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A novel R&D beamline for Industrial Applications with Intense, High-Energy Undulator Radiation

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Engineers and researchers in manufacturing industries are highly interested in what happens in their manufactured components and products when the products are in long-term operation because materials in the components might be subject to degradation and damage due to the long-term operation. Manufactures'demands for synchrotron-based X-rays are currently shifting from modeled specimens for operando experiments or small pieces extracted from the components by cutting to their mass-produced components without any cutting. The upgrade of SPring-8 named SPring-8-II will meet the demands of high-energy X-rays. In-vacuum undulators at SPring-8-II will provide pink beams with substantially reduced energy tails at the spectroscopic lower and higher sides for a specific harmonic. A specific harmonic of the pink beam will be able to be extracted using an X-ray prism called harmonic separator [1]. Then, brilliant high-energy pink beam with an energy band width of 1% will be obtained without any monochromators.

We have tested the concept of SPring-8-II in terms of the high-energy pink beams using double multilayer monochromators at SPring-8 [2]. We fabricated multilayer mirrors designed for 100 keV and installed them to a undulator beamline BL05XU of SPring-8. We obtained a pink beam with a band width of 1.0% for 19th harmonic of undulator radiation with 1st harmonic of 5.26 keV. We gained a 100-keV pink beam with total flux of 3×10^{13} photons/s and prepared a 4-m-long atmospheric section called a high-energy test bench section for the use of the pink beam in the second optical hutch at BL05XU. In this presentation, we show some highlighted results of experiments at the high-energy test bench section based on actual and potential industrial demands. Computed tomography and laminography enable three-dimensional (3D) imaging of metals and ceramics as well as resin materials inside manufactured components. Orientation microscopy with a 3D X-ray diffraction method [3] is sensitive to plastic deformation, creep, and fatigue of polycrystalline materials. Residual stress measurements with a strain scanning method allow us to evaluate stress in metallic components. These capabilities are suitable to investigate degradation, fatigue, and damage of materials inside manufactured components and products with metal housing.

References:
[1] I. Inoue et al., J. Synchrotron Rad. 25, 346 (2018).
[2] H. Yumoto et al., Proc. of SPIE Vol. 11492, 114920I (2020).
[3] J. Kim et al., J. Appl. Cryst. 56, 1416 (2023).

I plan to submit also conference proceedings

No

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