

# Experimental Plan – Task 2: Surface Alloys Feasibility Study

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- **Develop sacrificial/self-grading volatility protection layer**

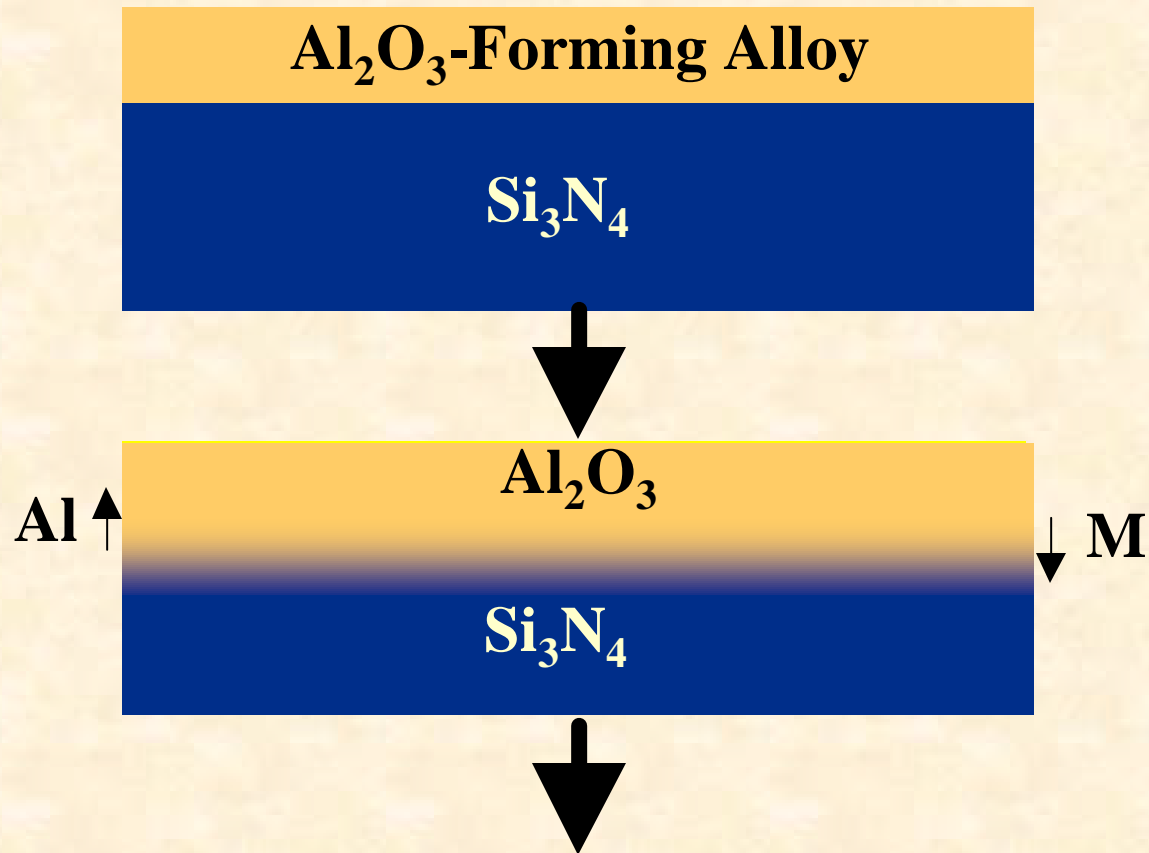
- Alumina formers selected for feasibility study because alumina formation is well understood
- Deposit thin (2-3 micron) layer of alumina forming alloy on to silicon nitride substrate. Thin layer to accommodate CTE mismatch
- Al consumed to form volatility resistant alumina surface layer
- Four compositions selected with range of CTE, high temperature strength properties in metal layer, and base metal chemistry; NiAl(Hf), Cr<sub>2</sub>AlY, NiCrAlY, FeCrAlY

# Experimental Plan - Surface Alloys Continued

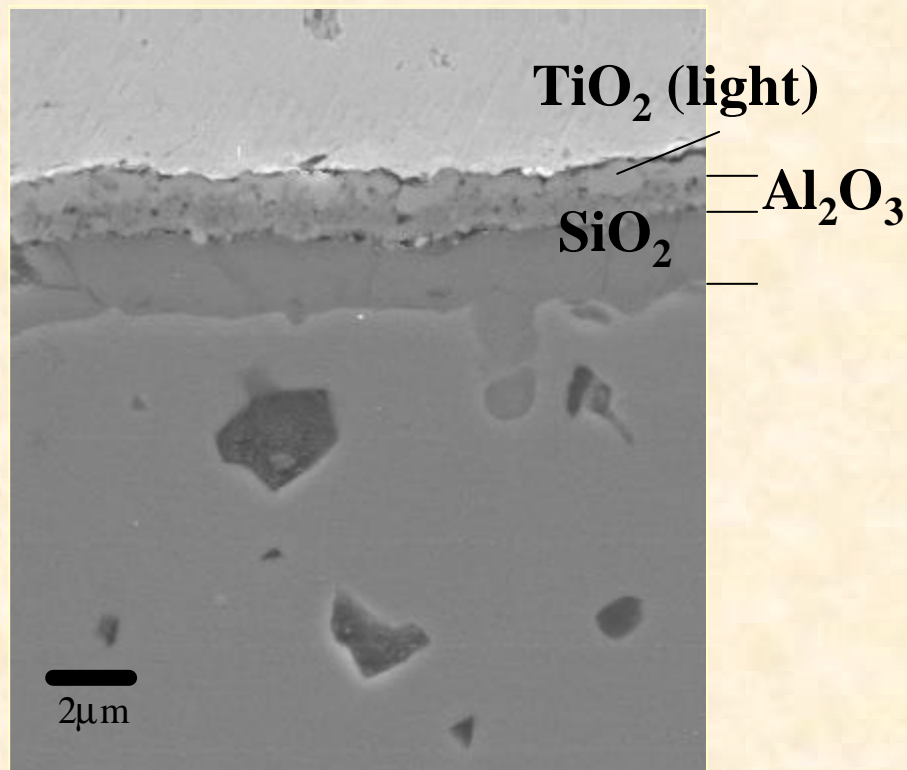
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- **Determine key issues:**
  - conversion of the metal layer to the ceramic
  - Does a dense, adherent oxide layer form after the oxidation treatment?
  - Will other porous oxide phases form?
  - Will the oxide stay adherent, i.e., is CTE too large?
- **Expectations:**
  - Duplex oxide layer with outer layer of alumina and an inner graded oxide layer of base metal of the aluminide, Si and Al

