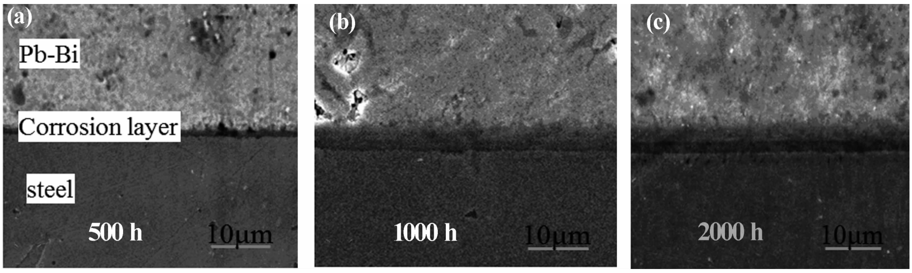

Fig. 1 SEM micrograph of cross-sections of SIMP steel after exposing to LBE at 450 ℃.

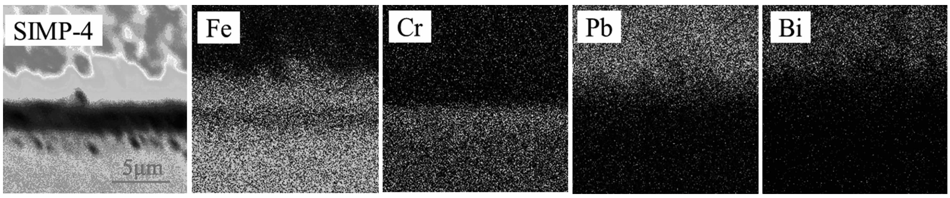

Fig. 2 EDX analysis of the cross-section of SIMP steel after exposing to LBE at 450 ℃ for 2000 h.

From the results for EDX analysis of SIMP steel after corrosion at 450℃, it is found that double corrosion layers, containing different element, is formed. Fe is observed in the outer corrosion layer and, Cr and Fe are observed in the inner corrosion layer. Furthermore, Pb and Bi penetrate into the outer layer. This result agrees with the result of outer magnetite and inner Cr Fe spinel formed during ferritic/martensitic steels corrosion in LBE[2-4]. The results for the elements mapping of SIMP steel after corrosion at 450 ℃ for 2000 h are shown in Fig. 2. According to the EDX line analyses, in comparison with total composition of steel matrix, Fe depleted in the whole corrosion layer and Cr is enriched in the inner oxide layer.

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3 - 24 Temperature Dependence of Cavity Swelling in RAFM/T91 and SIMP Steels under 196 MeV Kr-ions Irradiation

Li Yuanfei, Wang Zhiguang, Yao Cunfeng, Sun Jianrong, Shen Tielong, Wei Kongfang
Zhu Yabin, Pang Lilong, Cui Minghuan, Wang Ji and Zhu Huiping

Due to the properties of swelling resistant, low activation and high thermal conductivity, ferritic/martensitic (FM) steels are regarded as the candidate structural materials for GEN Ⅳ and fusion DEMO reactors[1]. It is well known that a mass of insoluble gas will be formed in materials by nuclear transmutation in nuclear energy systems. These insoluble gas atoms combined with defects which are produced during collision stage and surviving after the cooling stage will lead to cavity formation[2-4]. It will significantly alter the physical and mechanical properties of materials and can cause major difficulties in design of the advanced nuclear reactors[4]. In the present work, we focused on the temperature dependence of cavity swelling in steels under high energy Kr-ions irradiation.

Irradiation of specimen (RAFM/T91 and SIMP steels) was carried out in a high temperature chamber of sector focus cyclotron (SFC) in Laboratory of Heavy Ion Research Facility in Lanzhou (HIRFL), China. With 196 MeV Kr-ions delivered from the accelerator, besides one series sample irradiated to the ion fluence of 2.2×10^{16} ions/cm^2 at 450℃, the other two series specimens were irradiated to the same ion fluence of 2.4×10^{16} ions/cm^2 at room temperature (RT), and 550℃, respectively.

