Diamond for 4th generation X-ray sources

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The next generation of X-ray sources [1,2] will provide photons with special properties as compared to present third generation sources. X-ray lasers will generate ultra short photon bunches in the 100fs regime with a uniform or a bunch train spacing, high instantaneous power in the 10-100GW range, and will be highly transverse coherent.
In order to preserve the properties of the source along the beamline and allow for as many experiments as feasible, diamond with its unique thermal and mechanical properties is the most promising material. The following topics will be discussed in the framework of utilizing diamond crystals, and diamond material in a wider sense, as the building blocks.
-Power considerations: Thermal management, the cryogenic cooling of diamond, and damage due to high instantaneous power.
-Photon beam timing: The XFEL process together with the actual linear accelerator operation generates photons on intrinsic timescales ranging from the sub-fs microstructure of a single pulse up to the bunch train length of 1ms. The response of the crystal in the time domain will be used to tailor the pulse length. Time delay units will provide photons for self clocking experiments. Transparent beam-splitters/monochromators will be used multiply the number of experimental stations at one XFEL undulator.
-Coherence preservation: The preservation of the wavefront of the photon source is strongly correlated with the precision of surfaces and the bulk properties. The homogeneity of the material and the acceptable degree of perfection of single crystals and geometrical constraints are relevant parameters.
In Figure 1 the example of a cryogenically cooled diamond crystal is shown. One solution of the thermal management task dealing with the photon pulse train in the European XFEL laboratory [2] suggests the use of large scale diamond heat spreader designs.

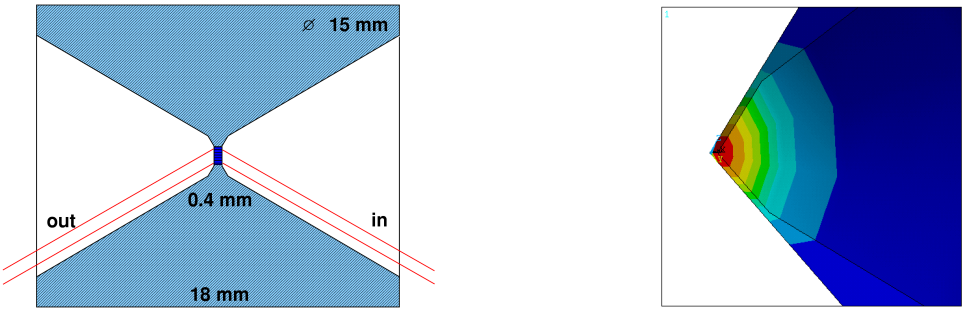

Figure 1: Model of a future diamond monochromator crystal. A perfect diamond at the position of the footprint of the beam is attached to a large diamond heat spreader.

Apart from being used as monochromator crystals, diamonds are envisioned to be the material of choice for windows, quarter wave plates, and refractive optics.

References

[1]- Linac Coherent Light Source (LCLS) Conceptual Design Report, SLAC-R-593, April 2002, UC-414
[2]- TESLA TDR, XFEL Supplement, DESY 2002-167, October 2002, Editors: R.Brinkmann et. al.