# Sacrificial, Self-Grading $\text{Al}_2\text{O}_3$ -Forming Precursor



# Sacrificial, Self-Grading $\text{Al}_2\text{O}_3$ -Forming Precursor



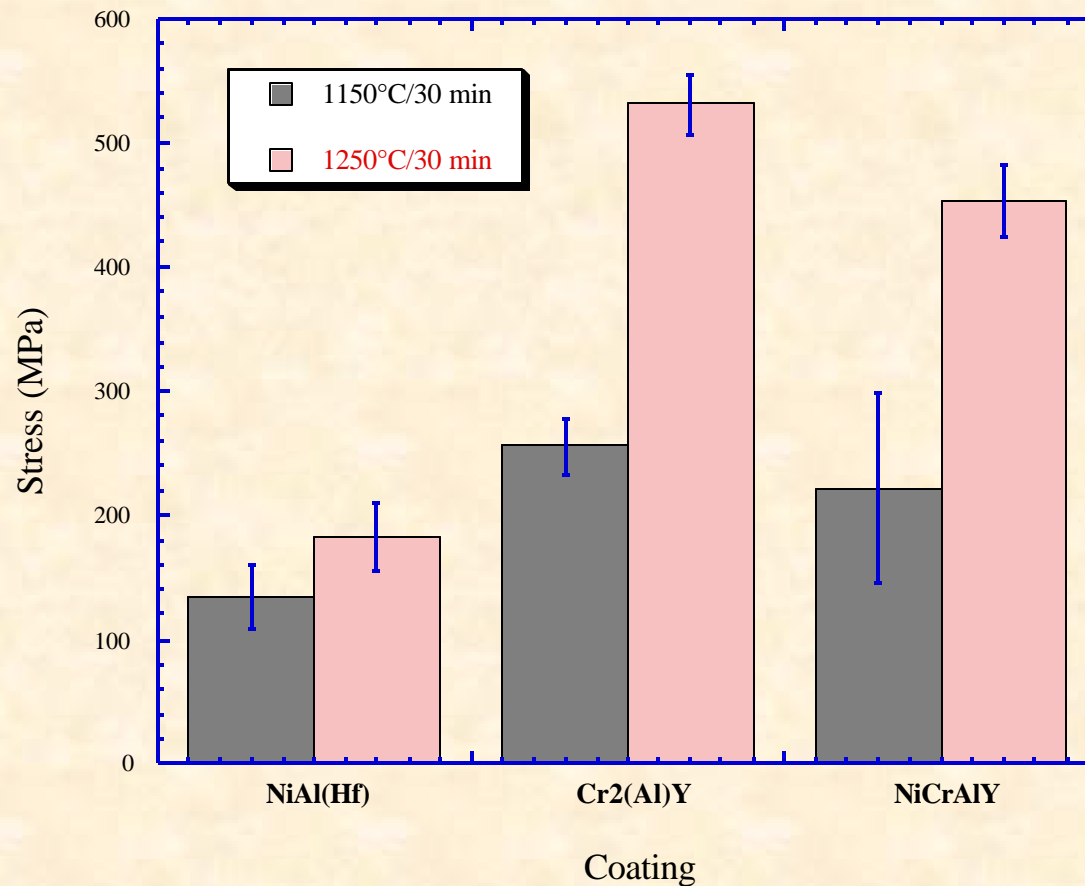
Exposure of  $3\mu\text{m}$  sputtered Ti-51Al-12Cr on SiC showed excellent adherence after ten, 100 hour cycles to  $1100^\circ\text{C}$  in laboratory air.  
No spallation occurred.

# Kyocera SN282 Silicon Nitride

Heat Treatment: 1150°C/30 min & 1000°C/72 hours

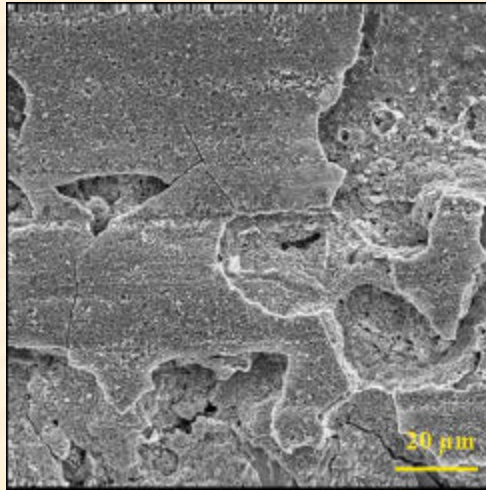
Coating Type	Performance	Reactivity with Substrate	CTE	Bulk Strength of Coating Material	Avg. Hydrostatic Stress (Mpa)
NiCrAlY	Very Poor	Low	High	High	222
NiAl(Hf)	Good (after 500 hours)	Low	Low	Low	134
FeCrAlY	Good (after 72 hours)	Low (possibly Fe)	Low		529
Cr <sub>2</sub> (Al)Y	Fair	Low			256
TiCrAl	Good	Low	Low		

