Contribution ID: **176** Type: **Contributed talk**

# Crystal Optics Thermal Deformation: Transient Analysis and its Impact to Cavity Based X-ray Free-Electron Laser

*Wednesday 28 August 2024 17:45 (15 minutes)*

Thermal deformation and performance of the crystal optics for high-repetition-rate Free Electron Lasers (FEL) critically depends on the pulse energy and repetition frequency among many other parameters. Time-domain modeling of the thermal deformation of the crystal can help to define acceptable operational parameters across the pulse-energy repetition-rate phase space. In this paper, we present results on pulse-by-pulse full transient thermal deformation of 50-μm thick diamond crystals for a Q-switched Cavity [*Tang et al, 2023] Based X-ray Free Electron Laser (CBXFEL) simulated by using finite element analysis (FEA). The cavity is composed of four diamond crystals. The photon energy was chosen at 9.831 keV to enable high-efficiency Bragg reflection from the diamond (400) reflection at 45.0°. X-ray pulse repetition rate varies from 50 kHz to 1 MHz. Two critical times for the good operation of the crystal are (1) at the time the XFEL makes the 1st-turn so that the crystal sees the recirculated XFEL in the cavity; (2) at the time that the next electron beam arrives for the amplification, so that the crystal outcouples the amplified FEL power. The 1st-turn time (tcavity) is, critical for CBXFEL, related to the total optical path length of the cavity. The electron beam repetition time (tper) is, critical for the X-ray optics in beam transport in the beamline downstream, inversely proportional to the repetition rate (frep): tper = 1/ frep. For the same average power, simulation results show that the crystal thermal deformation seen by the beam decreases with repetition rate at the 1st-turn time of a 300-m long cavity, increases with repetition frequency at the electron beam repetition time. For the wavefront preservation requirement of the crystal, the pulse energy limits at both critical times decreases with repetition rate, especially at the electron beam repetition time. The upper bound of the thermal deformation of the crystal at the electron beam repetition time for any repetition frequency can be estimated from the CW case.

## I plan to submit also conference proceedings

No

**Primary author:** ZHANG, Lin (SLAC National Accelerator Lab)

**Co-authors:** ZHU, Diling (SLAC National Accelerator Laboratory); Prof. HASTINGS, Jerome (SLAC National Accelerator Lab); Prof. HUANG, Zhirong (SLAC National Accelerator Lab)

**Presenter:** ZHANG, Lin (SLAC National Accelerator Lab)

**Session Classification:** Mikrosymposium 6/2: FELs: New facilities and Opportunitites

**Track Classification:** 6. FELs: New facilities and opportunities