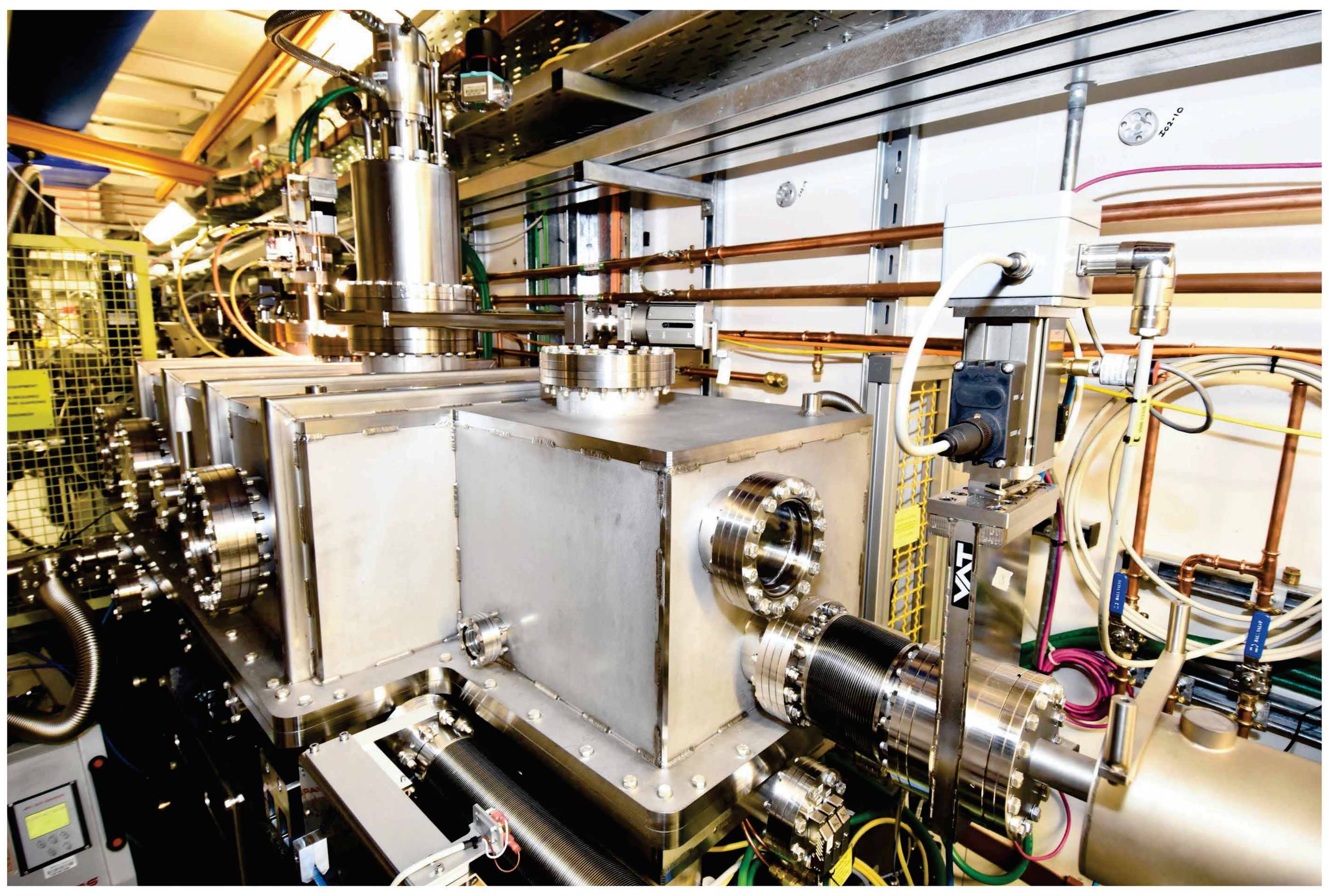
DMM THERMAL MECHANICAL DESIGN

Dr Jon Kelly, Diamond Light Source, Harwell Science and Innovation Campus, Didcot, Oxon OX11 0DE

