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Microfocus bremsstrahlung source based on betatron high-resolution radiography and tomography

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The production of a microfocus radiation source based on relativistic electron beams is important for high resolution radiography and tomography. Ordinary betatrons generating secondary hard radiation caused by interaction of the internal electron beam with the target (typically a thick target), that is larger in its area than the cross section of the millimeter-size beam, are used for obtaining the images of a number of objects. But, in [1, 2] the idea was proposed to use internal target much smaller than diameter of the electron beam of the cyclic accelerator to reduce the focal spot of the generated Bremstrahlung. Here, if the beam will circulate for a sufficiently long time on the radius of the micro-target location, then, due to betatron oscillations, electrons will fall on such a target with a sufficiently high efficiency. This paper presents the results obtained for generation of linear-microfocus Bremsstrahlung under interaction of 18 MeV electrons with thin target which was oriented along the direction of the internal beam of the B–18 betatron in order that the electrons can interact with the narrow front face of the target. Magnified images of the compound steel object have been obtained using the radiations generated in the narrow internal Ta targets, the width of which is approximately 100 times smaller than the diameter of the electron beam. The formation of the object structure image with participation of the absorption and phase contrast effects is shown. The study has shown the possibility to successfully generate hard radiation in a narrow target which width is about one hundred times smaller than the diameter of the betatron electron beam, and to use this radiation for obtaining the magnified high-resolution images of micro-defects into products made of heavy materials with participation both the absorption and phase contrast effects in formation of the images. In our case, the radiation spectrum of the betatron generated in narrow internal targets extends from several keV to 18 MeV. For light targets, the images of non-thick objects are formed by a soft part of the radiation spectrum. In our case of heavy target, the radiation spectrum is dominated by hard radiation due to strong absorption of radiation of the soft part of the bremsstrahlung spectrum in the target. The radiation generated in such target is applicable for obtaining images of thick objects made from heavy materials. The images of a compound object consisted of four steel bars demonstrated the high resolution of a series of 10 μm gaps between adjacent bars due to the small horizontal size of the focal spot of the linear microfocus bremsstrahlung source. The results also demonstrate the edge phase contrast due to the high degree of spatial coherence of the radiation. The obtained results attest to the high quality of the radiation beam generated by new microfocus source based on compact betatron that can also be used in a laboratory physical experiment, for example, in materials science to study internal interfaces of media, microdefects and micro-inclusions in the heavy composite materials. In our case, the 18-MeV betatron-based linear microfocus source generates bremsstrahlung with a spectrum up to the electron energy, while the microfocus X-ray tubes widely used for various purposes have so far reached the photon energy of 750 keV.

Biography

V A Smolyanskiy received his Master's degree from Tomsk Polytechnic University (TPU). At present, I am a post-graduate student in TPU. I study under the program «Photonics, Instrument Making, Optical and Bioengineering Systems and Technologies», specialty «Instruments and Methods of Control over Environment, Substances, Materials and Products». I also work in the research and production laboratory "Betatron tomography of large-sized objects". My research is devoted to innovative and highly effective methods for generating hard bremsstrahlung with a photon energy of more than 1 MeV for use in high-resolution tomography.

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