor

This installment of "The Baseline" provides a basic overview of lamp types for spectroscopic applications. It should help inform the novice experimenter how to select the right source and how to take proper care of it. We classify lamps as incandescent-filament or gas-discharge because their electrical and spectral properties are distinctly different. Despite this distinction, the two types share technologies and construction so many points about handling apply to both.

FILAMENT LAMPS

Incandescent lamps. Incandescent lamps have a tungsten filament that is heated by an electric current. The filament emits blackbody-like radiation continuous in wavelength and strongly dependent on temperature. These lamps are the most stable as sources and are used as primary standards of illuminance.

Filament lamps have an essential electrical feature — the resistance of the filament increases with the current. This means properly designed lamps self-limit the amount of current drawn from a constant voltage source. Changing the source voltage changes the power in the filament (and its temperature).

When the filament is cold it has a much lower resistance and allows a surge of current when voltage is applied. This power surge can overheat the filament and cause it to fail. Because of this, calibrated sources (and other valuable sources) use power supplies that ramp the current to full value.

At the operating temperature of the filament, 2700 K, the tungsten is soft and almost fluid. So it is during operation that these lamps are most sensitive to shock and vibration. Heavy-duty lamps are designed with lower operating temperatures and heavier filaments, but these lamps also have lower efficiency in the UV/Vis region.

Filament lamps contain an inert gas, usually argon, that reduces the transfer of tungsten to the lamp wall.

Halogen lamps. Halogen lamps are incandescent lamps with halogen (bromine or iodine) added. The halogen reacts with tungsten deposited on the wall and transports it back to the filament, but for this tungsten-transport cycle to work properly, the wall and filament must operate at higher temperatures than the ordinary incandescent lamps. The efficiency and brightness are higher because the filament is warmer (3200 K).

For home and automotive use, halogen lamps are enclosed in a body that prevents you from touching the primary wall. This outer body prevents serious burns and screens out UV radiation that is sufficient enough in some types of lamps to cause severe sunburn. Many spectroscopic sources (such as FEL lamps) do not have this protection, so beware of the high temperature and sunburn hazard.

DISCHARGE LAMPS

Discharge lamps contain radiating gases that are energized by the flow of electric current. The spectral power distribution of the lamp is characteristic of the particular gases and the temperature of the plasma. The emission may be modified by a phosphor coating on the inside of the lamp.

An important property of discharge lamps is the negative current-voltage characteristic. As the current increases, resistance drops. So, unlike filament lamps, discharge lamps are not self-limiting in power. This means that unless the current is otherwise limited, the lamp will draw more and more power until something gives (a fuse blows or the lamp fails).

Discharge lamps must have a ballast (or operate on a special power supply) to limit the current. Until recently, most ballasts were made of passive elements that impeded current flow (capacitor, induc-

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tor, or resister). These ballast types interact strongly with the lamps, increasing lamp-to-lamp variation. Now, electronic ballasts are available that actively control the current level.

Ignition of discharge lamps may require an auxiliary device that provides a pulse of high voltage sufficient to create an ionic path for current flow.

Hollow cathode lamps. Hollow cathode lamps (HCLs) are in the category of glow-discharge lamps because they do not achieve an arc. The lamp is principally used in atomic absorption (AA) spectroscopy where the material of the cathode matches the analyte. The elements in the cathode are sputtered into the discharge and emit line spectra. Any gases present (such as Ar and Ne) likewise emit. As power to the lamp increases, the bandwidth of the sputtered elements broadens, and analytical sensitivity reduces. The optimum current (or power) for AA is not necessarily the maximum current recommended by the manufacturer.

For other applications, currents exceeding the recommended maximum may be acceptable. However, for many elements this maximum is related to lamp life. At excessive currents the cathode can melt or metal vapor can be flashed onto the front window.

Fluorescent lamps. Fluorescent lamps are bulky and of relatively low brightness. The temperature of the discharge gases is low (500 K) while the temperature of the electrons is high (10,000 K). The atoms are excited by high energy collisions with electrons. The scientific use of these lamps is limited to irradiation of large surfaces, such as in environmental growth chambers.

High-intensity and compact-arc lamps. High-intensity and compact-arc lamps produce the high brightness necessary for spectroscopic work. The gases are heated in the arc to the point that they are nearly the same temperature as the electrons (4000–10,000 K). The gaseous elements are excited by thermal processes. Although the emissions are characteristic of atomic spectra, the high pressures cause tremendous broadening of some lines (1–20 atm typical, >100 atm possible).

A general purpose UV/Vis source in this category is the xenon or xenon-mercury lamp, which is available in wattages ranging from 50 W to several kilowatts. Another source in this category is the deuterium lamp. Although not as bright as Xe lamps and available only in rather low wattages (30–50 W), this lamp offers a continuum in the UV range and suffers less from the kind of intensity fluctuations found in Xe arc types.

Electrodeless discharge lamps. Rather than pass electricity through the lamp, it is possible to energize the discharge with radio-frequency or microwave radiation external to the discharge body. This removes the need for electrodes, components that are particularly susceptible to degradation. These sources are excellent for atomic spectroscopy, but are available only for a limited number of elements.

Lamp usage tips

- Wear protective eye glasses and gloves to handle even cold lamps.
- Determine the right lamp for your system using source radiance to measure brightness.
- Inspect lamp regularly — check cold lamp for cracks and changes, check hot lamp with the aid of a dark glass.
- Secure a stable power supply.
- Leave the lamp on rather than turning it off and on repeatedly, but do not leave lamp unattended unless your system is well protected against failures.

IMPORTANT USAGE TIPS

Handle lamps with caution. High intensity arc and halogen lamps can have >5 atm pressure when cold. It is prudent to wear protective eye glasses and gloves to handle even cold lamps. To extend the useful life of quartz lamps do not handle the envelope with bare fingers — finger oil will etch the quartz at high temperature. If necessary, clean the outer surface with alcohol and lens tissue.

High-power designs. Higher power designs do not mean brighter sources for discharge lamps. As the wattage increases so does the arc diameter. The brightness can actually decrease for higher wattage types. Use source radiance as the measure of brightness to determine the right lamp for maximum throughput in your system.

Inspection. Examine the lamps you use. Inspect the cold lamp regularly for formation of cracks and changes. Inspect the hot lamp with the aid of a dark glass. For example, in a halogen lamp, you might see the adjacent coils touching and shorting out, rendering the source unpredictable and unstable.

Power supplies. Remember that the stability of your lamp is no better than the stability of your power supply (or ballast). Cheap, poorly made products will be a constant source of frustration. It is better to spend more on this item when stability is important.

Wear and tear. Finally, ignition and warm-up take a toll on both filament and discharge lamps. It is usually better to leave the lamp on for a time (up to 1 h) than to turn it off and back on. However, it is also unwise to leave high-wattage or high-pressure lamps unattended unless your system is well protected against failures, particularly nonpassive ones.

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