Instrument Science Report WFC3 2001-018

Selection of the window coatings for the WFC3/IR channel

Massimo Stiavelli, STScI,
Joseph Sullivan, BATC,
Christopher Hanley, STScI
July 30, 2001

Abstract
This ISR briefly documents the choice of coating for the WFC3/IR detector window. We also show that the expected throughput of the IR channel optics exceeds the CEI Specs requirement over the entire wavelength range.

1. Introduction

The WFC3/IR channel contains two transmissive elements: the window of the detector package and the Refractive Corrector Plate (RCP). These elements affect the instrument throughput in two ways: *i)* by introducing reflection losses at their surface, and *ii)* by absorbing light at some preferential wavelength. Both issues have been addressed in the design of WFC3/IR. Reflection losses are minimized by a suitable choice of coatings as described in Section 2 of this ISR. Absorption losses, most notably the water absorption feature at 1.383 μm are minimized by a suitable selection of IR glasses as described in Section 3. In Section 4 we compute the expected throughput of the instrument optics.

2. IR glasses

For the IR channel the selected glass was Suprasil 311. The RCP is 7 mm thick while the detector package window is 4 mm thick. The corresponding transmittance of non-coated Suprasil 311 is shown in Figures 1 and 2. The dip at 1.383 μm is due to residual water absorption in the glass and becomes more pronounced when the glass thickness increases. The overall low value of transmittance is due to the lack of an AR coating on these elements. The transmittance of the flight elements will be higher since they are coated by using the shifted E-beam coating described in the next section.

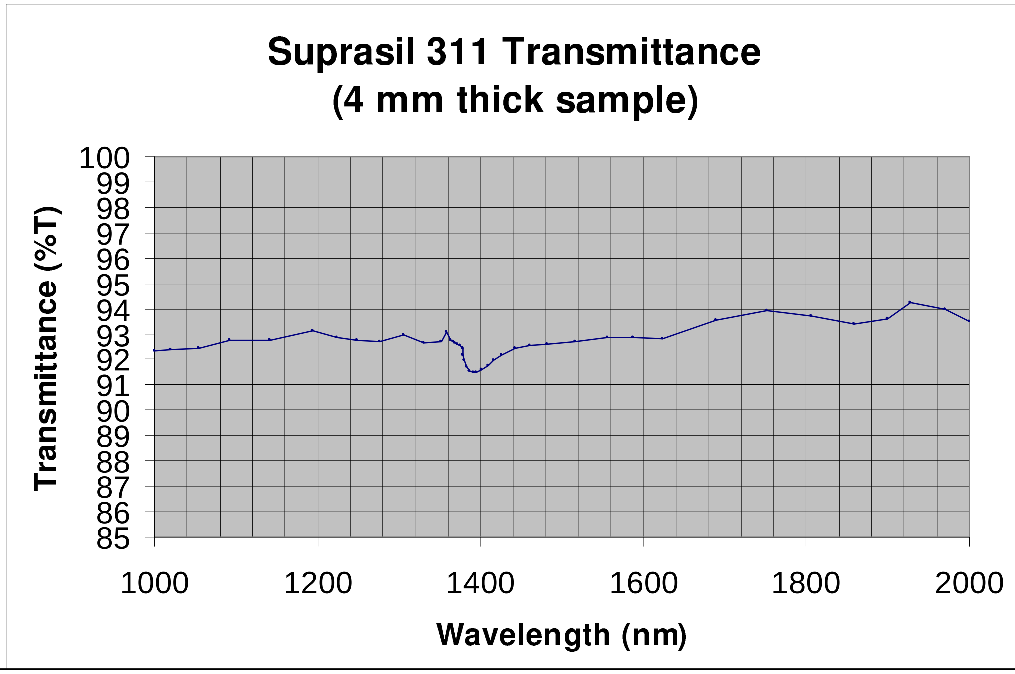

Figure 1 : transmittance of a 4 mm thick window of Suprasil 311 without AR coating. This thickness is representative of the detector window. The dip at about 1.383 µm is due to residual water absorption in the glass.