# Average Hydrostatic Stress as a Function of Heat Treatment and Coating Type on Kyocera SN282 Substrates

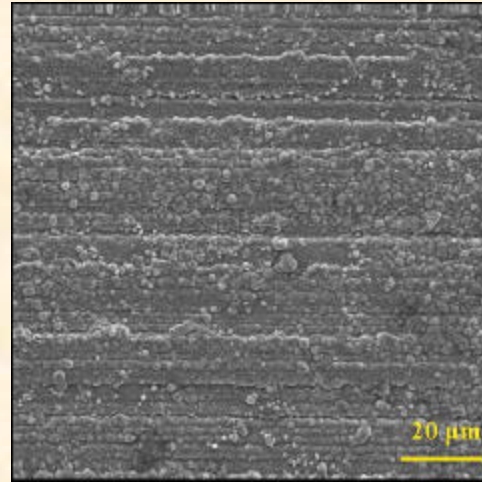


# Top Surfaces of Coatings on NT154 after Heat Treatment at 1150°C for 0.5 hour

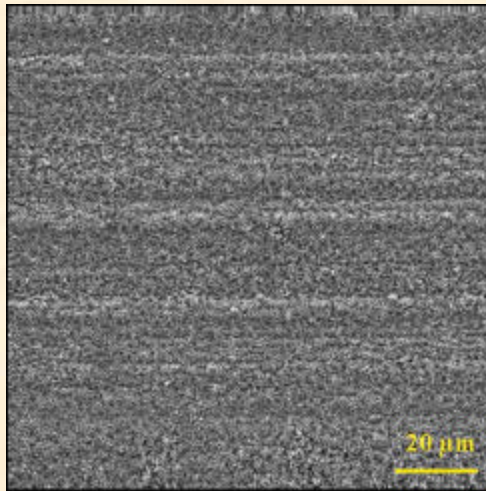
*NiCrAlY*



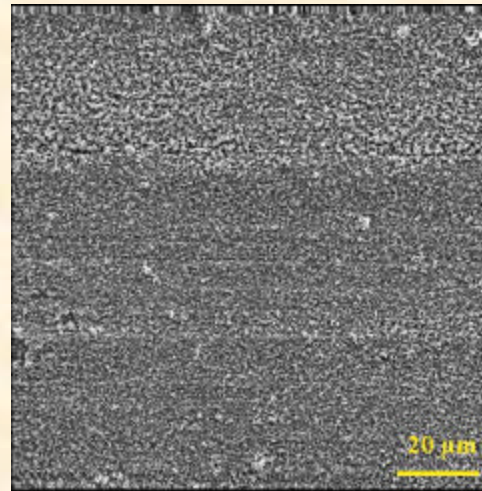
*FeCrAlY*



*NiAl(Hf)*

