The effect of rare earth cerium addition on primary microstructure and oxide scale formation of polycrystalline superalloys based on Co-Al-W system

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ABSTRACT

Cobalt superalloys strengthened by γ′ phase are promising materials for high temperature applications owing to remarkable strength at elevated temperatures. Except of mechanical properties, numerous researchers are involved in improvement of high temperature oxidation of these alloys. In this work, minor addition of cerium was added in order to improve oxidation properties.

The as-cast Co-9Al-9W (reference alloy) and Co-9Al-9W-XCe (X=0.1, 0.5 at%) alloys were prepared by Induction Vacuum Melting (VIM). The primary microstructure of alloys was characterized by means of Light Microscopy (LM), Scanning Electron Microscopy (SEM) and electron backscatter diffraction (EBSD). The analysis was performed on upper, medium, and lower part of ingot. Afterwards, the samples were exposed to oxidation cyclic oxidation at 800 °C. The specimens were subjected to 25 h cycles of exposure at 800 °C and air cooling to room temperature. The scale formed on alloys was analyzed via SEM/EDS method.

Cerium caused modification of Co-Al-W alloys, especially by segregation to interdendritic spaces and formation of ternary $CeCo_{5-x}Al_x$ phases. The influence of cerium on cyclic oxidation and the scale formation at 800 °C was determined.

OBJECTIVES

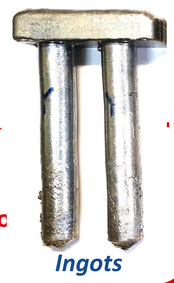
The composition of investigated alloys

Nominal composition [at. %]	Measured chemical composition [EDS] [at. %]			
	Co	Al	W	Ce
Co-9Al-9W (reference)	85.7	6.3	8	-
Co-9Al-9W-0.1Ce	85.9	6.2	7.9	-
Co-9Al-9W-0.5Ce	85.2	6.3	8.1	0.4