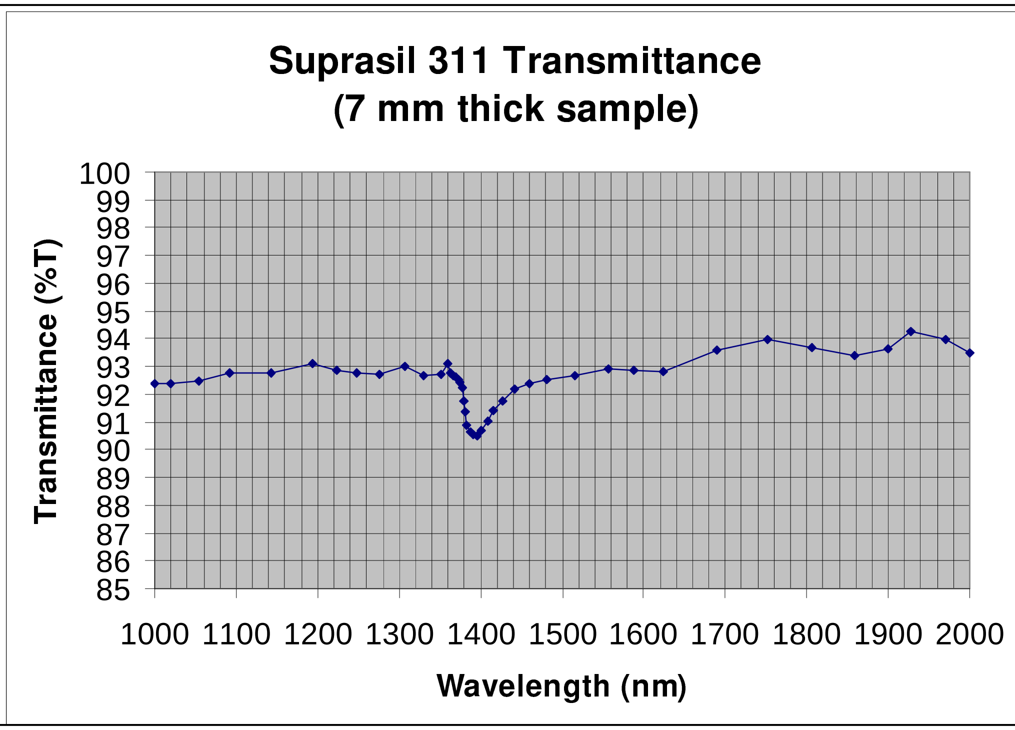

Figure 2 : transmittance of a 7 mm thick window of Suprasil without AR coating. This thickness is representative of the RCP. Notice how the increased thickness increases the depth of the water dip at 1.383 µm without changing the overall transmittance (dominated by surface effects).

3. The anti-reflection coatings

The options for anti-reflection (AR) coatings for the WFC3/IR transmissive elements are shown in Figure 1. In the figure E-beam and Ion beam refer to the coating procedures, namely electron beam evaporated or ion beam sputtering, respectively. For the shifted E-beam coating we show the model prediction (model by JS). The MgF_2 option has the lowest risk and a featureless transmittance but also the highest reflectivity among the options considered here. Both Ion Beam and E-beam coating options display many features and exceed at some wavelengths 99 per cent transmittance but dip down to 96 per cent at other wavelengths. Of these the Ion Beam is the highest risk. Thus, the best compromise between risk and performance appears to be the shifted E-beam coating. A similar coating was chosen by ACS for their WFC channel.

