5 - 2 Precipitated-phase FeCrVTi$_x$ Medium-entropy Alloys with Optimized Corrosion Resistance and Strength-ductility Synergy

Sun Jianrong, Cui Jinghao, Cheng Zhaoyi, Chang Hailong, Zhang Linqi, Tian Yinan and Li Jian

The corrosion behavior of metallic materials is an inevitable natural phenomenon. Seawater is a common service environment for metallic structural materials (ships, bridges, oil rigs, submarine pipelines, *etc.*), and the damage caused by seawater corrosion is severe because that corrosion can accelerate the failure of metallic materials. On the other hand, Pressurized Water Reactor (PWR) is widely used in worldwide nuclear power plants in operation. In this water-cooled reactor, the fuel cladding materials are exposed to the extreme environments of strong radiation and water corrosion for a long time. Based on the requirements of high strength, high ductility, radiation resistance, corrosion resistance and other characteristics, the FeCrVTi$_x$ medium entropy alloys (MEAs) were designed as structural materials for the working under extreme environments. Precipitated phases are usually considered to be beneficial for mechanical strengthening, and harmful to corrosion resistance property. But in present work, the induced precipitated Laves phase in the FeCrVTi$_x$ MEAs (medium-entropy alloys) by Ti addition not only improves the corrosion resistance, but also enhances strength and toughness at the same time. The results indicate that the FeCrVTi$_x$ MEA has better corrosion resistance (lower corrosion current density of 37.2 nA/cm^2, higher pitting potential of 966 mV, wider passive region of 1 030 mV) than 304SS. The introduction of precipitated phase by Ti addition leads to better mechanical properties, lower corrosion current density and almost maintain the pitting potential compared with the FeCrV MEA. Results of morphological characterization and composition of the passive film reveal that the selective dissolution of the precipitated phase can lead the segregation of TiO_2 on the surface of the passive film, Ti addition also increase the content of V oxides to form more stable passive film, but high content and size of precipitated phase can deteriorate the corrosion resistance due to the micro-galvanic effect accelerate the corrosion of precipitated phase. Therefore, only appropriate distribution, size and content of the precipitated

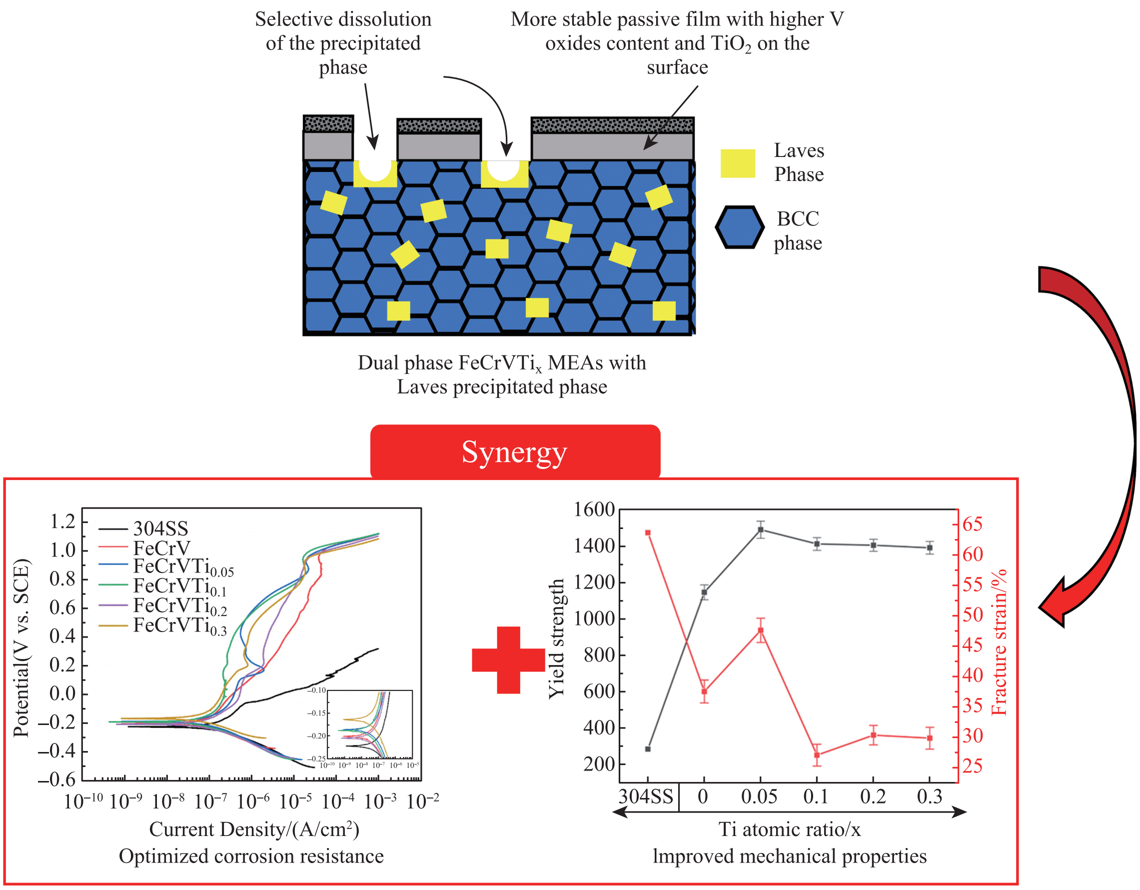

Fig. 1 (color online) Potential-dynamic polarization and Stress-strain curves of the FeCrVTi$_x$ MEAs and 304SS.

phase induced by specific Ti addition achieve the synergy of optimized corrosion resistance and improved mechanical properties. This work provides an idea for searching reliable structure materials in advanced nuclear systems under the extreme environment of strong radiation and water corrosion.

