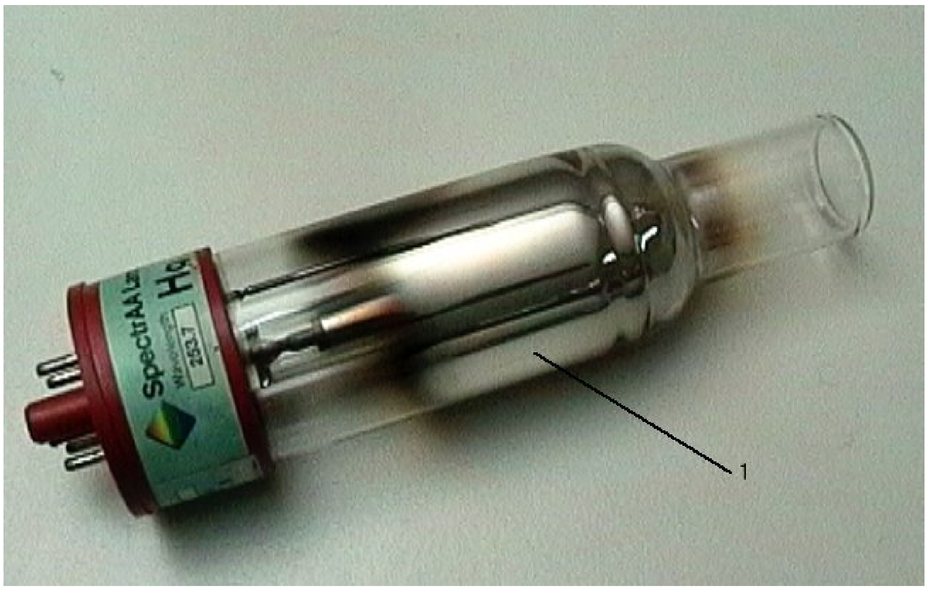
Hollow Cathode Lamp Frequently Asked Questions

Why does a new Varian lamp look used?

- Processing is a vital step in lamp production, which aims to remove impurities from the lamp. During processing, the cathode material is heat treated under vacuum to ensure that all absorbed gases are removed. During this purification stage, a layer of the cathode material is deposited on the inside of the glass envelope of the lamp. The amount of material deposited varies, depending on the volatility of the element.
- The extended processing cycle and the use of specially pure materials ensures dependable performance from Varian hollow cathode lamps.



1. Some hollow cathode lamps have a thin layer of cathode material deposited on the inside of the glass envelope

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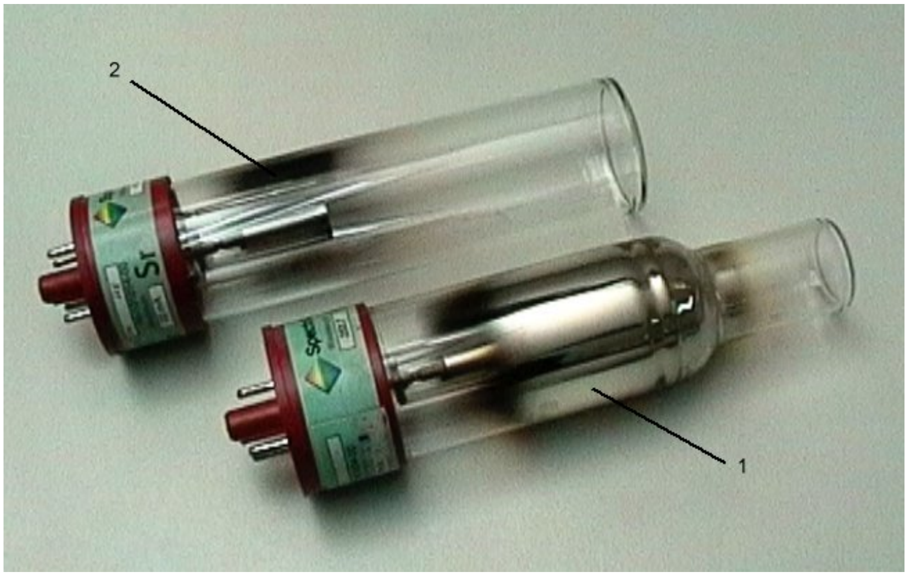
What is the black spot?

