DECHEMA FORSCHUNGSINSTITUT

Development of high-temperature oxidation resistant coatings for titanium aluminide alloys

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Motivation

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Use of titanium aluminide alloys in aircraft engines

- Attractive properties for structural applications at high-temperatures. [1]
- Weight reduction of engines which leads to reduced fuel consumption, noise and NOx emissions.
- However, application limited to the coldest stages due to mechanical and environmental limitations above 700°C:
  - Ductility loss at room temperature after exposure at high temperature. [2]
  - This is linked to oxygen and nitrogen up-take into the substrate subsurface zone.

Current development

- Improving the high-temperature resistance of TiAl alloys in order to extend the use of TiAl alloys over 800°C.

New generation aircraft engine: the LEAP (Photo credit: Safran Aircraft Engines)

Strategy

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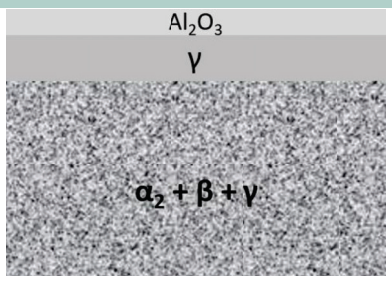
1st step: γ-TiAl coating

- γ-TiAl can act as a barrier against oxygen dissolution
- Coating solutions:
  - Pack cementation
  - Aluminium deposition by electrochemical process and subsequent thermal treatment

2nd step: Halogen effect application

- Halogen effect: Surface modification which allows protective alumina formation during oxidation
- Solutions:
  - Liquid phase application
  - Gas phase enrichment
  - Ion implementation

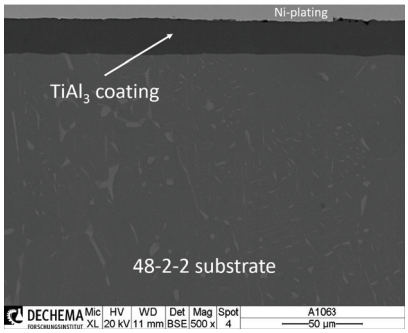


TNM-B1 protective layer system (after [3])

Pack cementation coating

3

- No significant microstructure change of subsurface zone
- $TiAl_3$ coating → brittle phase (observation of cracks)
- Thicker than desired (between 20 and 30 µm, specifications ≈ 5 µm)



BSE image of pack cementation sample

Aluminium deposition by electrochemical process

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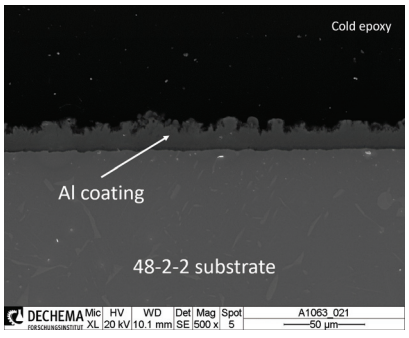
- No significant microstructure change of subsurface zone
- Dense and adherent Al-coating



SE image of aluminium deposition by electrochemical process

Outlook

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Pack cementation process

- Reduce aluminium activity by using masteralloy → thinner γ-TiAl coating.
- Halogen effect application.
- Subsequent pre-oxidation treatment to form protective alumina layer.

Electrochemical process

- Study of native oxide layer removal by electrochemical process.
- Study of diffusion thermal treatment.
- Halogen effect application.
- Subsequent pre-oxidation treatment to form protective alumina layer.

Literature

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[1] D.M. Dimiduk. *Mater. Sci. Eng., A*, **263**, 281 (1999)

[2] S.L. Draper *et al. Intermetallics*, **13**, 1014 (2005)

[3] J. Grüters *et al. Intermetallics* **60**, 19 (2015)

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