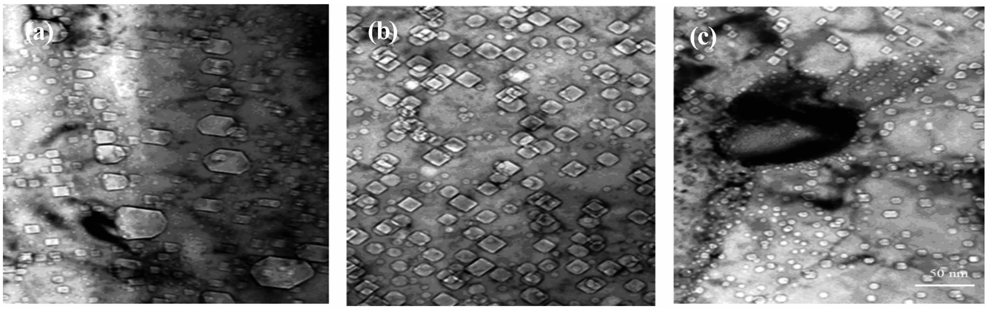

Fig. 1 Microstructures of cavity formed in RAFM steel samples irradiated at different temperatures. (a) RT(2.4×10^{16} ions/cm^2); (b) 450℃(2.2×10^{16} ions/cm^2); (c) 550 ℃(2.4×10^{16} ions/cm^2).

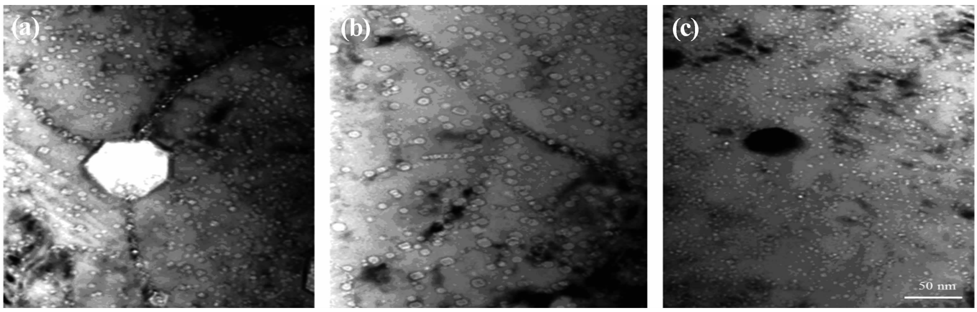

Fig. 2 TEM images showing cavity formation in T91 samples irradiated at different temperatures. (a) RT(2.4×10^{16} ions/cm^2); (b) 450℃(2.2×10^{16} ions/cm^2); (c) 550℃(2.4×10^{16} ions/cm^2).

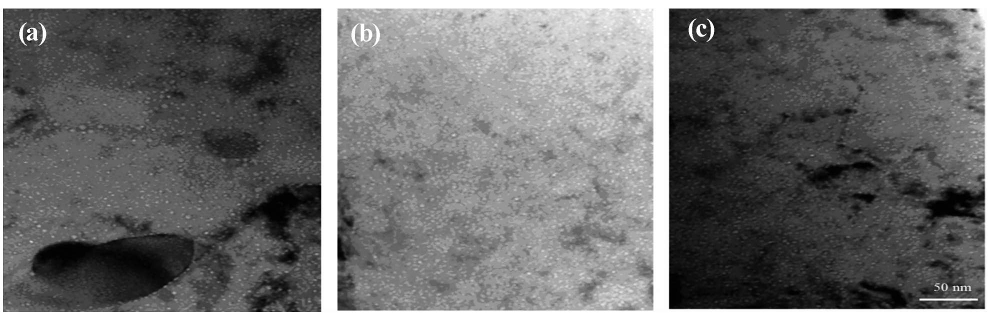

Fig. 3 TEM images showing cavity formation in SIMP steel samples irradiated at different temperatures. (a) RT(2.4×10^{16} ions/cm^2); (b) 450℃(2.2×10^{16} ions/cm^2); (c) 550℃(2.4×10^{16} ions/cm^2).

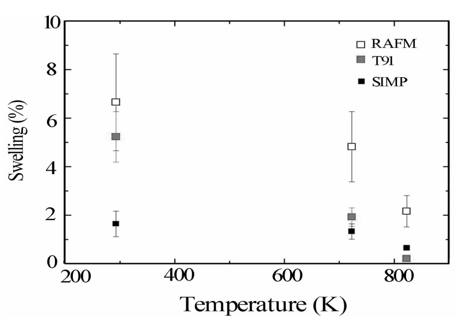

Fig. 4 Cavity swelling values at the peak damage region of the specimens by Kr irradiation at different temperatures.