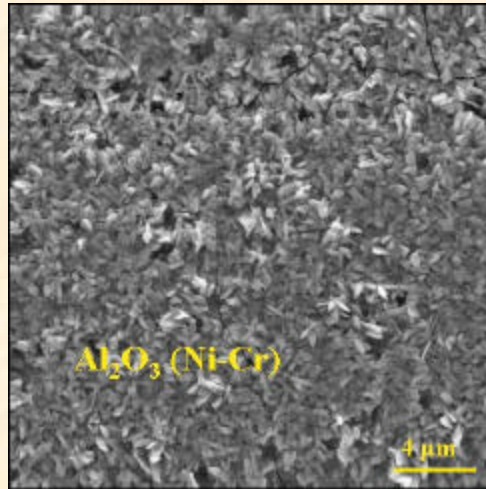


*Cr<sub>2</sub>(Al)Y*

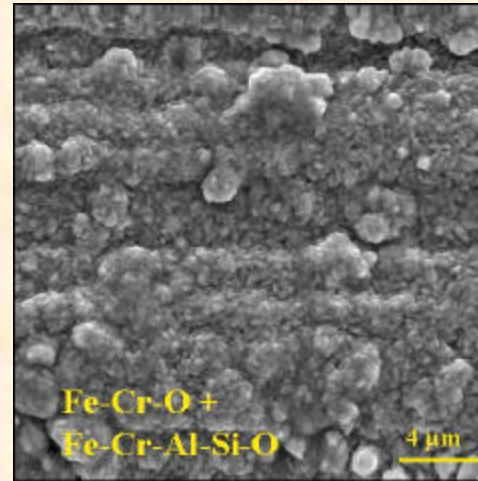


# Top Surfaces of Coatings on NT154 after Heat Treatment at 1150°C for 0.5 hour

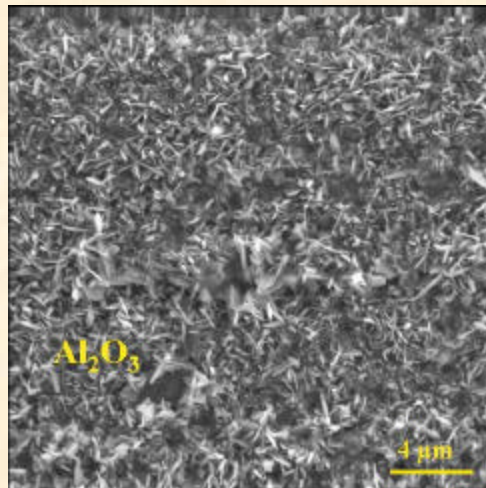
*NiCrAlY*



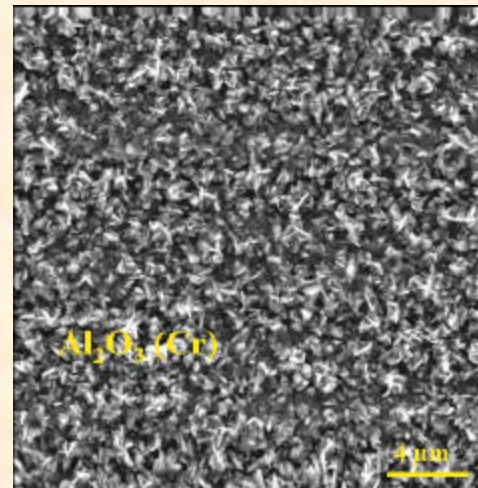
*FeCrAlY*



*NiAl(Hf)*

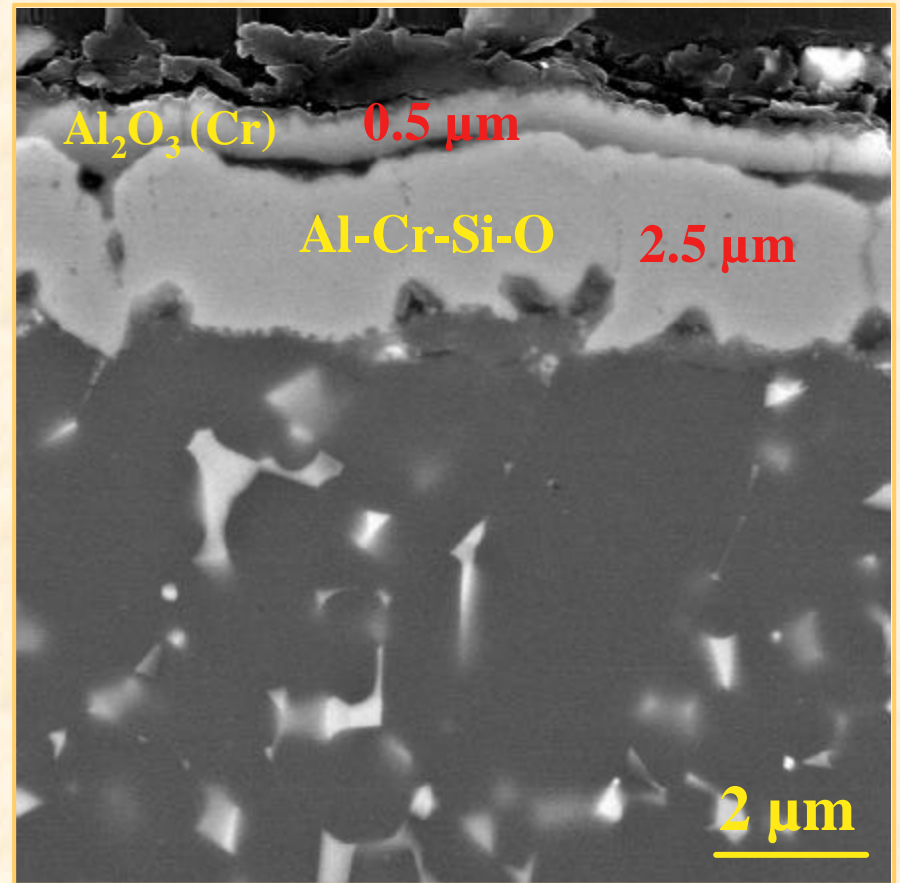
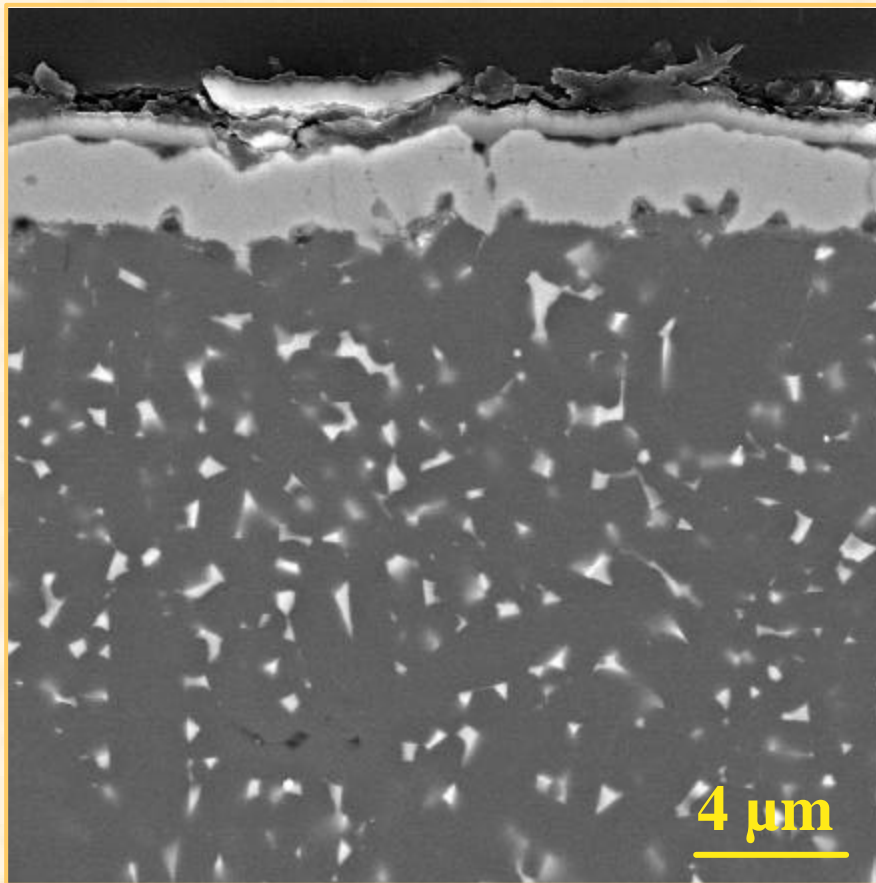