Abstract

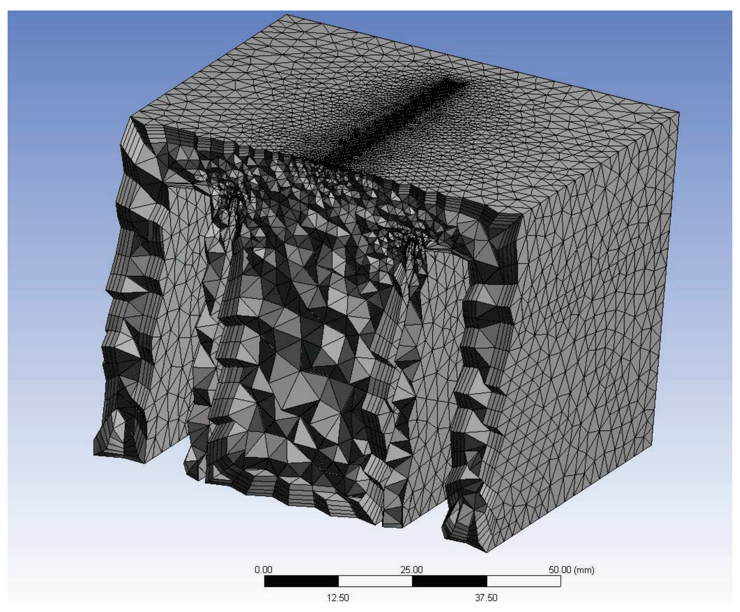
A Double Multilayer Monochromator (DMM) was designed in-house for the VMXi beamline. Thermal mechanical finite element analysis was performed to design a novel optic geometry, employing In/Ga eutectic cooling. The integration of a DMM into the existing beamline required additional power management components, such as a low energy power filter, a power detector and compact CuCrZr masks. This paper describes the thermal management challenges and their solutions. The DMM has been fully commissioned and is operational within the original I02 beamline.



