THERMAL STABILITY OF $W_{1-X}Si_X$/Si MULTILAYERS FOR X-RAY OPTICS UNDER RAPID THERMAL ANNEALING

E. Majkova, S. Luby, M. Jergel, R. Senderak
Institute of Physics, Slovak Acad. Sci., 842 28 Bratislava, Slovak Republic,

G. Haindl, F. Hamelmann, U. Kleineberg, U. Heinzmann
Universität Bielefeld, Fakultät für Physik, 4800 Bielefeld, Germany

The thermal stability of multilayers (MLs) for X-ray mirrors can be increased by using the pair of materials in thermodynamic equilibrium. In this work this was achieved by doping of W layer by Si to decrease the driving force for interdiffusion. The $W_{0.66}Si_{0.33}$ /Si, $W_{0.5}Si_{0.5}$ /Si, $W_{0.33}Si_{0.66}$ /Si and for comparison W/Si MLs with ten bilayers were fabricated by e-beam deposition in UHV onto oxidized Si substrates. The nominal thickness was 5.5 nm for Si and 2.5 nm for W or $W_{1-x}Si_x$ layers. The samples were heat treated by halogen lamp rapid thermal annealing and by standard annealing in vacuum up to 1000° C for 30 s and 25 min, respectively. Samples were analyzed by soft X-ray reflectivity measurements, small and large angle X-ray diffraction and by the Rutherford backscattering spectrometry. From the results it follows the increased stability of $W_{1-x}Si_x$/Si MLs in comparison with W/Si ones. The temperature which the sample can withstand without a serious damage increases from 500 to 850°C with x increasing from 0 to 0.66 (this composition corresponds to the stable tungsten disilicide). As deposited MLs were amorphous. The crystalline bcc W or WSi_2 phases appeared at 500°C for $x \leq 0.5$.

The increased thermal stability of $W_{1-x}Si_x$/Si MLs is attributed:
(a) to the structural stability of amorphous mixtures against crystallization. For x=0.66, well developed WSi_2 phase appeared only at 1000°C/30 s annealing. Hence, Si helps to keep W in the amorphous state;
(b) to the suppressed interdiffusion at the interfaces. For x=0.66 the stoichiometry of the structure does not change due to the crystallization of WSi_2 (like for lower values of x) and there is no need for the diffusion of Si for the further growth of the tungsten silicide.

On the other hand the reflectivity of $W_{1-x}Si_x$/Si MLs is lower in comparison with the W/Si one because of lower optical contrast.