- The black spot is produced deliberately. This deposit on the inner glass envelope ensures that the fill gas is free of impurities and contributes to the long shelf-life of Varian lamps.
- During processing, we subject the zirconium anode to ion bombardment. This vaporizes a small amount of anode material and deposits it on the lamp envelope near the anode, creating the characteristic black patch. This zirconium metal film is highly reactive and acts as a very efficient scavenger of traces of oxygen and other impurity gases that might otherwise reduce the lifetime of the lamp. It is called a *"getter"*.
- The black *"getter"* spot behind the anode helps to prolong the useful life of the lamp - and also ensures continued spectral purity throughout the life of the lamp.



- 1. The thin layer of cathode material deposited onto the inside surface of the glass envelope is noticeably different to the black *"getter"* spot.
- 2. Black *"getter"* spot

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Why treat the cathode?

- When lamps are fully assembled, they are subjected to an aging process during which the lamp is operated under controlled conditions. This ensures that the lamp is ready for immediate use when it is taken out of its shipping box. All *"settling in"* of the lamp is completed before the lamp leaves the factory. After aging, the lamp is subjected to thorough testing. No lamp leaves our factory without having satisfied our demanding test standards for intensity and stability.
- See also What type of testing do lamps have during production?

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Does the flickering glow around the anode mean that the lamp is faulty?

- No. This is a consequence of current flowing through low-pressure gas. It has no effect on the atom plume. *"Lamp flicker"* applies only to emission from the cathode. Most emission lines emitted by the lamp are in the UV region, which is not visible to the naked eye. Use the % gain (or EHT value) displayed at the Optimize page to determine whether a lamp is faulty. Good lamps, properly aligned, should have a low % gain value (or low EHT value) and a fairly steady emission signal. Danger signs are a high % gain value (or high EHT value) and a wildly fluctuating emission signal.
- See also How do you know when a lamp is worn out?

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What is the purpose of the fill gas?

- The fill gas allows the sputtering of the cathode material. The fill gas is ionized when a high voltage is applied between the electrodes. These ions are accelerated towards the cathode. When they hit the cathode surface, they knock metals atoms loose. The atom plume thus formed is excited by further collisions with other high energy particles during this process. The excited atoms are unstable and relax back to their ground state, emitting radiation characteristic of that element. For most elements, more than one analytically useful spectral line is generated.

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How much fill gas is added?

- After the lamp has been processed, it is evacuated and back-filled with high-purity neon or argon. The fill gas pressure is carefully selected to give the optimum balance between lamp intensity and useful operating life. Argon is only used when a neon spectral line would interfere with the wavelength for the selected element.

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What type of testing do lamps have during production?

- All lamps are tested to confirm that the desired emission spectrum exceeds an acceptable value and that the lamp provides good stability (low drift). No lamp leaves our factory without having satisfied our demanding test standards. These tests ensure that users receive lamps of the highest quality with excellent sensitivity and optimum signal-to-noise performance throughout the life of the lamp.
- Specifically, each lamp receives the following testing:

- High voltage isolation,
- Strike voltage,
- Performance (EHT and noise),
- Drift test (lamp stability), and
- Lamp recognition (for coded lamps).

- Click here to see typical results from our lamp stability test.

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Do any Varian lamps have solid cathodes?

- Cathodes for lamps such as Cu, Fe, Ni and Al are machined from the solid metal. Lamps such as V, Pd, Au and Ir have sheet metal inserts. These are all single element lamps. There are a variety of multi element lamps available with up to six elements incorporated into a single lamp. Multi element lamps have similar performance to a single element lamp in the convenience of one lamp.

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Do other elements in the cathode affect lifetime?

- No. Lamps should exceed 5000 mA hours of operation regardless of the element actually determined.

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Are there any performance compromises with multi-element lamps?

- Multi-element lamps can provide similar performance to that obtained using single element lamps. Depending on the lamp, there may be some trade-off in calibration graph curvature and intensity of emission. In many instances, these 2 effects can be overcome by using UltrAA (high intensity boosted discharge) lamps. The other compromise is that some wavelengths may not be available in a multi-element lamp because of spectral interferences.

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Can all lines be used in multi element lamps? Is there any spectral interference?

- All the usual primary lines may be used with Varian multi-element lamps,. The primary lines have been checked for spectral interference and minimal or no interference has been noted. The secondary lines have not been checked and for this reason only, the use of secondary lines is not recommended. Where there are interferences, the use of UltrAA (high intensity boosted discharge) lamps can help to minimize these effects.

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Known spectral interferences

- **Ag/Cd/Pb/Zn:**
  A weak silver ion line close to Pb 217.0nm. The calibration graph is a little less linear at higher absorbances compared with that obtained from the single element lamp.