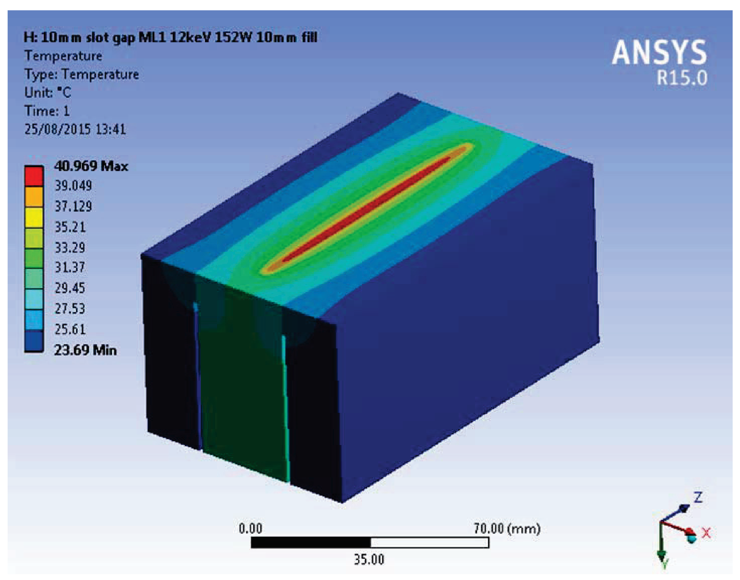
VMXi DMM installed on the beamline

Multilayer Eutectic Cooling

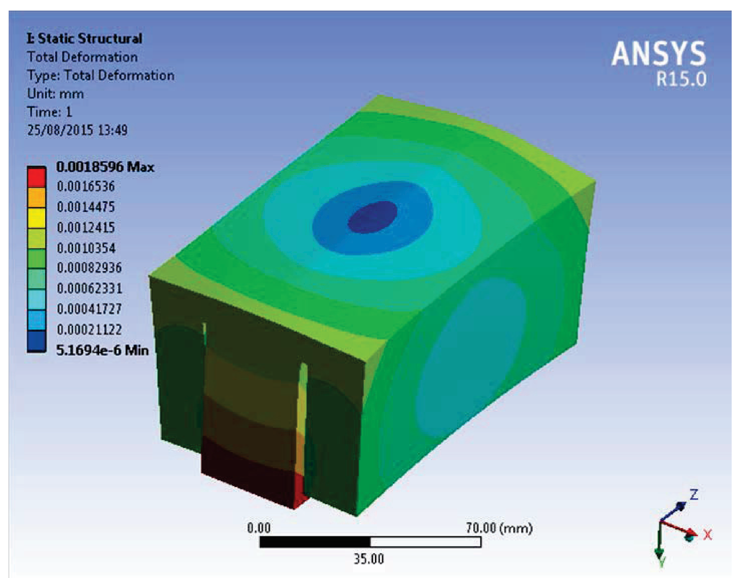
The DMM was designed to operate over the energy range of 10 – 25 keV using two multilayer stripes 2.0 nm and a 2.4 nm. The worst case was assumed to be at 12 keV as the ID is optimised for flux at this energy. This is also a larger angle of incidence and hence small foot print. The absorbed power with the future CPMU K2.04, 500mA would be ~ 480W over a 97.5 x 3.4 mm foot print. This flux density would not be challenging for a cryocooled silicon optic; however concerns over the stability of the deposited layer under thermal contraction lead to a water cooled solution. To minimise turbulence induced vibration, a eutectic bath method was chosen.