Figs. 1～3 show the TEM microphotographs of cavity formed in the peak damage region of RAFM steels, T91 and SIMP steels irradiated at different temperatures, respectively. Dense number density and different size distribution of the cavities can be seen from the obtained TEM images clearly. Cavities with large size were formed in the peak damage regions of RAFM and T91 under room temperature irradiation. For the case of RAFM and T91, the maximum value of the cavity size was reaching to approximately 60 and 75 nm, respectively. In addition, typical bimodal distribution of the cavity is manifested by the TEM images. The cavity size in SIMP steel is smallest. Irradiation at 450 ℃, although cavity size value in the three irradiated steels become smaller, the bimodal size distribution of the cavities are also revealed in RAFM and T91. Cavity size in RAFM in the peak damage region is relatively lager, yet that of the SIMP steel is smallest as before. For the case of irradiation at 550℃, cavity size in the samples is much smaller than that of the former discussed. Some factors conspire to prevent the cavity growth[5]. On one hand, concentrations of the thermal equilibrium vacancies are higher, and supersaturated concentrations of the vacancies are partially vanished. On the other hand, the mobility of the vacancy-type defects is relatively higher, and vacancies can be easily emitted from the defect clusters, which lead to the recombination phenomena in the matrix.

Measurements and analysis yield the cavity swelling values illustrated in Fig. 4 in the peak damage regions of the irradiated specimens. On the whole, SIMP steel keeps relatively lower cavity swelling values at different irradiation temperature conditions.

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3 - 25 Preferable Multiple-bit Upset Patterns in Anisotropic SRAM Device

Zhang Zhangang, Liu Jie, Hou Mingdong, Sun Youmei, Su Hong, Geng Chao, Gu Song
Liu Tianqi, Xi Kai, Yao Huijun, Luo Jie, Duan Jinglai and Mo Dan

Multiple-bit upset (MBU) occurs when the single energetic particle strikes a memory circuit and causes more than one bit to flip, as opposed to single-bit upset (SBU) in which only one bit is affected[1]. For static random access memory (SRAM) circuits, MBUs are particularly important since the MBU occurrence can limit the effectiveness of error correcting codes (ECC)[2]. With the technology downscaling, the rate of MBU increases due to the reduced spacing between adjacent cells, reduced critical charge and reduced individual cell dimensions. Thus, investigating and analyzing the mechanism of MBU is an increasing priority.

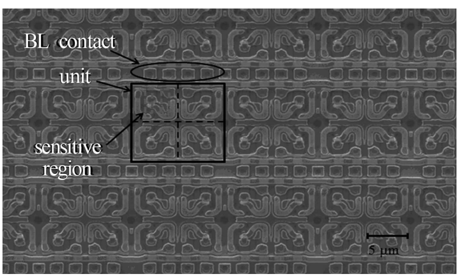

Fig. 1 SEM picture of the layout of IDT71256 SRAM cells. Every unit contains four memory cells. SEU sensitive region of the4-transistor, polysilicon resistor load SRAM cell is the drain of the off-transistor.

In the experiment, an IDT71256 32k×8 bits SRAM device was irradiated at HIRFL by using ^{40}Ar, ^{86}Kr and ^{209}Bi ions with initial energy of 25, 25 and 9.5 MeV/u, respectively. MBUs including double-bit upsets (DBU), triple-bit upsets (TBU) and quadruple-bit upsets (QBU) were detected and their patterns, which mean the physical arrangement of the bit-errors in a MBU, are shown in Tables 1～3, respectively. The majorphysical patterns of DBUs include two adjacent cells in a row, followed bythe occurrence of two adjacent cells in a column, and two cellsin diagonal (Table 1). This phenomenon can be explained by the anisotropiclayout of the SRAM cells, as shown in Fig. 1. Sensitive regions of adjacent cells have minimum distance horizontally, while vertically they are separated by bit-line (BL) contact. The preferable TBU and QBU patterns turn out to be the L-shaped and square-shaped configurations, respectively (Tables 2 and 3). The generated charge by single incident ion is more easily collected by multiple adjacent cells belonging to the same unit, than by farther nodes.