*Cr<sub>2</sub>(Al)Y*





## *Polished Cross Section of Cr<sub>2</sub>(Al)Y Coating on SN8282*

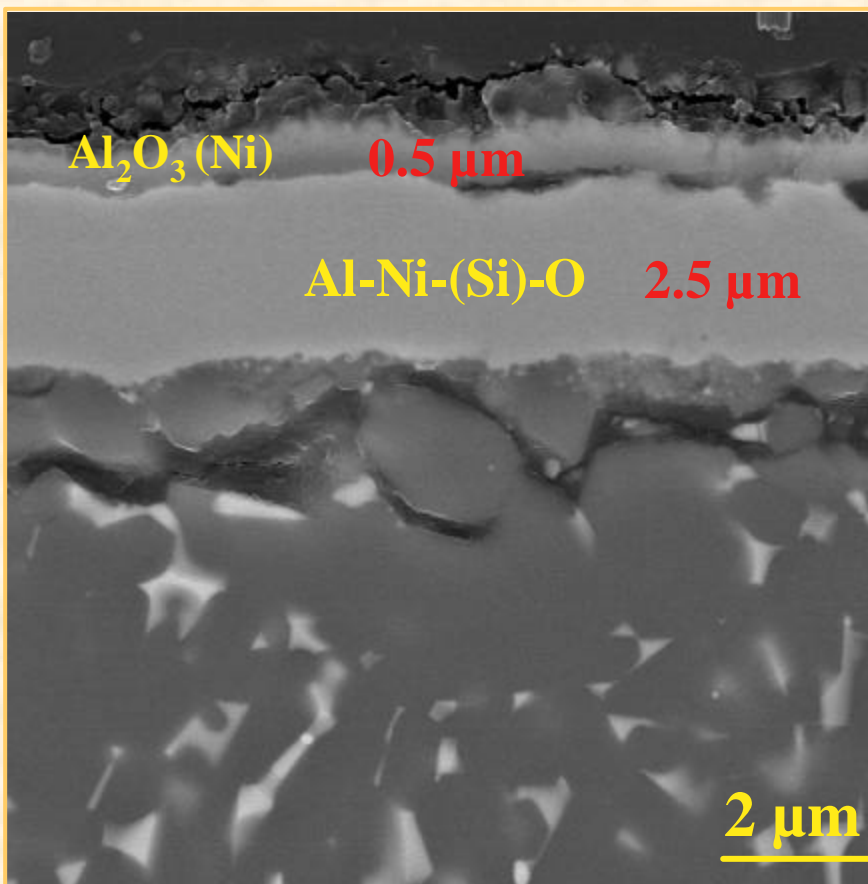
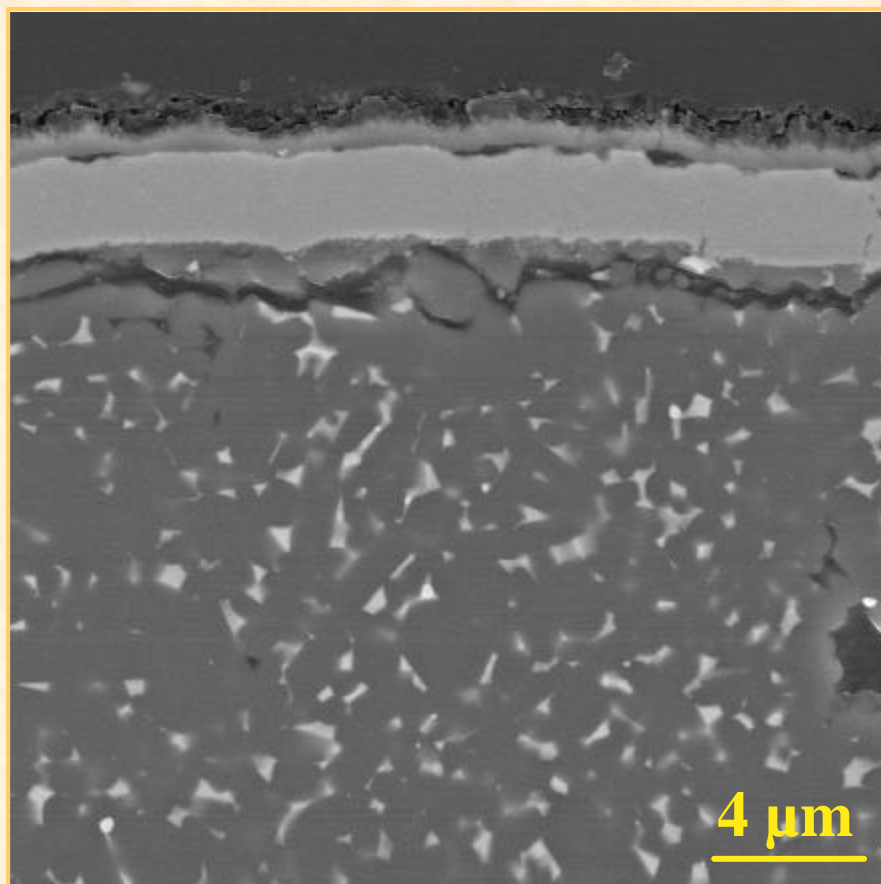


