Study of the role of alloying elements Cr, Ni, Fe, and Al in the improvement of high-temperature (700–800 °C) fracture toughness of Ti-based composites

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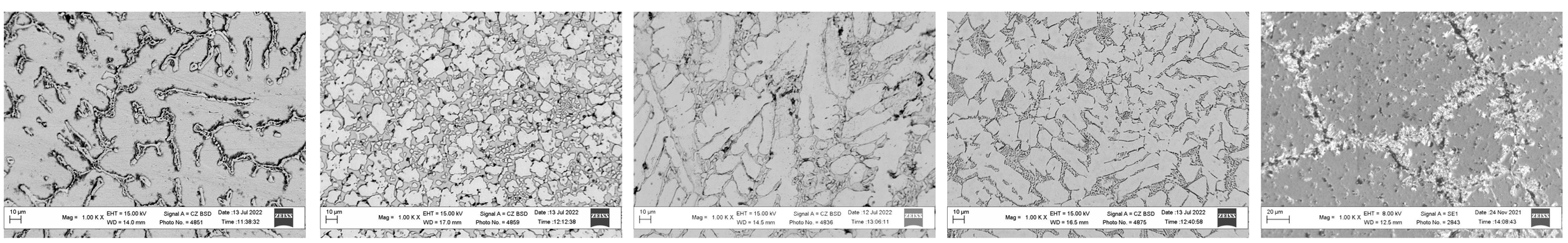
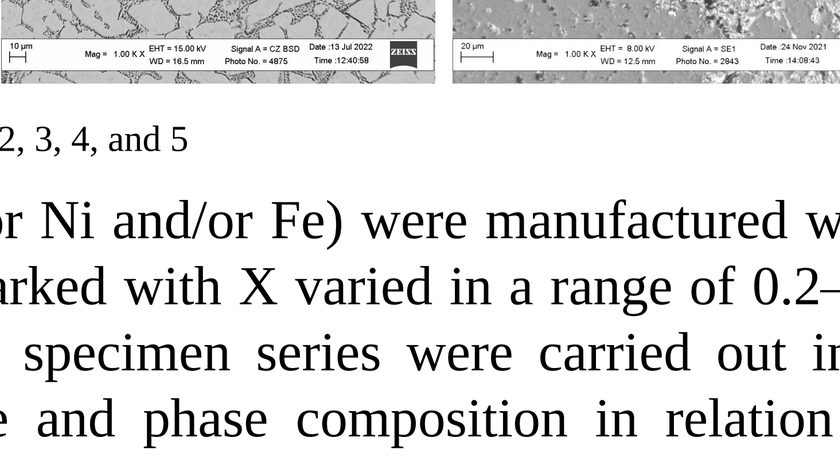
Introduction. Advanced Ti-based composites are being used for manufacturing components of state-of-the-art power equipment as well as aircraft and rocket engines owing to their high strength-to-weight ratio and comparatively high fracture toughness in a temperature range of 20°C to 650°C. These materials have an advantage over conventional titanium alloys, an operating temperature of which is limited by 350–550°C. This work is aimed at studying the role of alloying elements Cr, Ni, Fe, and Al in the improvement of high-temperature (700–800°C) fracture toughness of Ti-based composites.



SEM microstructures of specimen series 1, 2, 3, 4, and 5

Results and Discussion. Ti–Al–X composites (X=Cr and/or Ni and/or Fe) were manufactured with electron arc smelting. The contents of alloying elements marked with X varied in a range of 0.2–79 wt%. Single-edge notch beam fracture toughness tests of specimen series were carried out in a temperature range of 20°C to 800°C. The microstructure and phase composition in relation to fracture toughness data and failure micromechanisms of the composites were analyzed. The role of alloying elements Cr, Ni, Fe, and Al in the improvement of high-temperature fracture toughness of Ti-based composites was substantiated. It was found that both Ti–Al–Cr and Ti–Al–Ni composites of the optimal phase composition are promising in terms of fracture toughness for high-temperature (700–800°C) applications.

Series	Chemical composition (wt%)	Phase composition
1	Ti-1.6Al-1.7Si-4.3Zr-3Mo-6.5Cr-8V	β-Ti; Cr_2AlC
2	Ti-1.6Al-39Fe	β-Ti; $Ti_{50}Fe_{50}$
3	Ti-0.6Al-79Fe	α-Fe; $TiFe_2$
4	Ti-1.8Al-40Ni	β-Ti; Ti_2Ni
5	Ti-1.5Al-41Cr	β-Ti(Cr); Cr_3C_2; Cr_2AlC; $TiC_{0.67}$



Temperature dependences of fracture toughness of Ti-Al-X composites (SENB method under three-point bending; the average values)

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