CVD Diamond Windows for Synchrotron Radiation Beamlines

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At synchrotron radiation (SR) facilities around the world, beryllium (Be) windows are used as standard beamline front-end components. In fact, due to its low atomic number resulting in good optical transmission, as well as rather good thermal properties, Be has long been the material of choice for front-end windows. Be windows have generally two functions: a first thicker window absorbs the low energy photons (lowering heat load on the downstream components), while the second, generally thin, Be window, separates the ultra high vacuum of the storage ring from the environment of the beamline (often this window has also the safety function of absorbing the pressure wave of an incidental downstream inrush of air) [1].

Despite these advantages, in SR applications requiring high synchrotron beam quality, Be shows also drawbacks, the main being coherence degradation due to the roughness of the Be foil (leading to phase shift), as well as to Fresnel diffraction on the surface pits and voids of the foil [2]. For these reasons, an increased attention is being dedicated to the development of CVD (chemical vapour deposition) diamond windows. In fact, the optical quality of CVD diamond allows today the problems encountered in the usage of Be to be avoided. Moreover, CVD diamond has also excellent thermal and mechanical properties [3], which could allow both functions of the Be front-end windows to be combined in a single diamond window. The challenge with the latter solution lies in the low thermal expansion of diamond, resulting in big differential thermal expansions with respect to the frame material. A further challenge is represented also by the brazing process of thin diamond foils to the window frame material so to achieve the desired vacuum tightness.

An optimised design of a CVD diamond window for the Swiss Light Source (SLS) beamlines will be presented in this work. The single diamond window has in this case both the functionality of a thermal filter, as well as of a vacuum and safety element. Results of a numerical optimisation of the mechanical behaviour of the window in the case on an air inrush, as well as its thermal behaviour during brazing, bake-out and under photon beam absorption will be given. Results of thermo-mechanical and optical tests performed on the prototype of a high-vacuum brazed window will also be presented. Based on this design, an off-the-shelf diamond window is being brought to market through Diamond Materials GmbH.

Essential bibliography:
[1] Gambitta A. et al.: "Beryllium windows for the X-ray diffraction beamline at Elettra", Sincrotrone Trieste, Internal Publ. No. ST/S-TN-93/59, 1993.
[2] Goto S. et al.: "Characterisation of Beryllium Windows Using Coherent X-rays at 1-km Beamline", Proc. 8th Int. Conf. SR Instr., San Francisco (CA, USA), August 2003.
[3] URL: http://www.diamond-materials.com/
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