ESS

Workshop on the engineering of in-monolith neutron optics

Part I

Report and Recommendations

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5/3/2017

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Held at PSI 11 April 2017

Objective

Over the last couple of months, in conjunction with instrument teams, and with input from the guide manufactures we at ESS have developed a conceptual engineering design for all of the in-monolith optics at the facility in the objective ensuring for all installations high and reliable performance, manufacturability, effective integration into in-monolith systems and simplified certification.

At present having just completed the first phase of engineering design we now seek the experience and knowledge of the broader community to critically review and input to the engineering aspects of our design before we commit to its detailed implementation on all 16 beamlines.

To conduct the review we have assembled a panel of scientists & engineers with recent experience and responsibility for the specification, design and construction of similar systems from PSI, TUM and LLB

Topics

From the ESS's perspective the engineering aspects where we currently see the communities input as most critical in a the areas of;

- Radiation heating and the thermal management strategies.
- Long term radiation, thermal and mechanical damage to substrates &coatings
- The criticality of operating atmospheres (vacuum, low pressure helium)
- Sealing and windows
- Alignment strategy
- Risk mitigation (Contamination, leakage, Failure)
- End of life waste management

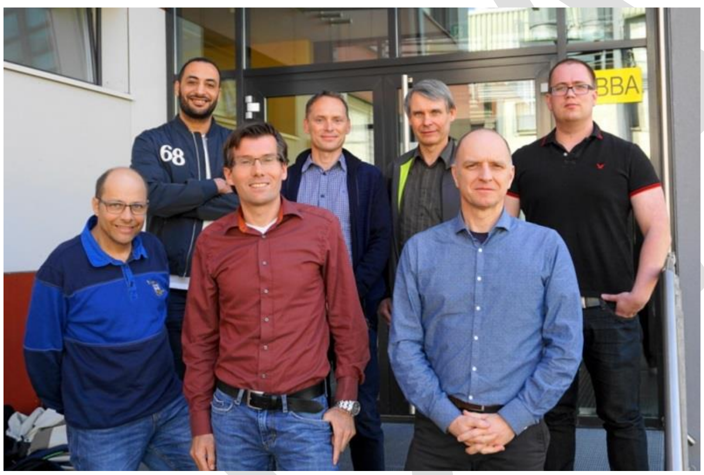
Contents

Panel

Name	Role	Facility
Phil Bentley	Presenter	ESS
Iain sutton	Presenter	ESS
Erik Nilsson	Participant	ESS
Talal Ossman	Participant	ESS
Dr Uwe Filges	Panel	PSS
Dr Peter Link	Panel Chair	FRM2-TUM
Christian Breunig	Panel	FRM2-TUM
Dr MENELLE Alain	Panel	LLB
Dr Michael Kreuz	Panel	ILL
Dr CALZAVARA Yoann	Panel	ILL

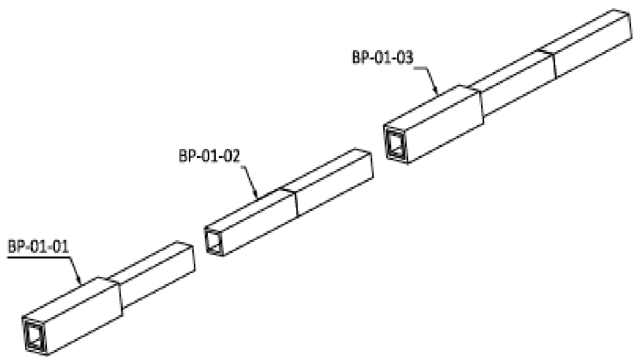
Absent

- Participation was declined by the ILL
- Phil Bentley did not attend



Recommendations from panel

Architecture



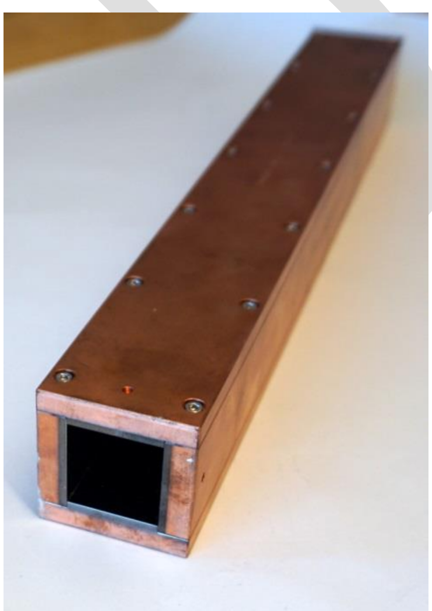
Recommendation

The proposed three-sectioned NBOA is endorsed by the panel.

