Maintenance Tips for the SPECTOR® Optical Coating

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Introduction

As the **SPECTOR** system is used to produce precise, high quality optical coatings, several fundamental practices need to be undertaken to ensure a successful run. In order to maximize yield, examining various issues related to the system process is necessary.

Particulate Reduction

As the **SPECTOR** system ages, the surfaces near the substrate become coated with film consisting of Ta_2O_5 and SiO_2. Depending upon the deposition conditions used, the film typically has a compressive stress of about 350 MPa. Consequently, as this film reaches a critical thickness, it detaches from the surface (e.g., liner or shield) and becomes a particulate that falls to the bottom of the vacuum chamber. The critical thickness depends upon what the surface characteristics are. For example, chamber liners that have a bead-blasted finish can usually withstand about 500 hours of deposition before particulates generate. On the other hand, highly polished hardware normally takes only 100 hours of operation before particulates begin to generate.

In order to minimize particulate production, it is recommended that:

- Chamber liners are cleaned every 500 hours.
- The door O-ring seal is wiped with a lint-free towel before every run to remove any particulates.
- The inside of the chamber is vacuum cleaned every 100 hours or so.
- Critical hardware (i.e., near the substrate) should be bead-blasted; however, excessive bead-blasting leads to longer pump down times.

Water Vapor Reduction

When the **SPECTOR** system is opened for servicing or substrate loading, water vapor is absorbed on the surfaces inside the system. The amount of water vapor absorbed depends upon how long the system is open, as well as the relative humidity of the laboratory. Too much water vapor in the system leads to absorption or scattering losses in the optical coatings. Baking out the system with quartz lamps reduces the water vapor. For quick calibrations of system rate and uniformity, we recommend a bake at 80° C for 15 minutes and then pump down to 8×10^{-7} Torr. For important 200, 100 and 50 GHz filter runs, bake the system at 150° C for 1.5 hours and then pump down to 3×10^{-7} Torr. Bake out procedures can be easily modified using the ***SOURCERER***® software.

Typical Pump Down Times for Various Bake Out Procedures (clean system)

- Atmosphere to 8 x 10^{-7} Torr (80° C for 15 minutes bake) requires about 45 minutes
- Atmosphere to 3 x 10^{-7} Torr (150° C for 1.5 hours bake) requires about 3 hours.

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Substrate Cleaning

For optics requiring the lowest of losses, the substrates should have an optical finish before coating. Even with the most highly polished substrates, the surface can become contaminated from particulates, water vapor and fingerprints if care is not taken. Isopropyl alcohol and dry nitrogen work well to remove particulates and some fingerprints. However, alcohol, like water vapor, may leave a residue on the substrate. This residue may be removed from the substrate by completing a bake out, as previously described, or executing an etch with the 12 cm RF Ion Assist Beam.

Etching or precleaning the substrates with the 12 cm RF Ion Assist Beam should be done with care. The assist beam can deliver low energy argon ions that sputter the surface of the substrate and remove the first few hundred angstroms of native oxide (or residue from alcohol). At higher energies more material is removed. However, the substrate may undergo a change in the surface texture or even a thermal stress failure. The conditions listed below remove about 10 angstroms of glass per minute. This type of etching also promotes adhesion.

Substrate Etch

- Source Flow: 9 sccm argon
- Beam Current: 75 mA
- Beam Voltage: 250 V
- Accel Voltage: 500 V
- Grids: Generation 3

Anti-Reflecting Coatings

High quality anti-reflecting (AR) coatings are essential for the operation of the optical monitor system (OMS). Substrates used for 200, 100 and 50 GHz filters require an AR coating prior to deposition of the filter. The **SPECTOR** system with an OMS can be used to deposit high quality AR coatings. The graph below demonstrates the quality of the AR coating for the first layer of a filter run. An AR coating deposited on time and power has more amplitude fluctuations (at low frequencies) than the AR coating deposited using the OMS control.

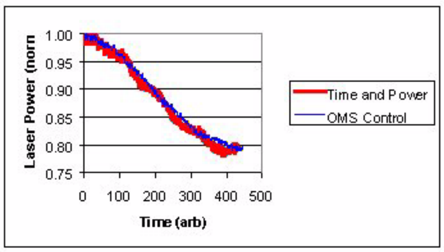

Figure 1 Time and Power and OMS Control

Veeco is currently designing and fabricating an AR coating tool. This tool will use an electron beam source for material deposition and an ion beam source for the assist, have a 26 inch diameter coating area and an optical monitor will control the deposition.

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Uniformity Calibration

To ensure a high yield of 200, 100 and 50 GHz filters, calibration of the system uniformity is vital. There are several different methods for calibrating the uniformity. These include, but are not limited to, the deposition of a single layer or a simple filter. Single cavity Fabry-Perot type filters offer an excellent quick check on how center wavelength will vary with radial position. These filters can be at half of the wavelengths of interest (e.g., 775 nm) to reduce calibration time on a **SPECTOR** system.

With the **SPECTOR** system's inherent versatility, it is essential to calibrate the system using the same conditions that will be used to deposit the final product. The recipe templates in ***SOURCERER*** capture most of the critical deposition conditions. However, other items, such as the heater condition or state of the shutter, position are important for checking the calibration and final product deposition runs. It has been established that these items will influence the uniformity.

Uniformity stability is also very important during the deposition of narrow band pass filters. The uniformity on a **SPECTOR** system may change when installing new targets or grids. We recommend conditioning newly installed targets for about 1 hour under the same deposition parameters as the planned filter run before depositing a coating. In a similar fashion, condition new or recently cleaned grids for about 1 hour before depositing any coating.

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Wobble Reduction

Currently, the high speed fixture used to support the 12" disks has a wobble of less than 0.02°. This usually produces an azimuthal center wavelength shift of about 0.6 nm on 200 GHz type filters. Presently, our Engineering Department is working on a next generation high speed fixture that will have a wobble of less than 0.01°, which will give an azimuthal center wavelength shift less than 0.2 nm.

Even when improved high speed fixture hardware is used, it is important to care for the high speed fixture. Particulates from the system (see previous section) may accumulate on the interface surfaces between the substrate and the high speed fixture. It is critical to remove all particulates from the shaft, collar and substrate prior to the substrate being mounted in the **SPECTOR** system. Keeping the high speed fixture assembly clean from particulates ensures a reduced wobble and an improved yield.

The substrate wobble may be checked using a visible laser directed at the substrate surface. The reflected beam creates an orbiting spot. The wobble (x) can be estimated from $x = \frac{\tan\text{-}1\ (d/1)}{2}$ where *d* is the diameter of the orbiting spot and *l* is the distance between the substrate and the spot. More accurate measurements are performed if *l* is very large, about 30 feet.

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Ask THE WIZARD

Q: Why are AR coatings used on substrates prior to filter deposition?

A: The substrate temperature is about 150° C during deposition of a filter. Depending upon the deposition conditions, there could be a 20° C change in temperature when different materials are deposited. This fluctuation in temperature results in distortion of the substrate dimensions due to the coefficient of thermal expansion. When using an optical monitor with a tunable laser, if the substrate dimensions change, an etalon effect (internal reflections) will distort the signal. An AR coating minimizes this effect on the substrate.

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