



Science &amp; Technology Facilities Council

Central Laser Facility

## D100X 100J Large Aperture Sapphire Window Specification

Specification written by	Paul Mason	Specification issued by	Trevor Winstone
Signature		Signature	
Date of issue	9 <sup>th</sup> March 2016	Checklist complete	Yes
Description	Uncoated single-crystal sapphire window 165 mm diameter		
Part number	Each optic set shall have a unique part number of the form: <b>D100X-W-SAC-165-HPUC-20-16</b>		
Serial Number	Each individual optic shall have a unique (non-removable) serial number, marked in block capitals (not hand written) on the edge surface and based on the part number above: <b>D100X-W-SAC-165-HPUC-20-16 / X</b> where <b>X</b> is the unique optic number		
Drawing number	This specification should be read in conjunction with RAL drawing number <b>SL-1033209-A</b>		
Material			
Type	Single-crystal sapphire		
Grade	High optical quality laser grade		
Orientation	Z-cut (c-axis perpendicular to plane optical faces)		
Critical Properties	Bubbles and inclusions: <ul style="list-style-type: none"><li>Total cross-section area of bubbles or inclusions within volume of 100 cm<sup>3</sup>, with an individual bubble size of &lt; 100 micron, to be less than or equal to 0.03 mm<sup>2</sup></li></ul> Striae: <ul style="list-style-type: none"><li>No striae detectable by a shadow graph test</li></ul> Homogeneity: <ul style="list-style-type: none"><li>&lt; 1 ppm</li></ul>		
Dimensions			
Shape	Circular		
Size (mm)	Diameter = 165.00 (+0.00, -0.25) mm Thickness = 20.00 (+0.00, -0.10) mm		
Edge chamfer	0.5 mm nominal 45 degree fine ground chamfer on all edges		
Parallelism	≤ 10 arc sec		

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Operational Information	
Operational wavelength	920 nm to 1040 nm
Operational aperture	Minimum 140 mm diameter centred on full diameter
Operating temperature	Temperatures from 100 K to 310 K All optical specifications to apply across this temperature range
Operating environment	High average power and high pulse energy laser operation in vacuum and pressurised (up to 20 bara) helium environment. Storage in ambient air and dry nitrogen
Surface Specification (Front & Rear surfaces )	
Finish	Laser grade polish
Roughness	Substrates to be polished by a process that typically yields < 0.8 nm RMS for scale lengths from 1 micron to 80 micron
Scratch/dig	10/5 consistent with MIL standard MIL-O-13830 within operational aperture
Flatness	$\leq 63$ nm peak-to-valley (equivalent $\Lambda/10$ @ 633 nm) over operational aperture
Flatness Gradient	$\leq 63$ nm per cm (equivalent $\Lambda/10$ per cm @ 633 nm) over operational aperture
Surface Specification (Edge)	
Finish	Fine ground finish
Transmissive Specification	
Transmitted wave front	$\leq 63$ nm peak-to-valley (equivalent $\Lambda/10$ @ 633 nm) in single-pass over operational aperture
Transmitted wave front gradient	$\leq 63$ nm per cm (equivalent $\Lambda/10$ per cm @ 633 nm) in single-pass over operational aperture
Precedence	Transmitted wave front takes precedence over surface flatness
Spatial wave front uniformity	<p>A power spectral density (PSD) analysis for the transmitted wave front should be undertaken over the spatial frequency (F) range <math>0.1 \text{ mm}^{-1}</math> to <math>1 \text{ mm}^{-1}</math> for which the PSD will be less than a defined upper limit. The upper limit value is defined by the following expression:</p> $\text{Upper limit on PSD} = F^{-1.5}$ <p>Where PSD is measured in units of <math>\text{nm}^2/\text{mm}</math> and F is measured in unit's <math>\text{mm}^{-1}</math>. Further information about the PSD analysis can be provided by STFC upon request.</p>
Coating Specification (Front and Rear surfaces)	
Coating type	Uncoated
Markings	
Permanent identifier	Each optic must have a unique (non-removable) serial number, as defined above, marked in block capitals (not handwritten) on the edge surface

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<b>Packaging</b>	
<b>Cleaning</b>	Each optic must be cleaned prior to packaging and packed in an ISO 6 (Class 1,000) or better cleanroom area
<b>Description</b>	Finished optics must be packaged in non-contact containers suitable for the mode of delivery and chosen to ensure safe transport, where the optics are held at the edges and without any packaging material in contact with the optic faces. Container packaging must be marked fragile optical components
<b>Identifiers</b>	The unique serial number must be added to the outside of each individual package with a list of all serial numbers being delivered shown on the delivery note. A label must be added to the outer packaging indicating: "Contents only to be opened in a cleanroom by technical staff familiar with the nature of the contents"
<b>Certification</b>	
<b>Interferograms</b>	Interferometric test data will be provided for each optic supplied in both hard and soft copy with unique serial number identified. Soft copies of interferometric data shall be provided in '.dat' file format (or similar) compatible with Zygo MetroProX (MX) analysis software. This will include surface flatness and surface roughness of both front and rear polished surfaces, transmitted wave front and PSD analysis. Interferograms will be measured using phase-shifting interferometry
<b>Inspection</b>	Inspection of the optic under a bright visible light source shall be done prior to shipment to confirm optic is clean and free from surface or bulk imperfections. Inspection photographs will be provided with each optic.
<b>Report</b>	<p>A quality control data sheet for each optic will be provided, including:</p> <ul style="list-style-type: none"> <li>• Defect map</li> <li>• Interferometric test data</li> <li>• Inspection photographs</li> <li>• Material certification (if appropriate)</li> <li>• Comparison of measured performance against specification</li> </ul> <p>The report shall include details of all measurement equipment used and show the unique serial number of the optic tested. A paper copy of the report will be supplied with the optics and an electronic copy emailed to <a href="mailto:nathan.sample@stfc.ac.uk">nathan.sample@stfc.ac.uk</a></p>

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