Heat Treatment: 1150°C, 30 min. in O<sub>2</sub>

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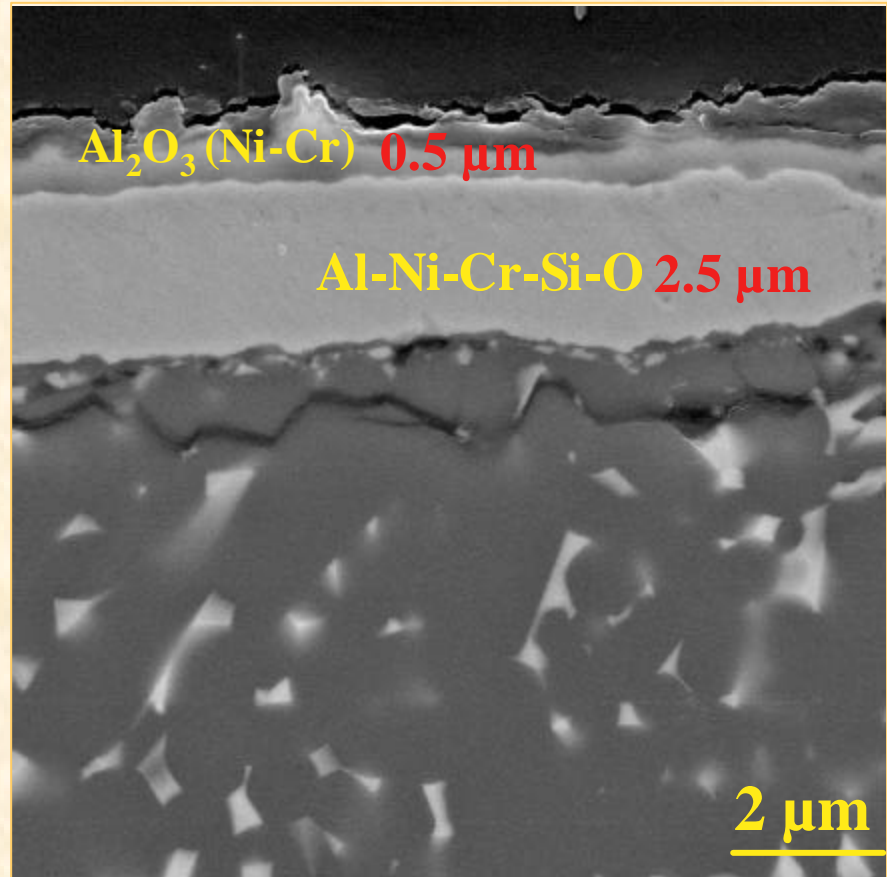
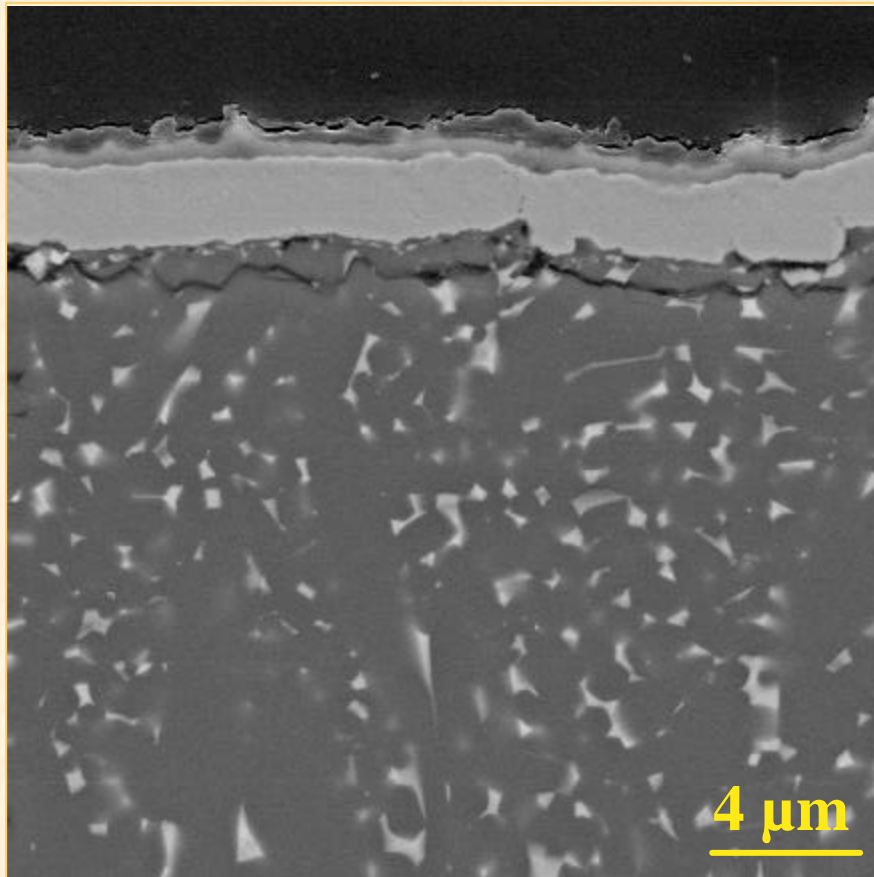
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## *Polished Cross Section of NiAl(Hf) Coating on SN8282*



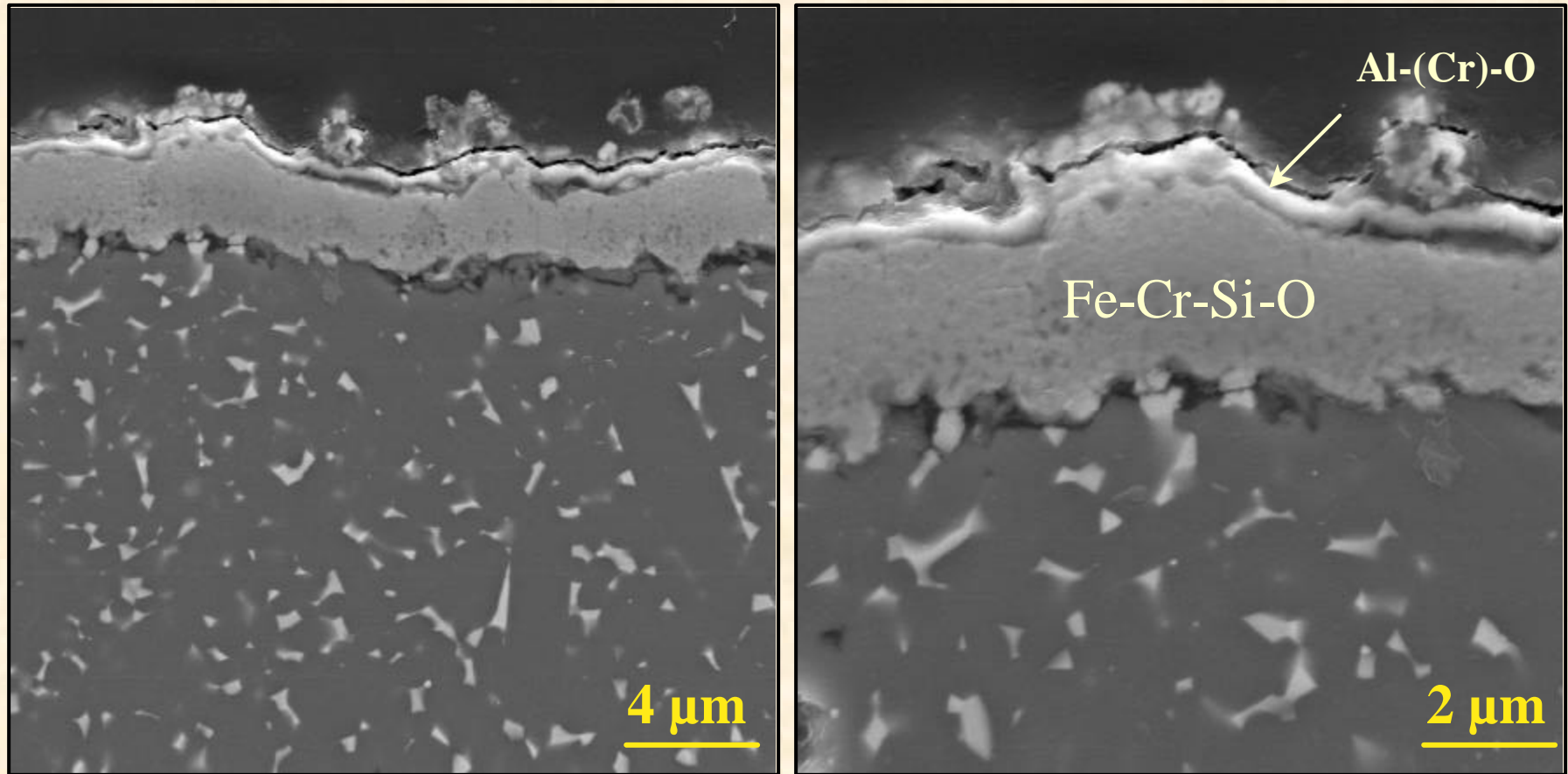
Heat Treatment: 1150°C, 30 min. in O<sub>2</sub>

