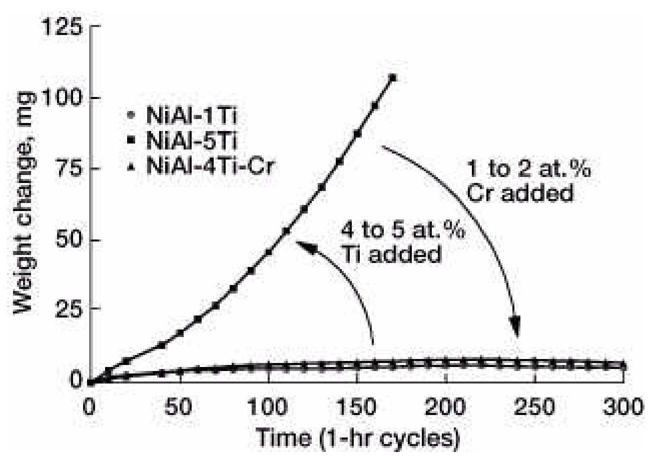
Single-Crystal NiAl-X Alloys Tested for Hot Corrosion

Single-crystal nickel aluminide (NiAl) has been investigated extensively throughout the last several years as a potential structural material in aero-gas turbine engines. The attractive features of NiAl in comparison to Ni-base superalloys include a higher melting point, lower density, higher thermal conductivity, and excellent oxidation resistance. However, NiAl suffers from a lack of ductility and fracture toughness at low temperatures and a low creep strength at high temperatures. Alloying additions of hafnium (Hf), gallium (Ga), titanium (Ti), and chromium (Cr) have each shown some benefit to the mechanical properties over that of the binary alloy. However, the collective effect of these alloying additions on the environmental resistance of NiAl-X was unclear. Hence, the present study was undertaken to examine the hot corrosion behavior of these alloys. A companion study examined the cyclic oxidation resistance of these alloys.

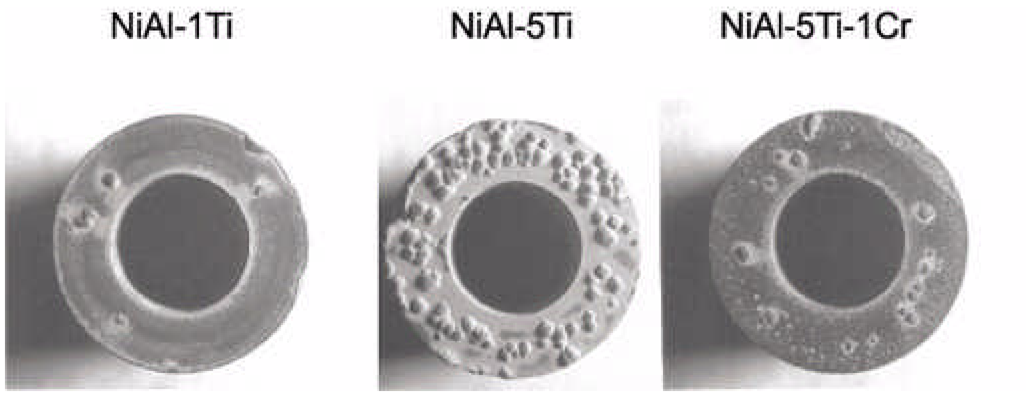
Several single-crystal NiAl-X alloys (where X is Hf, Ti, Cr, or Ga) underwent hot corrosion testing in a Mach 0.3 burner rig at the NASA Lewis Research Center. Samples were tested for up to 300 1-hr cycles at a temperature of 900 °C. It was found that increasing the Ti content from 1 to 5 at.% degraded the hot corrosion behavior. This decline in the behavior was reflected in high weight gains and large corrosion mound formation during testing (see the figures). However, the addition of 1 to 2 at.% Cr to alloys containing 4 to 5 at.% Ti appeared to greatly reduce the susceptibility of these alloys to hot corrosion attack and negated the deleterious effect of the increased Ti addition.



Weight change as a function of time for three single-crystal NiAl-X alloys.

After testing, the surface morphology consisted of either mounds or an inward, uniform attack that preserved surface features. The mounds initiated early and grew and coalesced through the 300 hours of testing. However, few new corrosion mounds were observed after 50 to 100 hours. Microstructurally, below the surface, the hot corrosion attack initiated as pits but evolved to a rampant attack consisting of the rapid inward growth of

Al_2O_3 and TiO_2. This attack stage progressed rapidly inward, totally depleting the Al and Ti in the degraded regions.



Hot corrosion of three single-crystal alloys.

It was also observed that the corrosion morphology was strongly affected by the surface preparation treatments. The sample surfaces were prepared by either electropolishing, chemically milling, or mechanical polishing. It was found that mechanical polishing changed the corrosion morphology and improved the hot corrosion response over that of chemically milled surfaces. Further details of this work are given in reference 1.

Reference

1. Nesbitt, J.A.: Hot Corrosion of Single-Crystal NiAl-X Alloys. NASA TM-113128, 1998.

Lewis contact: Dr. James A. Nesbitt, (216) 433-3275, James.A.Nesbitt@grc.nasa.gov
Author: Dr. James A. Nesbitt
Headquarters program office: OAT
Programs/Projects: HITEMP