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Thermal fatigue tests on CuCrZr photon shutters

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The CuCrZr alloy has emerged as a preferred material for thermal absorbers in synchrotron light sources, balancing mechanical strength, thermal conductivity, and cost-effectiveness. Yet, thermal fatigue design criteria for CuCrZr components under high-intensity X-ray beam exposure are not well established. This is due to a lack of experimental data from test specimens subjected to several thousand cycles of localized high temperatures exceeding 300℃. To address this gap, thermal fatigue tests were conducted on CuCrZr photon shutters at the NSLS-II instrumentation front end. This setup, receiving an X-ray beam from an undulator (16 kW/mrad² peak power density at 500 mA), resulted in a peak normal power density of 38.8 W/mm² on the shutters. Within the beam footprints, calculated peak temperatures ranged from 322℃ to 416℃. This paper presents the experimental setup, the test results, and finite element analyses of the photon shutters' thermo-mechanical responses. Drawing from both experimental and analytical findings, a conservative thermal fatigue design criterion for CuCrZr absorbers is proposed.

Footnotes

∗ Sharma et al., "A novel design of high-power masks and slits,"in Proc. MEDSI2014, Melbourne, Australia, 2014.

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