Reduced activation ferritic/martensitic steels (RAFs) have been expected to be a candidate material for blanket of fusion reactor, because of their excellent high-temperature strength. Their outstanding strength performance is attributable to the combined strengthening mechanisms of matrix and various grain boundaries. However, it is by no means easy to separate the contributions of such strengthening factors because of extremely fine and complicated microstructure. In this study, the instrumented indentation test was carried out under a wide variety of maximum indentation loads using the creep ruptured specimens to clarify the contribution of each microstructural factor to their strength and materials degradation.

The material used in this study was JLF-1 (Fe-9Cr-2W-0.2V-0.08Ta) and the rotor steel (Fe-10Cr-1Mo-1W-VNbN) was also used as reference steel. The indentation test was applied to the as-tempered steels and the creep ruptured specimens (JLF-1: 873 K/160 MPa, \(t_c=3047\) h, the rotor steel: 923 K/98 MPa, \(t_c=4524\) h). The test was performed at the maximum loads ranging from 1 to 1000 mN.

The hardness of creep ruptured specimen of JLF-1 was lower than that of the as-tempered steel and the difference in hardness showed no significant change, irrespective of the maximum indentation load, i.e., the plastic zone diameter. This reduction in hardness seemed to be caused by the decrease in strength of block interior (matrix), because the block size showed almost no variation. On the other hand, the decrease in hardness of the rotor steel was strongly dependent on the plastic zone diameter. The creep ruptured specimen had 1–1.5 GPa lower hardness than the as-tempered steel, except for the lowest maximum load of 1 mN where the decrease in hardness was estimated to be 0.4 GPa. At the maximum load of 1 mN, the plastic zone diameter was estimated to be around 1.9 \(\mu\)m and was smaller than the block size (2.2–3 \(\mu\)m), that is, the effect of block boundary was not reflected in the hardness. Consequently, it was revealed that the significant softening of the rotor steel resulted from the decrease in contribution of block boundary in addition to the decrease in matrix strength.