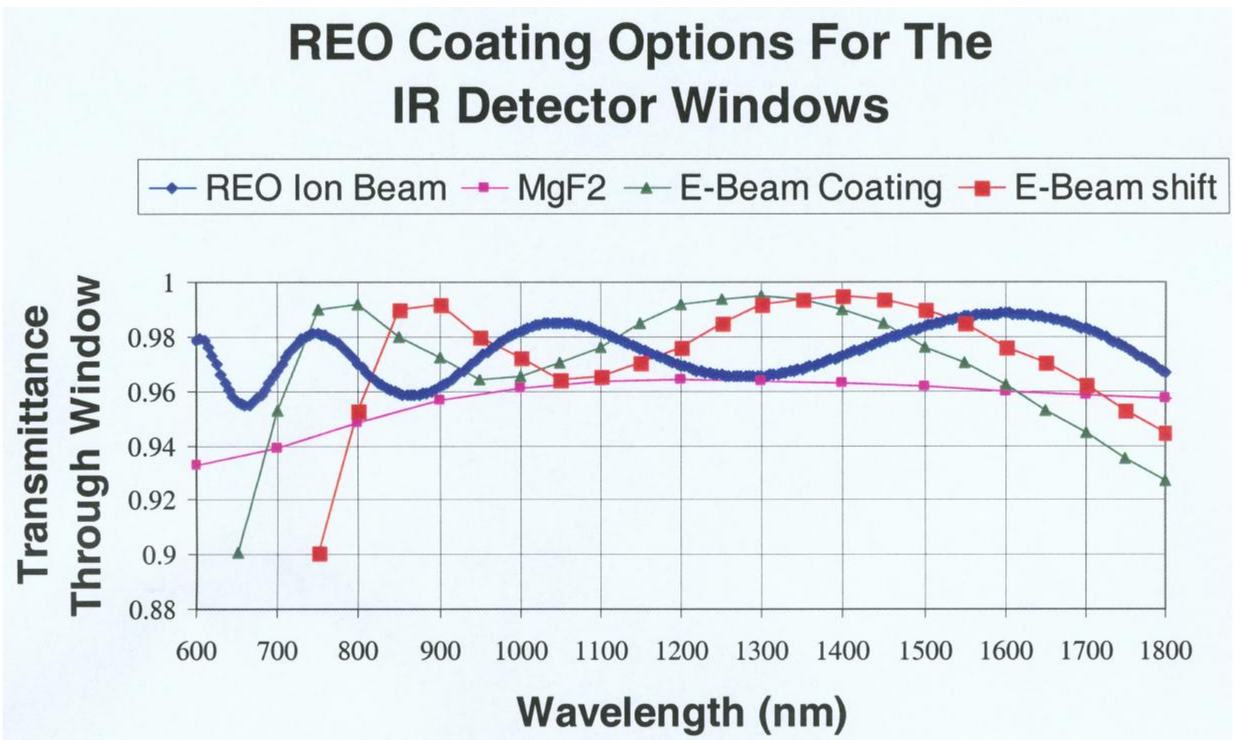

Figure 3 : transmittance as a function of wavelength of the various coating options for the IR channel window. The shifted E-beam coating (large red squares) is the best compromise between transmittance and risk.

The shifted E-beam coating was modeled more accurately using the REO design model. The more sophisticated model is shown in Figure 4 and agrees with (or is marginally better than) the prediction of Figure 3.

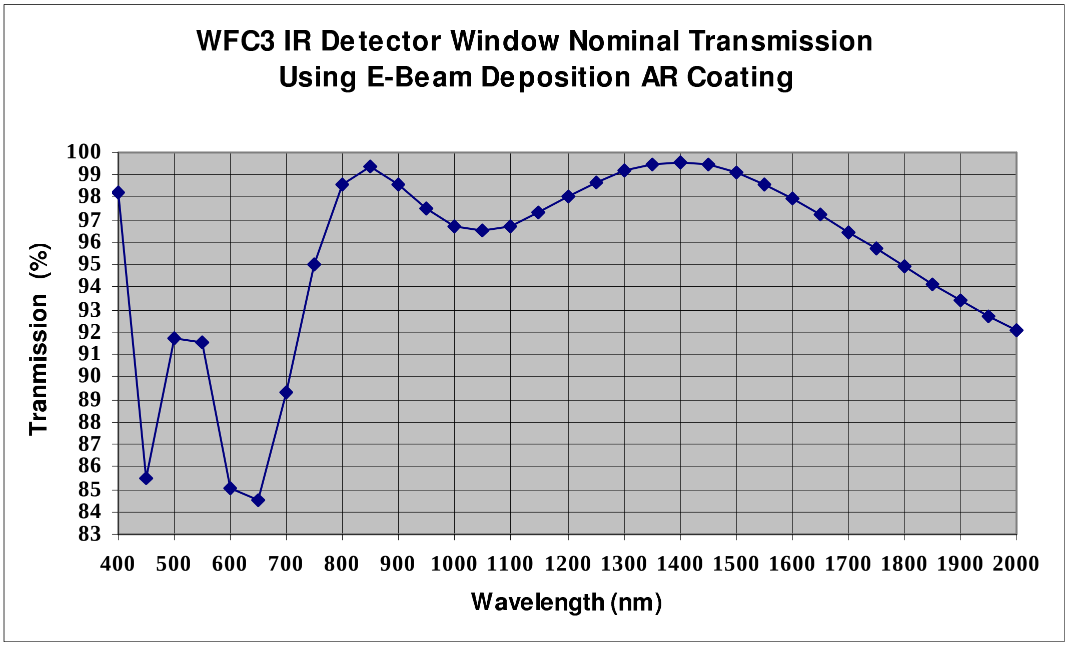

Figure 4 : shifted E-beam coating transmittance as derived from the detailed REO design model. These values are in agreement or exceed the predictions of the simple model of Figure 3.