5 - 3 Structure and Fracture Behavior of Ion-beam-modified SiC-Al_2O_3-ZrO_2 Ceramic Composites

Chai Jianlong, Zhu Yabin, Shen Tielong and Wang Zhiguang

The dense Al_2O_3-ZrO_2-SiC ceramic was prepared and irradiated with Si ions to different damage levels at room temperature. The irradiation induced microstructural evolution and mechanical properties were investigated. The mechanism of the transformation and amorphization induced by ion irradiation were discussed.

According to GIXRD patterns, the phase structures of α-Al_2O_3 and β-SiC remained unchanged after the ion irradiation, while the peak broadening for β-SiC indicated the degradation of the crystallinity (Fig. 1). In contrast, ZrO_2 particles undergo a phase transition from m→t due to the accumulation of oxygen vacancies[1,2]. Once oxygen vacancy concentration reached a threshold value, the strain fields around m-ZrO_2 generated by the presence of oxygen vacancies were enough to lower the transition temperature. Moreover, the point defects, defect complexes, and lattice strain accumulated with irradiation, which increased the free energy of the initial compound to form a high-energy metastable phase[3,4]. Furthermore, nuclear energy loss could also induce the phase transition[5,6]. At 5.5 dpa, it was found that SiC particles were completely amorphous, which attributed to the ion bombardment induced interstitials form point defect clusters. The result was the destruction of ordered structures and formation of amorphization regions. Also, the amorphous regions were connected with each other in banded distribution at 55 dpa, and caused the softening of materials. As shown in Fig. 2, due to the consumption of fracture energy, the toughness was improved remarkably with the increase of damage levels.

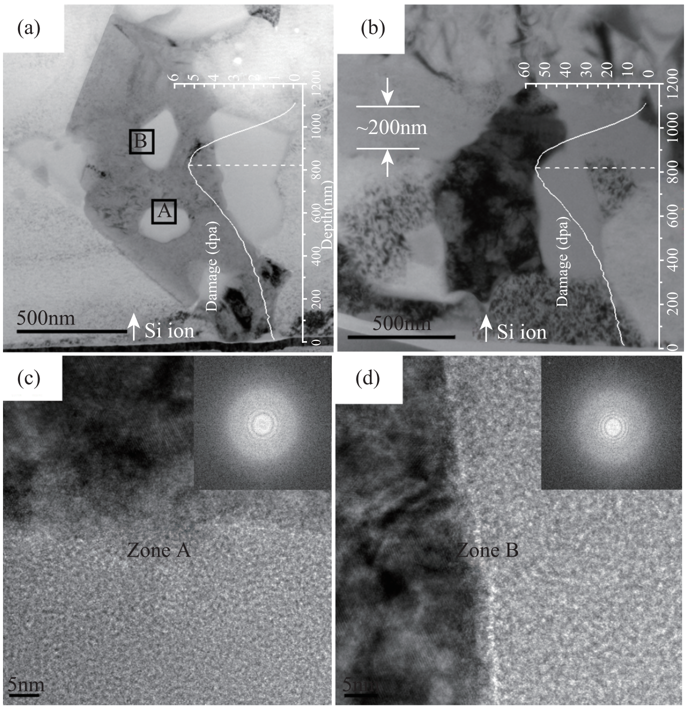

Fig. 1 (color online) TEM images of samples irradiated by Si ions: (a) 5.5 dpa, (b) 55 dpa, (c) and (d) are HRTEM and FFT of Zone A and Zone B.

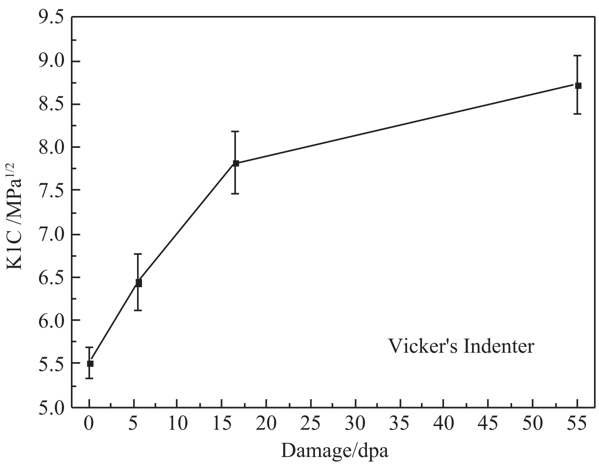

Fig. 2 (color online) Indentation toughness of ceramic composites with Si-ion bombardmentas as a function of damage level.

References

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