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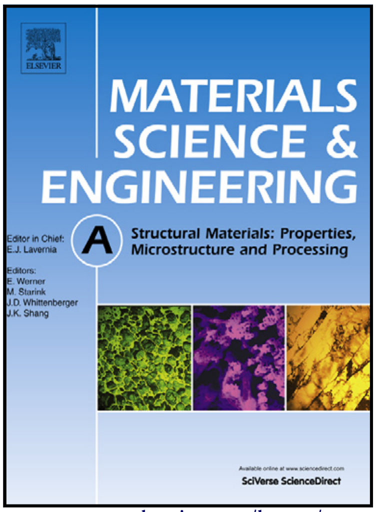


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# The influence of Al:Nb ratio on the microstructure and mechanical response of quaternary Ni-Cr-Al-Nb alloys

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*The influence of Al:Nb ratio on the microstructure and properties of Ni-Cr-Al-Nb alloys has been investigated following long-term exposure at elevated temperatures. The γ′ volume fraction, size and lattice misfit were seen to increase with a larger Al:Nb ratio, although these changes resulted in reduced hardness. The change in the critical resolved shear stress (CRSS) associated with strong dislocation coupling was determined to be the dominant strengthening mechanism and increased with decreasing Al:Nb ratio. A distribution of tertiary γ′ was observed to be necessary in maximising the mechanical properties of these alloys.*

Keywords: nickel-based superalloys; microstructure; gamma prime; aging; electron microscopy



## Introduction

To comply with increasingly stringent aerospace emissions targets [1] [2] gas turbine engine manufacturers are seeking to improve engine efficiency. Engine performance can be enhanced through an increase in the temperature at which the engines are operated or, alternatively, through higher rotational speeds. However, current nickel-base superalloys, used in the hottest sections of the engine, are working close to their physical limits and are unable to tolerate any further increase in temperature or stress [3]. The development of new nickel-base superalloys specifically designed to operate under more demanding conditions is therefore critical to the ongoing advancement of gas turbine engines.

Nickel-base superalloys typically consist of an A1 (strukturbericht notation) matrix (γ) solid solution, reinforced with a distribution of coherent $Ni_3Al$, $L1_2$ superlattice precipitates (γ′). Within the microstructure there can be up to three distinct distributions of γ′, each with a different size range, composition and effect on properties. Relatively coarse ~1 μm (in diameter) primary γ′ is formed during alloy manufacture and processing, whilst fine secondary and tertiary γ′ (~100 nm and <50 nm respectively) form on cooling from solution and through subsequent aging heat treatments [4].

The plastic deformation of coherent superlattice precipitates, such as γ′, demands the passage of paired dislocations, so that the energy associated with the anti-phase boundary (APB) created by the leading dislocation is minimised by the passage of the trailing dislocation [3] [5]. The precipitate size has been