Microstructure, high-temperature strength and fracture toughness of Ti–Si–X composites containing refractory phases

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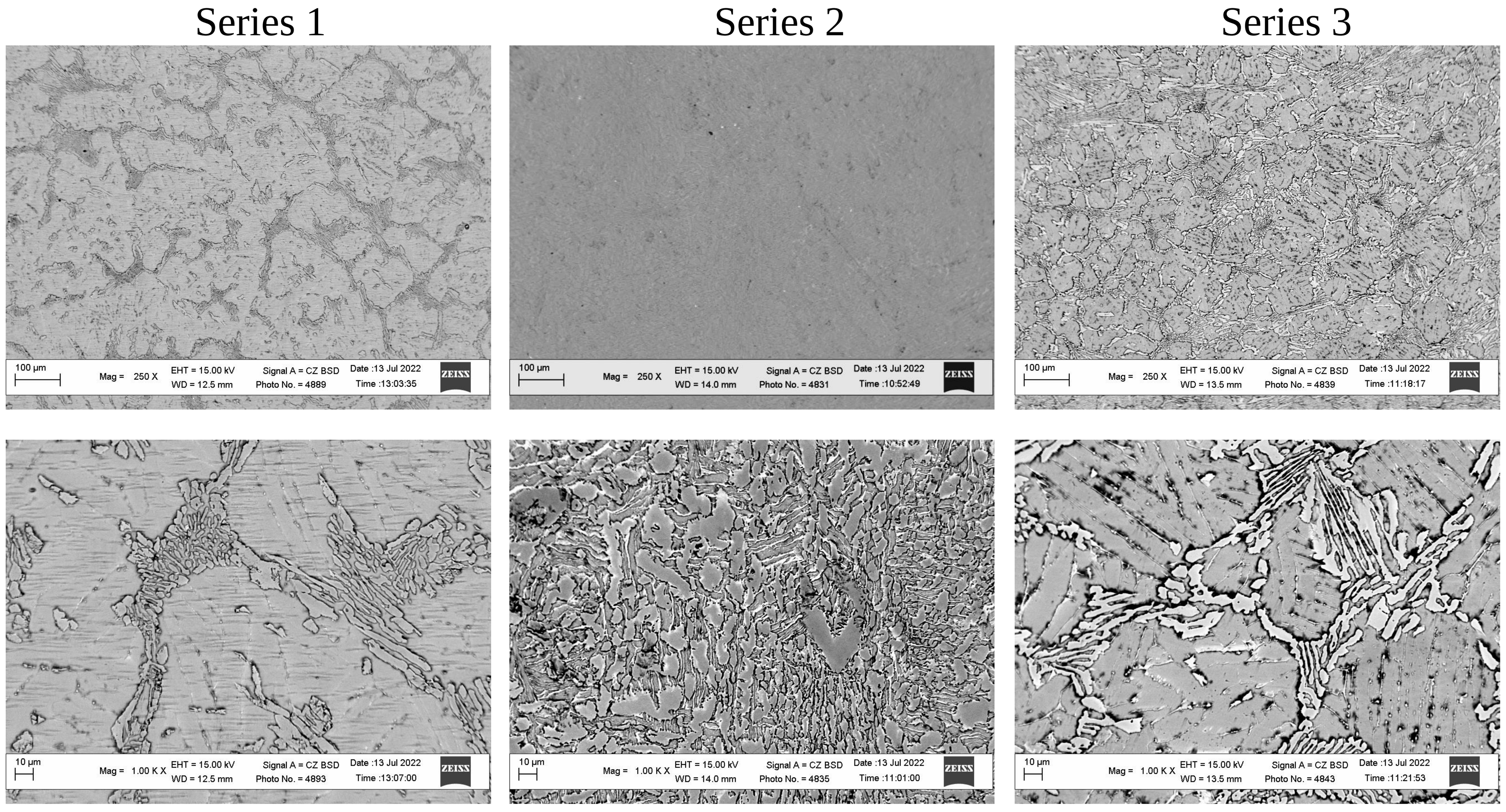
Introduction. State-of-the-art Ti–Si–X composites are being developed for applications in modern aircraft and rocket engines as well as power equipment owing to their comparatively low specific weight and high strength and fracture toughness in a temperature range of 20–650°C. This work is aimed at improving mechanical characteristics of the composites, namely, strength and fracture toughness, and increasing their operating temperature range up to 700−800°C.