2 millimeters of gap around the NBOA is considered largely sufficient for alignment between optical units and to the insert access.

Two chicanes should be incorporated to reduce streaming paths. Chicanes should be separated by at least 1000mm. The height of these steps should be calculated to ensure overlap of at least five times the gap in the worst case installed scenario.

Substrate Material



Recommendation

The use of copper as substrate for coating and for construction is supported for the reasons proposed.

There is sufficient past experience with this material in high radiation environments to believe that it will meet the desired service life requirements.

The suitability of this material as a support for high performance coatings has been demonstrated by both research facility based and commercial coating companies.

Coatings

Recommendation

The proposal to employ high M-value coatings and to employ copper substrates in this radiation field is a 'first of kind' which implies a degree of risk. Despite the number of short term tests which have been carried out into the performance of coatings and this substrates but currently no long time tests have been done nor will become available before a decision must be made.

Taking into account both the novelty of the application and the critical nature of components to the facilities instrument it is considered that the risk of coating failure in service to be significant to a number of guides and that measures should be adopted to mitigate this risk.

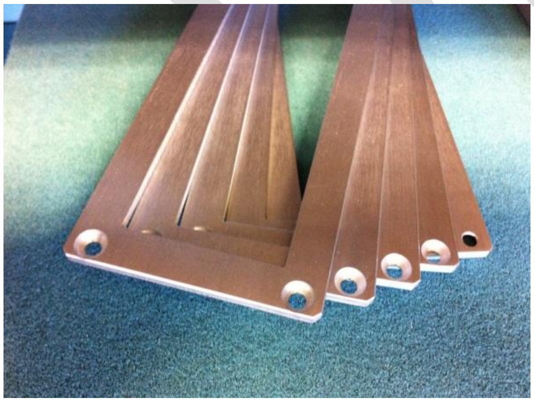
As a result, to reduce the risk of coating failure use in-monolith, it is recommended to restrict the use of coatings in this application to those in which significant operational experience exists.

As a result it is recommended to cap coatings of in-monolith optics in a general case to < M = 4.0

The use of coatings above this value should be restricted to positions downstream of the first 1000mm and reduced to small surfaces. Uses should be justified by a demonstration of the performance gain over M=4 in and that the loss of performance in the event of potential failure permit the instrument to continue meaningful operation.

Comment: A similar policy is proposed for the current PSI upgrade. At FRM II currently installed metal substrate guide coatings are within this scope. The value of the cap is question of appreciation the difficult to repair of the installations and the degree of risk of loss of scientific production considered acceptable by the facility management.

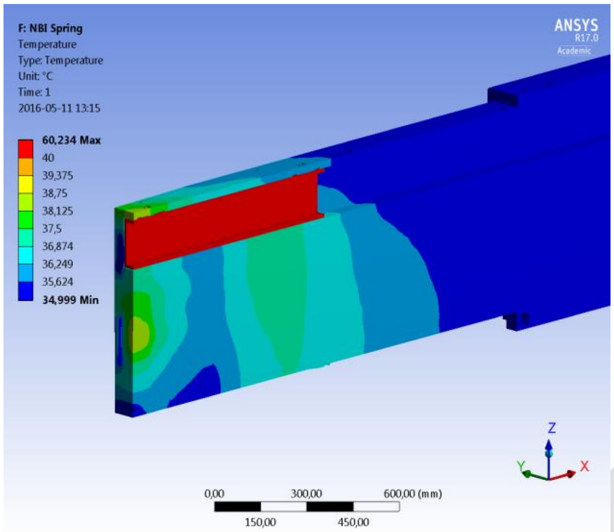
Frontal masks



Recommendation

The use of a borated mask on the front face of coppers substrates is not considered necessary to avoid substrate damage. It use should be considered to reduce the level of activation of components in service and which may result in reduced waste handling and disposal costs.

Operating temperatures



Recommendation

The proposed target for operating temperatures 60 degrees bulk temperature with a limit of 100 degrees in local spots and surfaces are appropriate in consideration of the criticality of the components, the lack of precise knowledge of the real in-service conditions and the extreme difficulty of replacement in case of damage. Designing to the proposed values leaves a reasonable safe margin to account for transient conditions, accidental conditions and minor degradation of cooling performance over time.

