Study of Accumulation of Residual Deformations Caused by Low-Cycle Pulsed Heating

A.S. Arakcheev\textsuperscript{a,b,c}, V.M. Aulchenko\textsuperscript{a}, I.I. Balash\textsuperscript{a,b,d}, A.V. Burdakov\textsuperscript{a,b,c}, O.V. Evdokov\textsuperscript{d}, A.A. Kasatov\textsuperscript{a}, S.R. Kazantsev\textsuperscript{a,b,d}, I.I. Shekhtman\textsuperscript{a}, A.A. Shoshin\textsuperscript{a,b}, B.P. Tolochko\textsuperscript{a,d}, A.A. Vasilyev\textsuperscript{a,b}, L.N. Vyacheslavov\textsuperscript{a,b}, L.A. Vaigel\textsuperscript{a,c}, V.V. Zhulanov\textsuperscript{a}

\textsuperscript{a}Budker Institute of Nuclear Physics SB RAS, Russia
\textsuperscript{b}Novosibirsk State University, Russia
\textsuperscript{c}Novosibirsk State Technical University, Russia
\textsuperscript{d}Institute of Solid State Chemistry and Mechanochemistry SB RAS, Russia

a.s.arakcheev@inp.nsk.su

The normal operation of fusion reactor based on tokamak involves periodical transient heat loads to divertor plates. The divertor s of ITER are should be covered by tungsten armour. The tungsten tends to cracking as a result of the pulsed heating. The reasons of the crack formation are deformation and mechanical stresses caused by the raise of temperature of thin surface layer.

The diagnostic of the dynamic of the deformations and stresses in tungsten under pulsed heat load is under developments at VEPP-4M beamline 8 (scattering station “Plasma”). The previous experiments are described in the article [1]. The idea of the diagnostic is based on the measurements of the dynamics of diffraction of polychromatic synchrotron radiation on single-crystal samples. The deformations in the material caused by pulsed heating leads to change in scattering angle and consequently in shape and position of diffraction peak. The pulsed heating simulated by 140µs and 50J Nd:YAG laser with an amplifier based on Nd glass. One-dimensional fast detector measures the distribution of scattered synchrotron radiation intensity.

The two significant modifications of the experiment were done: the two order increasing of the initial synchrotron radiation intensity allowed the using of thicker samples (~500 µm) and the new detector of synchrotron radiation with a silicon sensor was constructed [2]. The increasing of the thickness of samples from 200 µm to 500 µm significantly changed the behavior of deformations and stresses in the heated samples because the thickness became more then the distance of the temperature propagation during the pulsed heating. The fact is confirmed by the measured diffraction during the pulsed heating with the crack formation and the behavior of the residual deformations in the material after several consecutive pulsed heating. The last point may be used for estimation of the accumulation of residual deformations and stresses caused by low-cycle pulsed heating.

The using of new detector of synchrotron radiation with the silicon sensor solved two main problems of the previous detector with the gas sensor: the nonlinear sensitivity and the large width of the instrument function of the measurements at the relatively high energy of photons (~69keV). The last point is especially significant because the width of instrument function became less than the typical size of the changes in the shape of diffraction peak. It increased the accuracy of the calculation of the residual stress distribution.