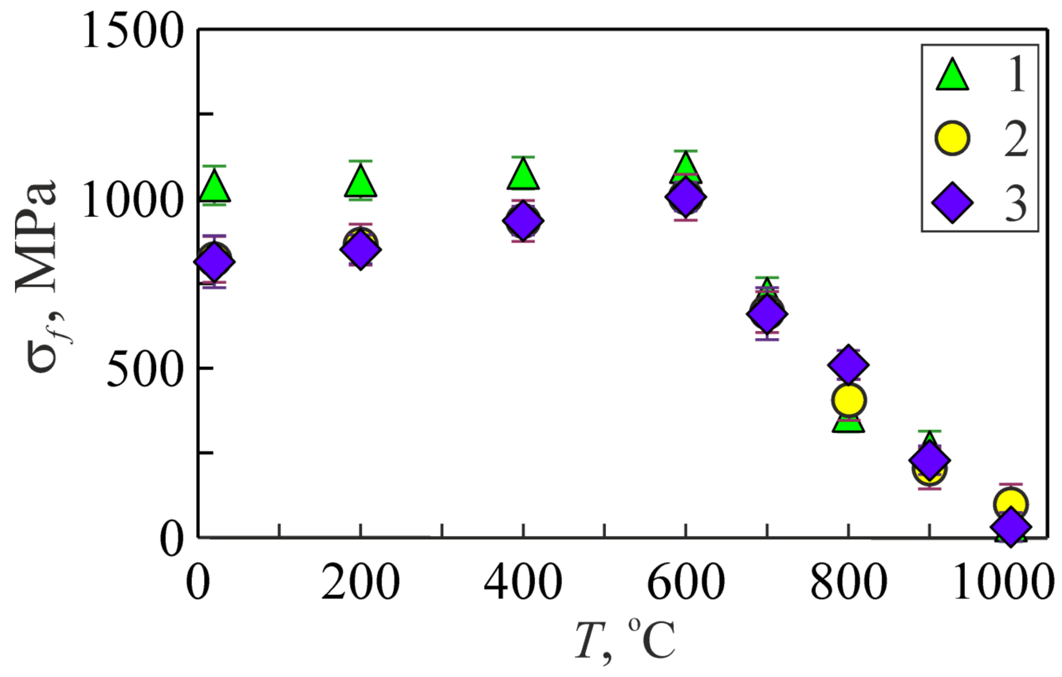
Experimental. Ti–Si–X composites (X=Al, Zr, and others) were manufactured with electron arc smelting. The content of alloying elements varied in a wide range (0.8–2.5 wt% Al, 5–8 wt% Zr). Strength tests of specimen series were carried out under three-point bending in a temperature range of 20°C to 1000°C. Fracture toughness tests of single-edge notch beam specimens were performed in a temperature range of 20°C to 900°C. The chemical and phase compositions of the composites were determined, as well as their microstructure and failure micromechanisms in relation to mechanical behavior were analyzed.



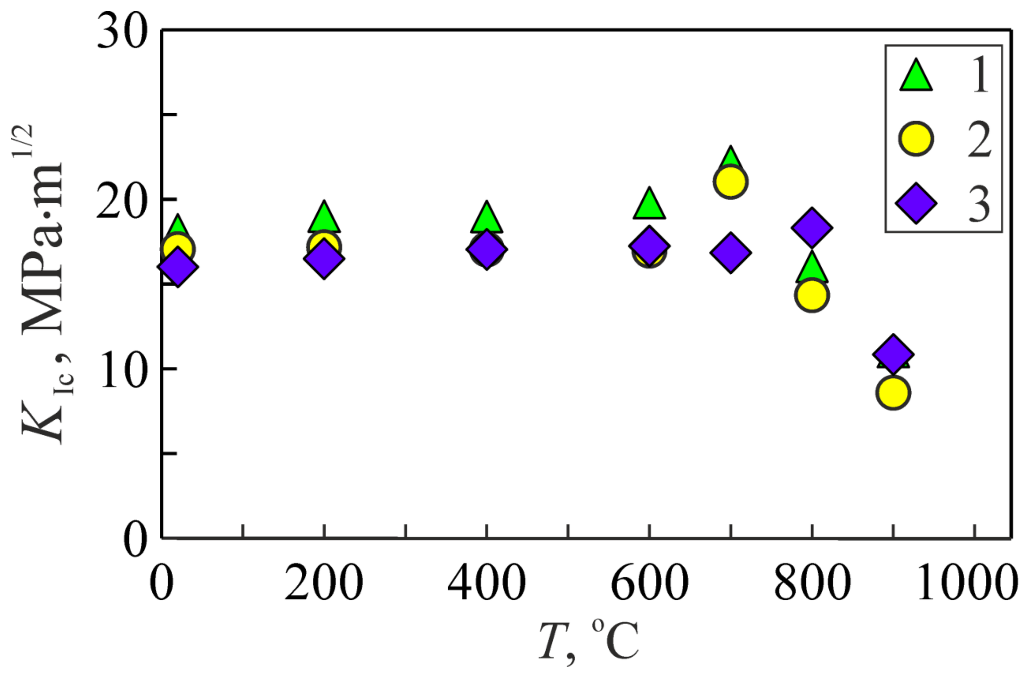
SEM microstructures of specimen series 1, 2, and 3

Results and Discussion. Based on the dependences of strength and fracture toughness on testing temperature for the specimen series as well as the microstructure and failure micromechanism analyses, it was found that the Ti_5Si_3 and complex $(Ti, Zr)_5Si_3$ refractory phases play a crucial role in enhancing fracture toughness of all the specimen series in the high-temperature (700–800°C) range.

Series	Chemical composition (wt%)
1	Ti-2.1Si-1.6Al-4.9Zr-0.1Fe
2	Ti-5.4Si-0.8Al-6.5Zr-1.7Mo-0.5Fe-0.3Cr
3	Ti-2.3Si-2.5Al-8.1Zr-0.5Mo-0.3Fe-0.1Cr



Temperature dependences of strength (under three-point bending) of Ti-Si-X composites of series 1, 2, and 3



Temperature dependences of fracture toughness of Ti-Si-X composites (series 1, 2, and 3; SENB method under three-point bending; the average values)

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