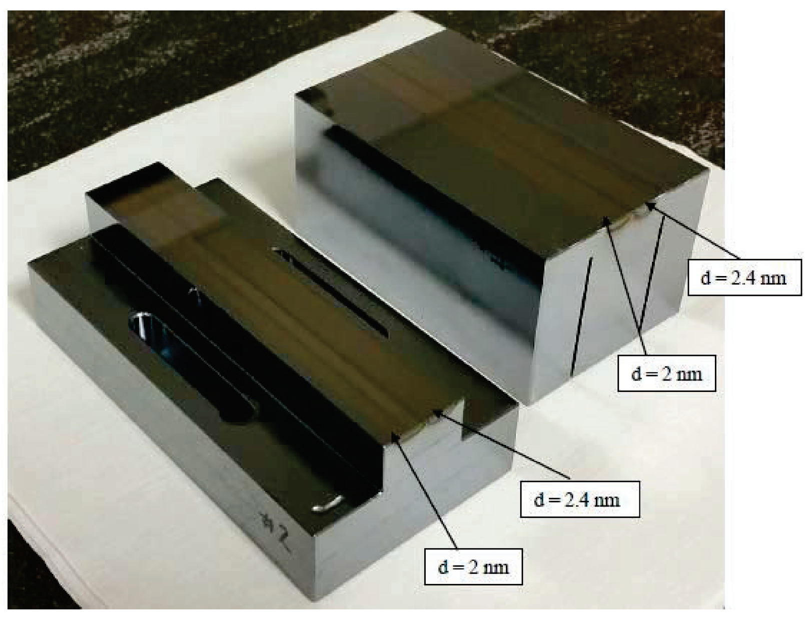
Section View of Meshed 1st ML



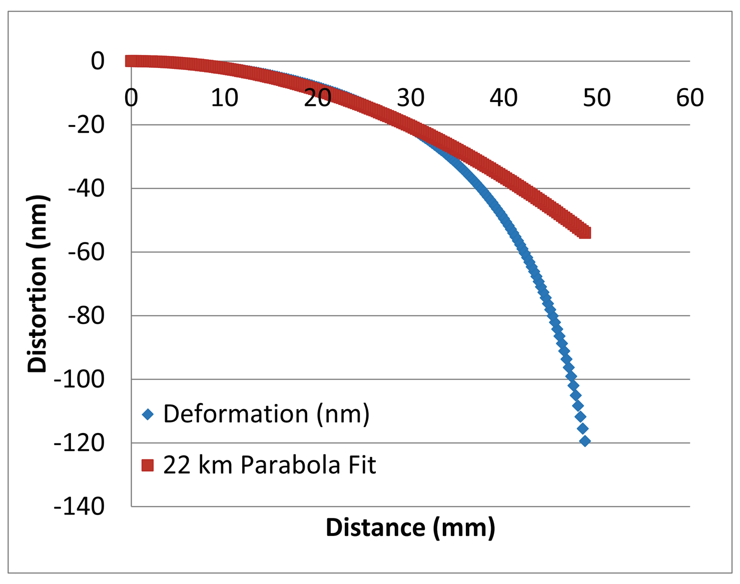
Temperature distribution of the DMM 1st multilayer with an absorbed power of 480W



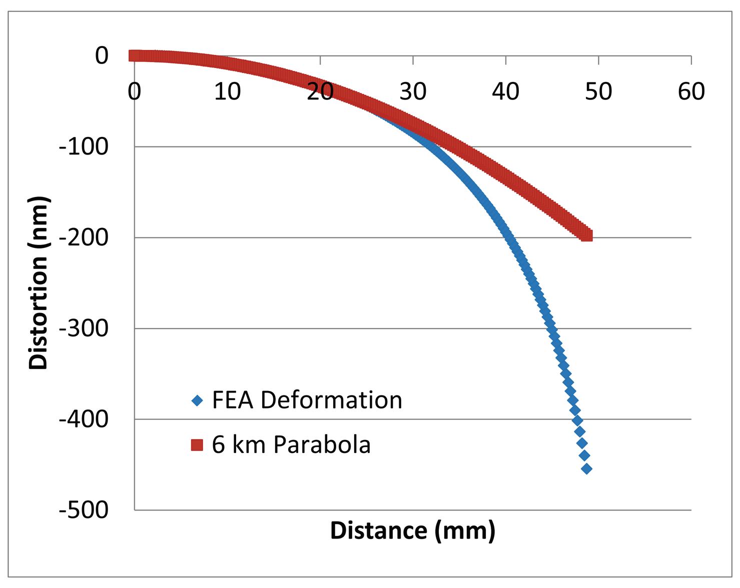
Mechanical Deformation of the DMM 1st multilayer with an absorbed power of 480W



VMXi DMM Multilayer Optics procured from Rigaku, 1st multilayer on the right shown upside-down



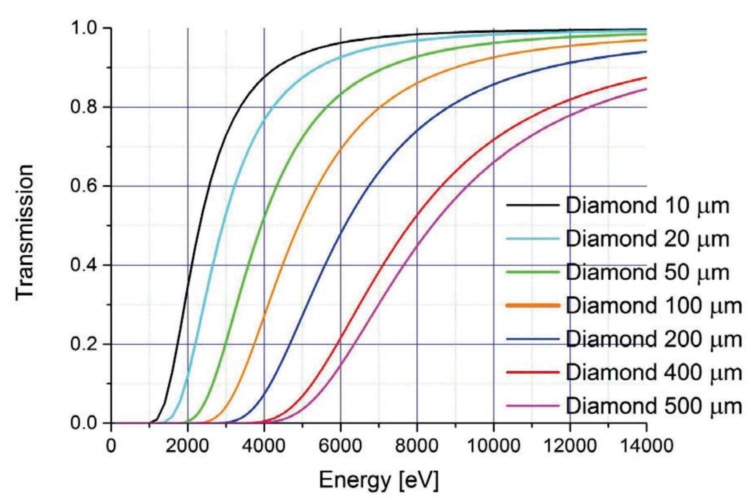
Tangential slope error & 22 km radius parabola plot fitted to DMM 1st multilayer with an absorbed power of 152W. Distortion vs. Distance from spot centre



