γ/γ′ Co-BASE SUPERALLOYS – NEW HIGH TEMPERATURE MATERIALS BEYOND NI-BASE SUPERALLOYS?

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In 2006 a new $L1_2$ phase, $Co_3(Al,W)$, was discovered in the Co-Al-W system which has led to the development of novel Co-base superalloys with γ/γ′ microstructures similar to those of the well-established Ni-base superalloys. First investigations on simple ternary alloys could show that these Co-Al-W based alloys exhibit higher solidus temperatures and show less segregations after casting compared to typical Ni-base superalloys. This leads to the question whether this γ/γ′ Co-base superalloys can be regarded as new class of high temperature materials that can compete with or even supersede established Ni-base superalloys.

In the first part of the talk it will be shown how alloy properties change, when the base element Ni is gradually substituted by Co in a series of Ni-Co-Al-W-Cr alloys with otherwise constant element contents of Al, W and Cr. All alloys form γ/γ′ microstructure after a standard aging treatment with a similar γ′ volume content. Liquidus and solidus temperatures are hardly influenced by the Ni/Co content, but the γ′ solvus temperature is strongly decreasing with increasing Co content. This indicates that the potential application temperature of γ/γ′ Co-base superalloys will not be beyond the maximum application temperature of advanced single crystal Ni-base superalloys. However, this also shows that γ/γ′ Co-base superalloys have a great potential as wrought alloys since the solvus temperature of the intermetallic compound is comparatively low, which gives a large processing window, and because a high volume fraction of the $L1_2$ phase at temperatures up to 900°C can be achieved.

In the second part of the talk results on such recently developed high-strength polycrystalline Co-base superalloys that were produced by the conventional cast-and-wrought method, will be presented and discussed. The solidus temperatures of our multinary Co-base superalloys are above 1300°C and the solvus temperatures range between 1000°C and 1100°C. The fraction of the $L1_2$ phase is above 50% and high energy X-ray diffraction measurements show that the lattice parameter of the $L1_2$ phase is in general larger than that of the unordered fcc matrix phase. Atom probe tomography investigations reveal the partitioning behavior of the alloying elements and oxidation tests show that the oxidation resistance is much better compared to that of ternary Co-Al-W based superalloys. In comparison to conventional Ni-base superalloys compression tests show that a higher yield strength above 800°C could be achieved and that the creep strength is superior at 750°C.

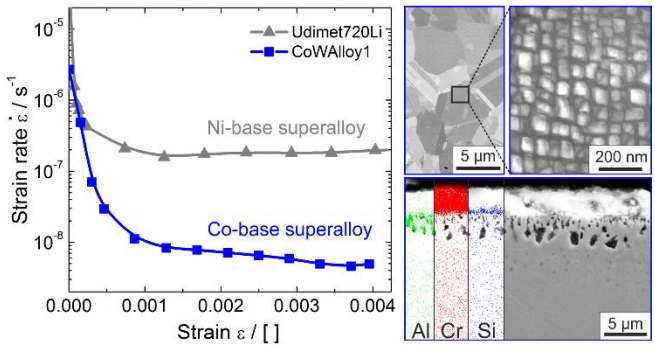

Figure 1 – Left: superior creep strength of polycrystalline Co-base superalloy CoWAlloy1 compared with Ni-base superalloy Udimet720Li at 750°C. Right: γ/γ′ microstructure and oxide scale of CoWAlloy1.