If simulations indicate temperatures above the limits established at the front face of the NBOA it is advised that separator blade should not be fitted to the forward most portion (300-500mm). To compensate the bender radius would be decreased and the number of channels increased avoiding any significant loss of performance.

Cooling

Recommendation

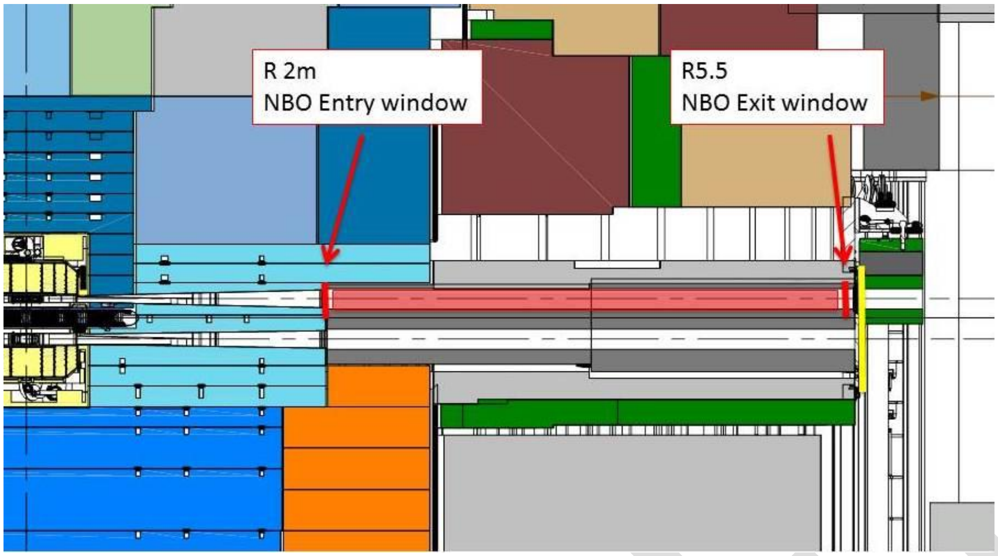
The cooling of optical elements through passive means ie without fluid circulation are strongly recommended, to ensure reliable and maintenance free long term operation.

The proposed solution through of housing the NBOA within a helium filled cavity within the cooled insert is supported as an effective and robust solution.

A gaseous atmosphere is seen as a valuable contribution to the cooling of silicon wafers within the optical elements and as a method to improve the rejection of heat from the optical units to the cavity walls If water cooling cannot be avoided, it use limited to as few circuits as possible, reducing the risk of leaks.

Use of local cooling pads to supply additional cooling is supported if required (simulations are needed). The contribution of alignment type leaf-springs to heat transfer should be considered as a simple solution if the need for additional cooling is shown to be minor.

Operating Atmosphere



Recommendation

The separation of the NBOA operating atmosphere from that of the monolith vessel is supported in that it ensures optimal operating conditions to the optics and mitigates their risk of accidental contamination.

The NBOA should operate in a pure helium atmosphere with a pressure higher than its surrounding. 1bar pressure is suggested based on current experience. The purity of the atmosphere should be monitored. It should be possible to evacuated/flushed/refill the volume in-situ. The presence of water is considered particularly problematic with a recommended limit of the water content being set to a dew point of -20 C° (corresponding a partial pressure of $pH_2O <$ 1.3hPa).

The thickness of the beam windows into this volume should be minimized. To permit this coupling the NBOA internal pressure to that of the monolith should be considered.

to avoid the need for replacement of windows in service the use of Zirconium alloys may be considered.

Mechanical interface NBOA - NBPI

Recommendation

The panel advises the NBOA team to look at reducing the number of different pockets, by using a modular (cassette) type approach required to simplify NBPI manufacture and integration and potentially reduce waste production and facilitate upgrades.

It is proposed to define a small number of standardized large pockets into which sleeved optical components are installed. It is recognized that one off inserts may be required for extreme cases.

The potential to reuse blind plugs by installing optical cassettes should be considered to facilitate operations on beam-ports which are expected to be activated in the early years of operation when activation may much reduced.

Recommendation

An optical mirror should be added to the rear face of the NBPI to give better indication of the beam direction.

Service life

Recommendation

The proposed service life of the NBOA is 20 years of full power operation is endorsed as reasonable and technically achievable with the design proposed.

It is recommended that for clarity the requirements are specified either in terms of integrated dose or failing this in "MW * years".