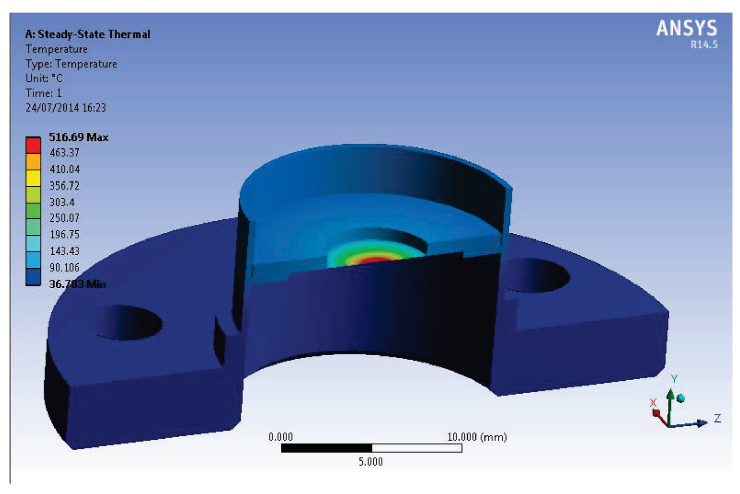
Tangential slope error & 6 km radius parabola plot fitted to DMM 1st multilayer with an absorbed power of 480W. Distortion vs. Distance from spot centre

POWER FILTERS

The DMM delivers a wide band pass monochromated beam at shallow Bragg angles (0.7º – 1.5º, 21 - 9.9 keV for 2.4 nm stripe). The shallow angular range means that the optics also act as mirrors reflecting the low energy harmonics. As DLS is a 3GeV ring the low energy 1st harmonic holds ~ 100W, which would cause unnecessary heating, distortion and damage to downstream components. A selection of filters were procured from Diamond Materials GmbH



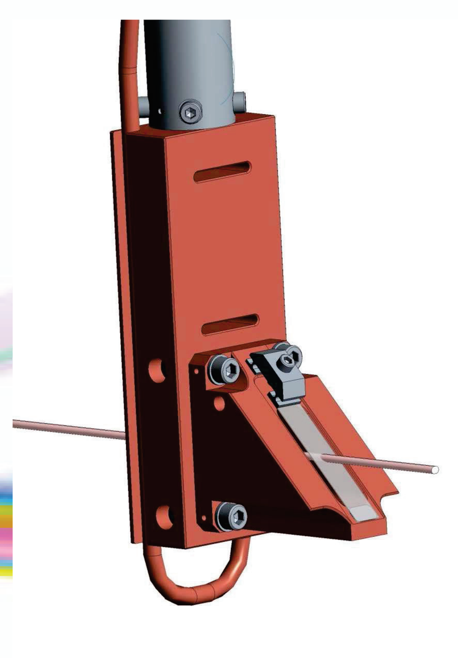
Diamond Transmission, 20, 50, 100 & 400 µm thickness were used



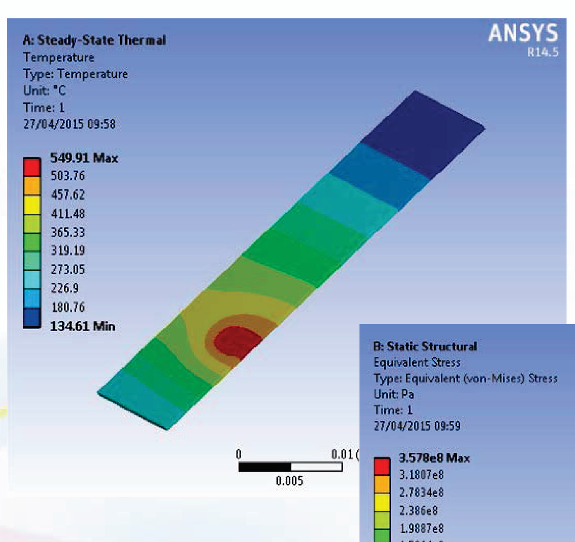
FEA result for 50 µm diamond filter thickness absorbing 110 W