Melting → 1600-1700 °C, 15 min

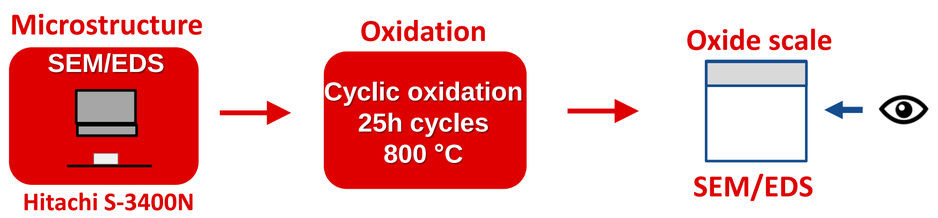
VIM furnace

Casting → 1600 °C, To cold graphite mc



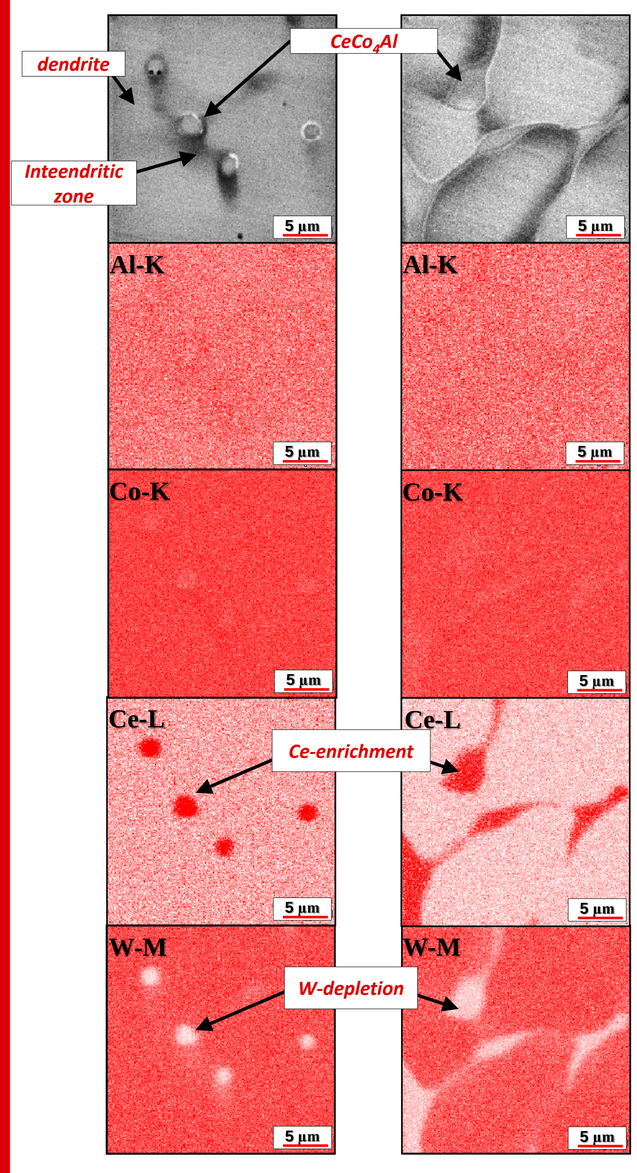
Ingots

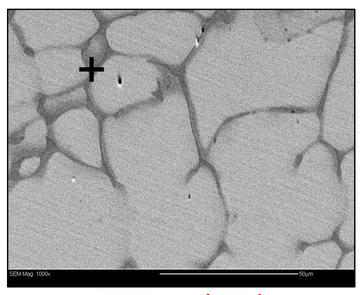
EXPERMIENTAL



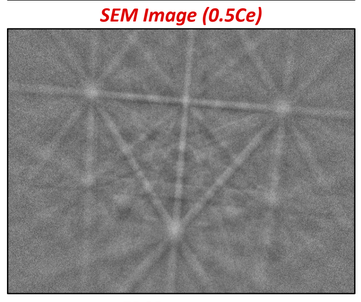
RESULTS

Microstructure

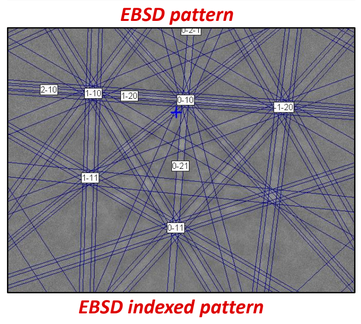




SEM Image (0.5Ce)



EBSD pattern



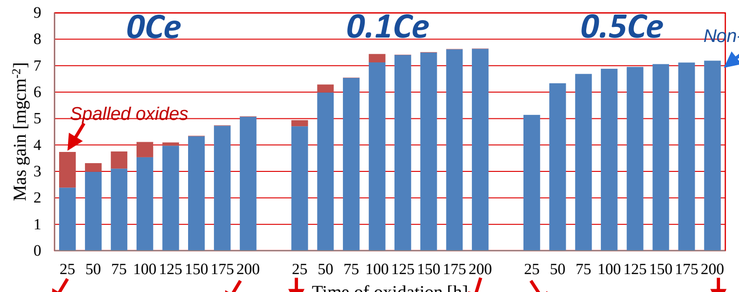
EBSD indexed pattern

MAD=0.347°

$CeCo_4Al$

EDS maps of element distribution in the alloy

Cyclic oxidation

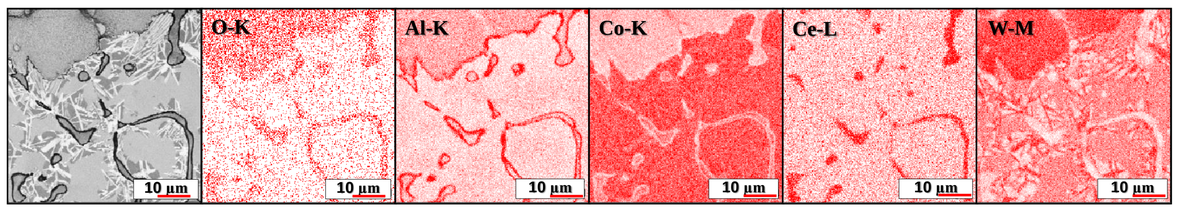


Total mass gain 8.1 mgcm⁻² → *constant scale growth* → *highest spallation*

Total mass gain (including spallation) 7.82 mgcm⁻² → *stabilization of scale growth after 100h*

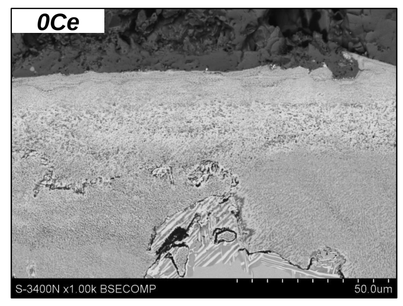
Total mass gain 7.31 mgcm⁻² → *no spallation*

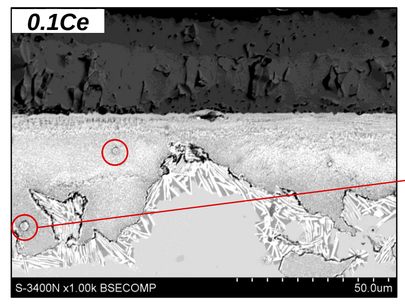
Interdendritic oxidation via channels rich in Ce-Co-Al phase

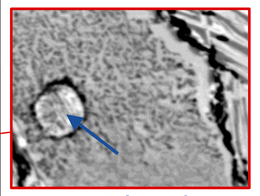


EDS maps of element distribution in the oxide scale of Co-9Al-9W-0.5Ce alloy

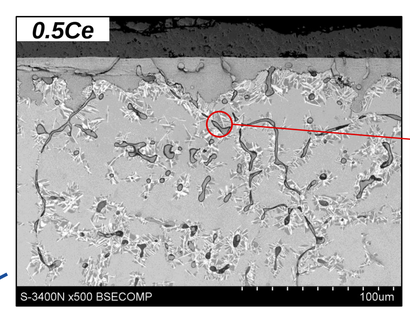
Oxide scale microstructure

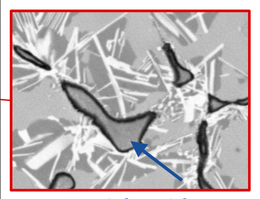






Ce-rich oxide





Ce-rich oxide

CONCLUSIONS

1. In Ce-doped Co-Al. alloys, Ce segregates to interdendritic spaces and forms $CeCo_{5-x}Al_x$ phases
2. Ce addition decrease spallation of oxide layer at 800 °C
3. *High Ce-content (0.5%) results in internal oxidation via interdendritic channels*

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