Characterisation and Mechanical Properties of Stainless Steel Matrix Composites Reinforced with $(Nb_x,Ti_{1-x})C$ Particles

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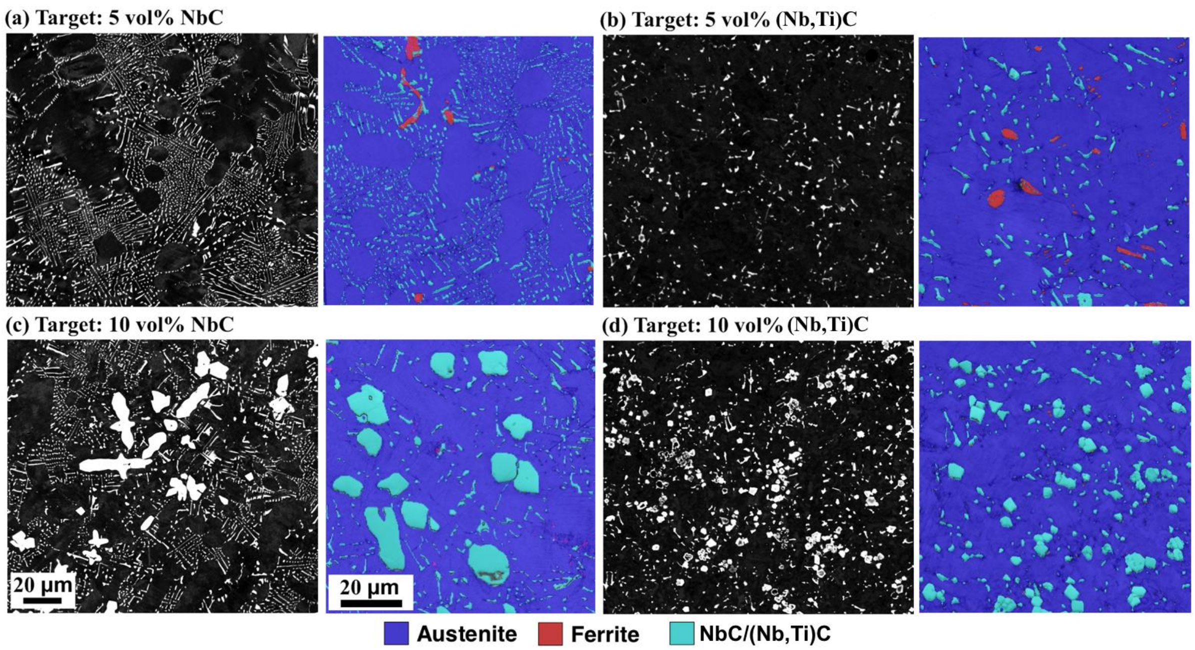
While TiC is frequently considered one of the best reinforcements for stainless steel matrix composites, the low density of TiC means that TiC particles are prone to floating when such composites are fabricated via melting and casting processes [1]. In such cases, NbC can be considered to be a more suitable reinforcement because it has a very similar density (though still slightly denser) to molten stainless steels [2]. However, relative to TiC, NbC is softer, much more expensive and forms Chinese-script structures that may be detrimental to mechanical properties. Thus, by dissolving TiC into NbC, it is possible to better match its density to that of molten stainless steels, minimise Chinese-script structures, save costs, and create a harder carbide [3]. Additionally, because both TiC and NbC are both insoluble in stainless steels, the composition of the stainless steel matrix can also be easily controlled to obtain desired phase(s) and microstructures. Therefore, it can be argued that $(Nb_x,Ti_{1-x})C$ may be a more optimal reinforcing phase for stainless steel matrix composites than either TiC or NbC.

In this study, a variety of stainless steels was melted with stoichiometric ratios of Nb, Ti and graphite to obtain stainless steel composites reinforced with *in-situ* $(Nb_x,Ti_{1-x})C$ particles. Each composite will also be compared with a NbC-reinforced counterpart since NbC is also a viable reinforcing phase from a density standpoint. The microstructure of each composite was characterised using Electron Backscatter Diffraction and Energy Dispersive X-ray Spectroscopy, and then related to the mechanical properties of the composite.

In general, NbC forms more extensive Chinese-script structures as opposed to discrete primary particles, as compared to $(Nb_x,Ti_{1-x})C$. While micro-hardness tests confirmed that $(Nb_x,Ti_{1-x})C$ particles were indeed harder than NbC particles, the NbC - stainless steel composites tend to report much higher bulk hardness values than their $(Nb_x,Ti_{1-x})C$ counterparts. This was attributed to the way indentation stresses are distributed in composites, where fibre/lamellar-like structures of the reinforcing phase promote a more efficient distribution of stresses. However, despite promoting better bulk hardness, Chinese-script structures were found to be very detrimental to wear performance, resulting in the $(Nb_x,Ti_{1-x})C$ stainless-steel composites being more wear resistant than their NbC counterparts. Furthermore, Chinese-script NbC structures also promoted an easy crack-propagation path which ultimately leads to poorer fracture toughness. Thus, for all intents and purposes, $(Nb_x,Ti_{1-x})C$ was found to be the more suitable reinforcing phase for stainless steel composites that are fabricated by melting and casting processes.



QBSD SEM images and EBSD phase maps showing the carbide morphology and phases present in austenitic stainless steels containing NbC or (Nb,Ti)C [3].

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