Requirements for bimorph mirrors at the European XFEL

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X-ray free-electron laser (XFEL) will generate ultrashort and very intense X-ray radiation in the wavelength domain reaching from the XUV all the way to the hard X-ray domain of one Angstrom. The European XFEL near Hamburg relies on super-conducting technology for the linear accelerator, which will enable more than two orders of magnitude increased average photon flux and three times higher peak brightness compared to other X-ray laser projects in the hard X-ray regime. First commissioning activities of the linear accelerator are scheduled for 2013 and user operation under SASE (Self-Amplified Spontaneous Emission) conditions will start in 2014 [1]. In full operation, the European XFEL will have ten or more experimental stations at five different beamlines. Experiments with SASE radiation between 250 eV and 12.3 keV with 10^{12} - 10^{14} photons in a 100 femtosecond pulse will be possible. Spontaneous synchrotron radiation up to 100 keV will be available with about 10^9 photons per pulse. The proposed experimental stations enable a variety of experiments on ultrashort time scales like coherent X-ray imaging, X-ray photon correlation spectroscopy and plasma physics.

One consequence of the high X-ray peak power in the range of 20 GW is an instantaneous heat load that can easily reach melting conditions for beamline components exposed to the beam. At the European XFEL this problem is addressed by up to 1 km long photon beamlines, where sensitive optical components like mirrors can be placed at several 100 meters distance from the end of the undulators. In this way, the X-ray beam is widened to several 100 micrometers in diameter and the heat load can be managed by small grazing incidence angles and low-Z coating materials like carbon.

On the other hand, long beamlines and the desire to preserve the almost perfect transverse coherence properties of the beam put a stringent set of specifications on slope errors and mechanical stability of X-ray optical components. Estimates show that slope errors of mirrors better than 0.1 microradian rms or about 2 nm height error over 1 m lengths are required in the hard X-ray regime to minimize wavefront distortions of the beam. Bimorph mirror technology could help to fulfil these stringent requirements, if radiation hardness problems can be solved.

References

[1] M. Altarelli, et al. (Eds.) XFEL, The European X-ray Free-Electron Laser, Technical Design Report, 2006, (DESY 2006-097) http://xfel.desy.de/tdr/index_eng.html

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