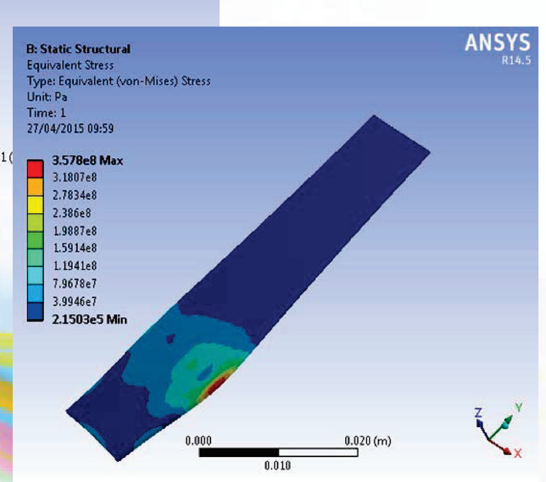
LARGE AREA DIAMOND FLUORESCENT SCREEN

FEA was performed to optimise the screen design. The diamond dimensions are 10 x 55 x 0.5 mm. The screen was clamped at one end via a flexure but cooled from both ends via In/Ga eutectic to a Cu water cooled support. The surface tension of the eutectic holds it in place while being mechanically de-coupled. This design was chosen to provide sufficient cooling without over constraint.

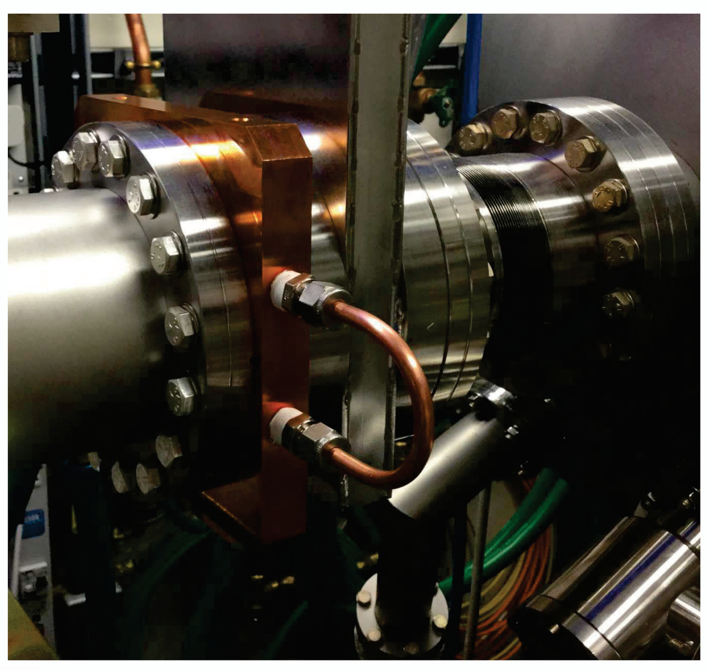


DMM Combined F Screen and mask





Diamond fluorescent screen thermal and Von-Mises stress plots with an absorbed power of 185W



WATER COOLED MASKS

A detailed raytrace was created to identify all the locations down the beamline where significant power might be deposited. The Gas Bremstralung Stop (GBS) and the transfer pipes were clearly vulnerable. Zero length water cooled masks were designed which were thin enough to be inserted between existing components by compressing the bellows. These masks were machined from CuCrZr alloy removing any requirements for brazing or welding (Ref. Sharma MEDSI 2014).

MEDSI 2016 — MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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For more information please visit www.diamond.ac.uk or contact jon.kelly@diamond.ac.uk