## *Polished Cross Section of NiCrAlY Coating on SN8282*



Heat Treatment: 1150°C, 30 min. in O<sub>2</sub>

## *Polished Cross Section of FeCrAlY Coating on SN282*

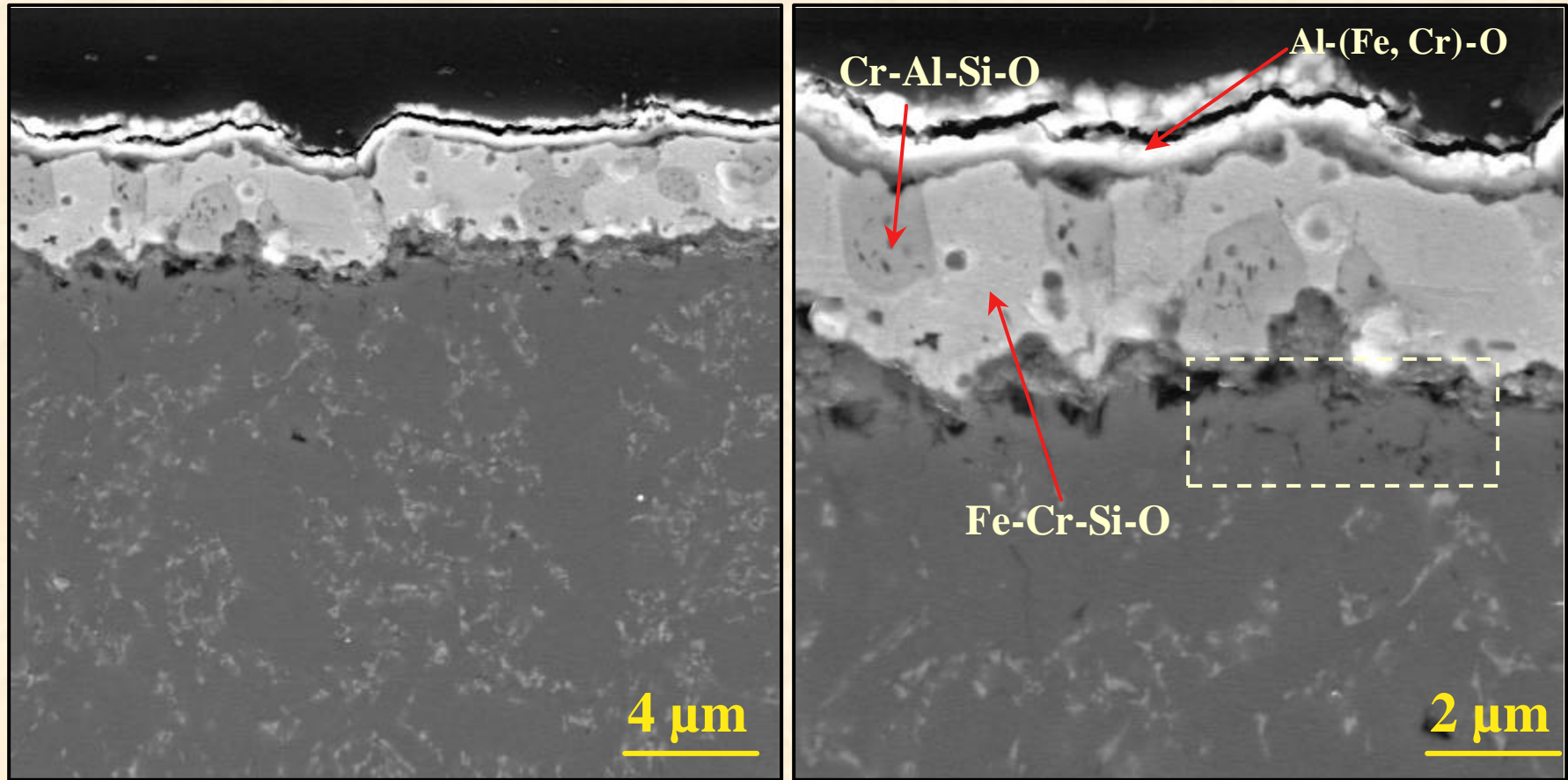


Heat Treatment: 1150°C/30 min. & 1000°C/72h

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# *Polished Cross Section of FeCrAlY Coating on NT154*