4. Instrument Throughput

Once window material and coatings are selected, it is easy to compute the expected instrument throughput for the IR channel. The instrument model includes the pick-off mirror, the detector package window, the RCP, 4 other Denton-coated silver mirrors, and the cold stop loss (assumed to be 7 per cent over the obscuration loss included in the OTA). We have accounted separately for the OTA and its obscuration. The throughput curves do not include the OTA and are shown with and without cold stop loss are shown in Figure 5. We also show the CEI Spec (4.4.2.2, throughput without cold stop) for reference. The instrument has a throughput always exceeding 70 per cent and peaking above 80 per cent at 1.2-1.6 μm.

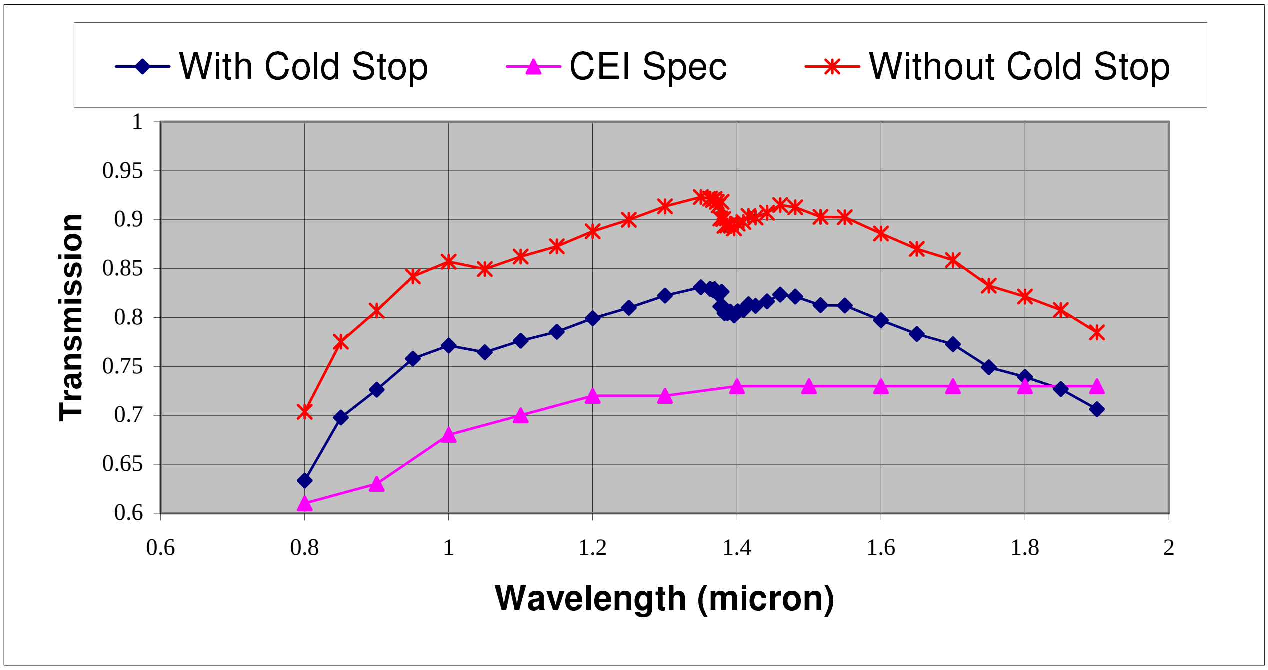

Figure 5 : predicted throughput of the WFC3 IR channel including (blue diamonds) or excluding (red crosses) the cold stop loss but excluding the OTA and the detector. The throughput remains above CEI Specifications (purple triangles) over the whole wavelength range of the instrument (0.85-1.7 µm).