A New Generation of Corrosion Resistant Evaporator Boats

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Kennametal Sintec: Products

Non oxide powders: BN, TiB$_2$, B$_4$C

Evaporator boats

Hot pressed boron nitride

Shot blast nozzles
Kennametal Sintec: Applications

Food packaging

Capacitor

Label

Decorative

Reflectors
Evaporator boats:

- Resistance heated boats or crucibles used in vacuum chambers at approx. 1500°C to evaporate aluminum, copper or silver.

- Metalizing of films and papers that are used for capacitors, decoration, packaging and in electronic industries.
Metalizing process

Metalization chamber

Evaporator boat at process temperature

Metal melt
Evaporator boat after metalizing

AI flow is at the highest near the wire touching point

Erosion

Chemical and physical attack

Corrosion

Erosion + corrosion affect the product’s life time
Goal: Extend the life time of the evaporator boat

Approach: Modify the material composition

Action: Add other elements to the powder blend to affect three main properties:

1. Chemical stability of the binder phase
2. Corrosion resistance
3. Stability against moisture attack
Effect of other elements:

Binder phase: By raising the melting point above operation temperature the binder phase would still be in a solid state and not reacting with Al during operation.

⇒ binder phase chemical stability, corrosion resistance

Performance: Since reaction with moisture can lead to cracks, addition of oxidation stable components suppresses influence of humidity.

⇒ stability against moisture, crack protection

Corrosion resistance: In situ formation of high temperature stable phases during the metalizing process leads to increased resistance towards metallic melts at operation temperature.

⇒ corrosion resistance
Corrosion resistance

- Formation of **passivation layer**: the corrosion resistance is enhanced
- **Regeneration**, *in situ* formation of borides: the erosion resistance is enhanced
- Formation of **high melting phases**: the mechanical and chemical stability at operation temperature is improved
Corrosion resistance

Boat with new formulation, after metalization process

Findings:

- Less transport of borides to the boats edges (deposits)
- High melting phases detected
- Products of binder phase strengthening reactions
- Fe-C-B as wire’s impurities was found (less binder phase attack)
Stability against moisture

Hot resistivity measurements

Before exposure to moisture

After exposure to moisture

High moisture pick up

Cracks

Premature material damage
Results

Before metalizing process

- both formulations were run at same conditions
- the erosion and corrosion are less for the modified boats than for the standard material
- the cavity is apparently deeper for the standard boats
- cavity depths for the modified boats were 30% less than for the standard boats

After metalizing process
Conclusion and outlook

- Liquid Al attacks the evaporator boats during operation
- Erosion and corrosion affect the boats performance and life time
- Most affected materials are the binder phase and TiB2
- Modified boats have been developed with regard to the binder phase and powder formulation
- Standard and modified boats have been tested at same conditions
- Modified boats were found to have less corrosion and erosion than the standard boats
- Cavity depths for the modified boats were found to be around 30% less than for the standard boats
- Modified boats were still running well at the end of the current process time
- Based on these findings, the life time of the modified boats is expected to be at least 20% longer than for the standard boats