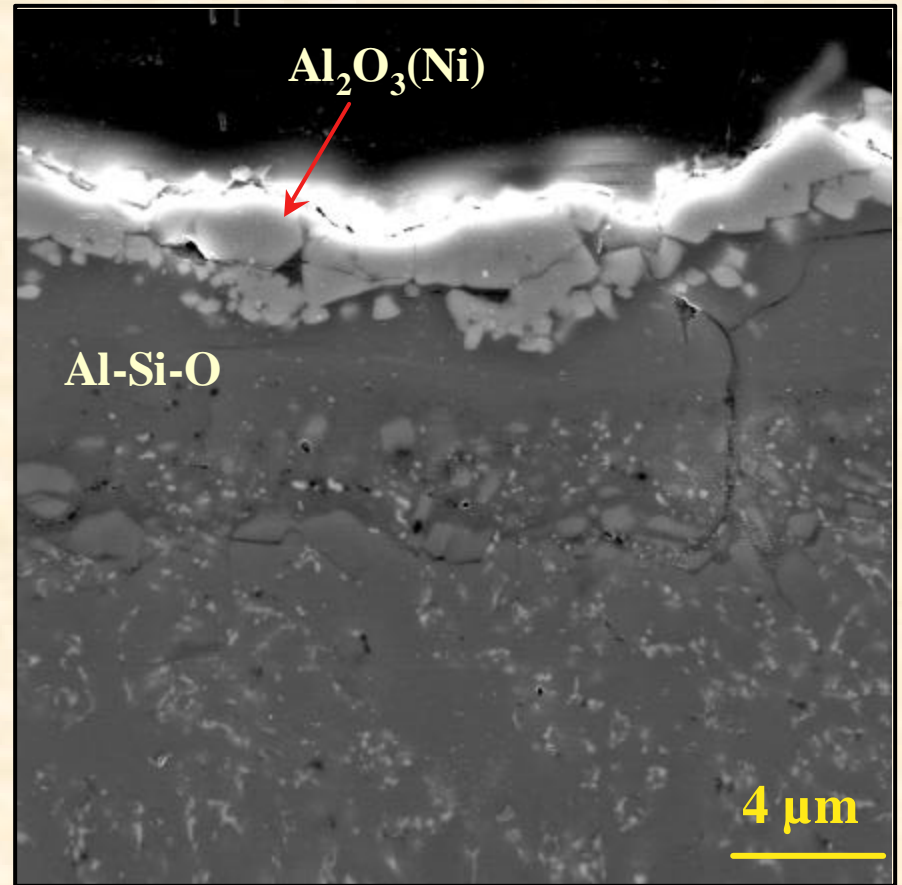
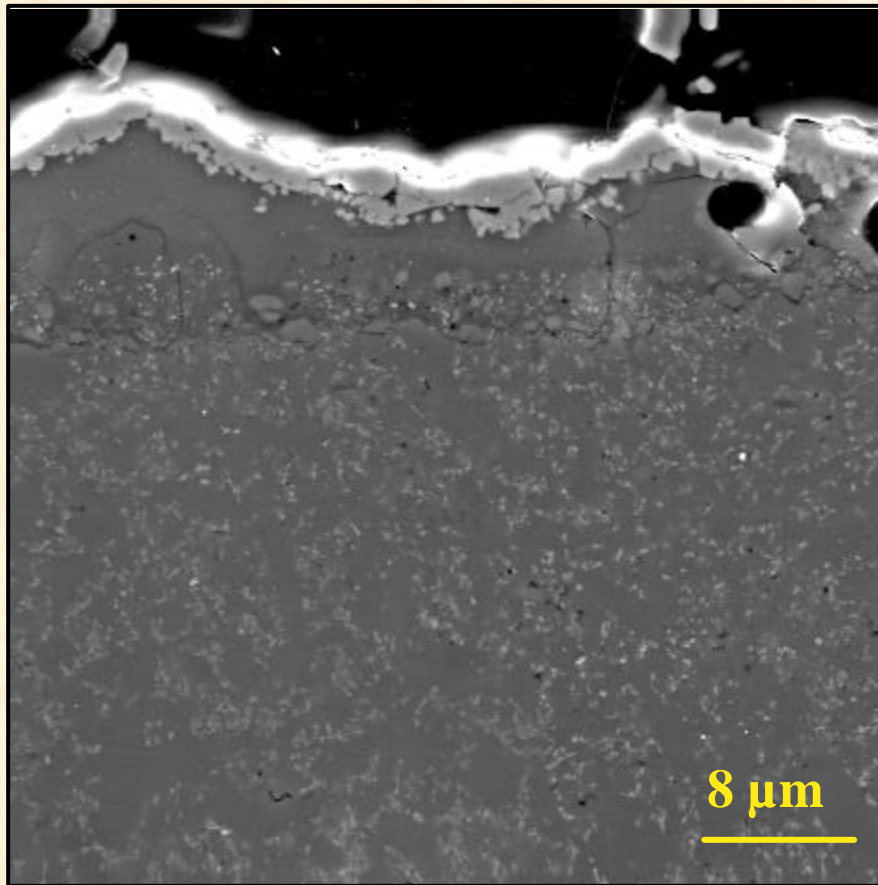


Heat Treatment: 1150°C/30 min. & 1000°C/72h

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*SEM Cross Section of NiAl(Hf) Coating on NT154  
Substrate After 500h Exposure at 1204°C & 100% H<sub>2</sub>O*



*SEM Cross Section of  $Cr_2(Al)Y$  Coating on NT154  
Substrate After 500h Exposure at 1204°C & 100%  $H_2O$*