- **Al/Ca/Mg:**
  None known

- **Co/Cr/Cu/Fe/Mn/Ni:**
  Weak Mn lines close to Cu 324.7nm and 327.4nm lines. The Mn 357.788 nm line also interferes with the Cr 357.868 nm line. There are also lines of Ni, Co, Cr and Mn within +/- 0.1 nm of the Fe 248.327 nm line which increases calibration curvature. The calibration lines are more asymptotic at higher absorbances compared with that obtained from the single element lamp. The poorer calibration linearity is the price that has to be paid for the convenience of having six elements in one lamp.

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Can spectral interferences be overcome?

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- Yes. The use of UltrAA (high intensity boosted discharge) lamps minimizes these effects.

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Is there a compromise in intensity with the Ag/Cd/Pb/Zn or Al/Ca/Mg multi element lamps?

- Ca, Cd, Mg, Pb and Zn are present in the optimum solid concentration. The respective intensities are comparable to those of the single element lamps. The relative intensities of Al and Ag are less compared with the single element versions. These elements are so intense anyway that the reduction has no real practical disadvantage.

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Is there a compromise in intensity with the Co/Cr/Cu/Fe/Mn/Ni multi element lamps?

- The atom plume of this lamp contains all the elements so the intensity of each element will be less compared with the corresponding single element lamp. This does not raise the shot noise level. In flame work, flame flicker is the dominant noise factor. This lamp is very popular because it allows the practical determination of six elements with one lamp.

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Why do lamps wear out?

- The most common cause of lamp failure is that which claims most pieces of scientific glassware: physical damage from rough handling or accidents.
- Even the most carefully handled lamp will eventually fail to operate however, as the fill gas is absorbed into the internal surfaces of the lamp. In time, the pressure of the fill gas will fall to a level that can no longer sustain the hollow cathode discharge. This will be manifested in both an erratic cathode discharge or complete failure to *"strike"*.
- Operating the lamp at excessive lamp currents will accelerate this process. Attempts to run a lamp at extreme currents can cause the cathode to overheat, and this can damage the cathode. This is especially true for the more volatile elements.
- To get the most out of a lamp, handle it with care and do not exceed the recommended operating current.

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How do you know when a lamp is worn out?

- The best indication of a lamp failing is an increase in the % gain (or EHT) value (displayed at the Optimize page) when compared with the value obtained when the lamp was new. The % gain and EHT values vary from one element to another, so a typical elevated figure cannot be quoted. The best way to determine whether the lamp is deteriorating is to monitor the % gain and the EHT value from new.
- Looking at the cathode can also give an indication on deterioration. After prolonged use, non cathode metal may be deposited at the end of the cathode as crystals of metal, and this can impede the release of cathode element and significantly reduce the beam intensity.
- See also What are the typical % gain or EHT values for hollow cathode lamps?

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What are the typical lifetimes of a hollow cathode lamp?

- Typically lamps last at least 50 % longer than the warranted period - this means typical lifetime is ~ 8000 mA hours. This is a general indication only. Some of the lamps that have been lifetime tested have lasted well in excess of this period. For example, multi-element lamps for Pb and Ag, Cd, Pb and Zn have surpassed 12000 mA hours.
- Click here to see typical results from lamp lifetime tests.

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Do you need further information on lamp construction and operation?

- Please see Features and Operation of Hollow Cathode Lamps and Deuterium Lamps.

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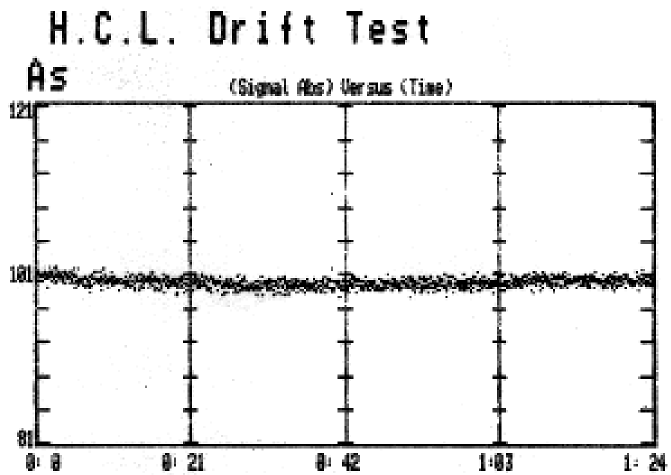
Typical drift test results

Arsenic (As) hollow cathode lamp



This trace shows the variation in emission intensity from the lamp with time. The test is conducted over 1 hour 24 minutes. The steady trace demonstrates the superb stability and low drift that are produced by Varian hollow cathode lamps (after a suitable warm-up period).

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