ZANON SS-Ti transition

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14.11.2024

Context:

Brazing qualification is acc. to Eng. Spec EDMs 1389669.
For the metallographic examination we follow acc. to EN 12797 (below).

6.4 Procedure

The procedure used shall be one of the following.

a) *Macroscopic examination.* The section shall be examined at a low magnification, up to x25. The joint shall be examined for lack of flow, flux entrapment, porosity, cracks and any other imperfections;

b) *Microscopic examination.* The sections shall be examined by means of a metallurgical microscope at suitable magnifications. The joint shall be examined for detail not revealed by macro-examination, the structure of the brazed joint, erosion, parent metal/filler metal reactions, grain boundary phenomena and any other metallurgical requirement;

c) *Sophisticated techniques.* These techniques shall be used for detailed examination of filler metal compositions, as-brazed and after heat treatment, diffusion of filler metal into parent materials, and any other data relevant to the investigation of the quality of the brazed joint.

At CERN, we did:

- Microscopic examination from 40x to 700x of magnification
- Sophisticated techniques: detailed examination from regions that at 100x minimum showed major defects such as cracks.

**Zanon qualification by APAVE was up to 200x mag*

During metallographic qualification it was observed the presence of cracks in the shear lap region, on the Ti side.

The Brazing procedure was reviewed and compared for both CERN and ZANON (shown in next slide)

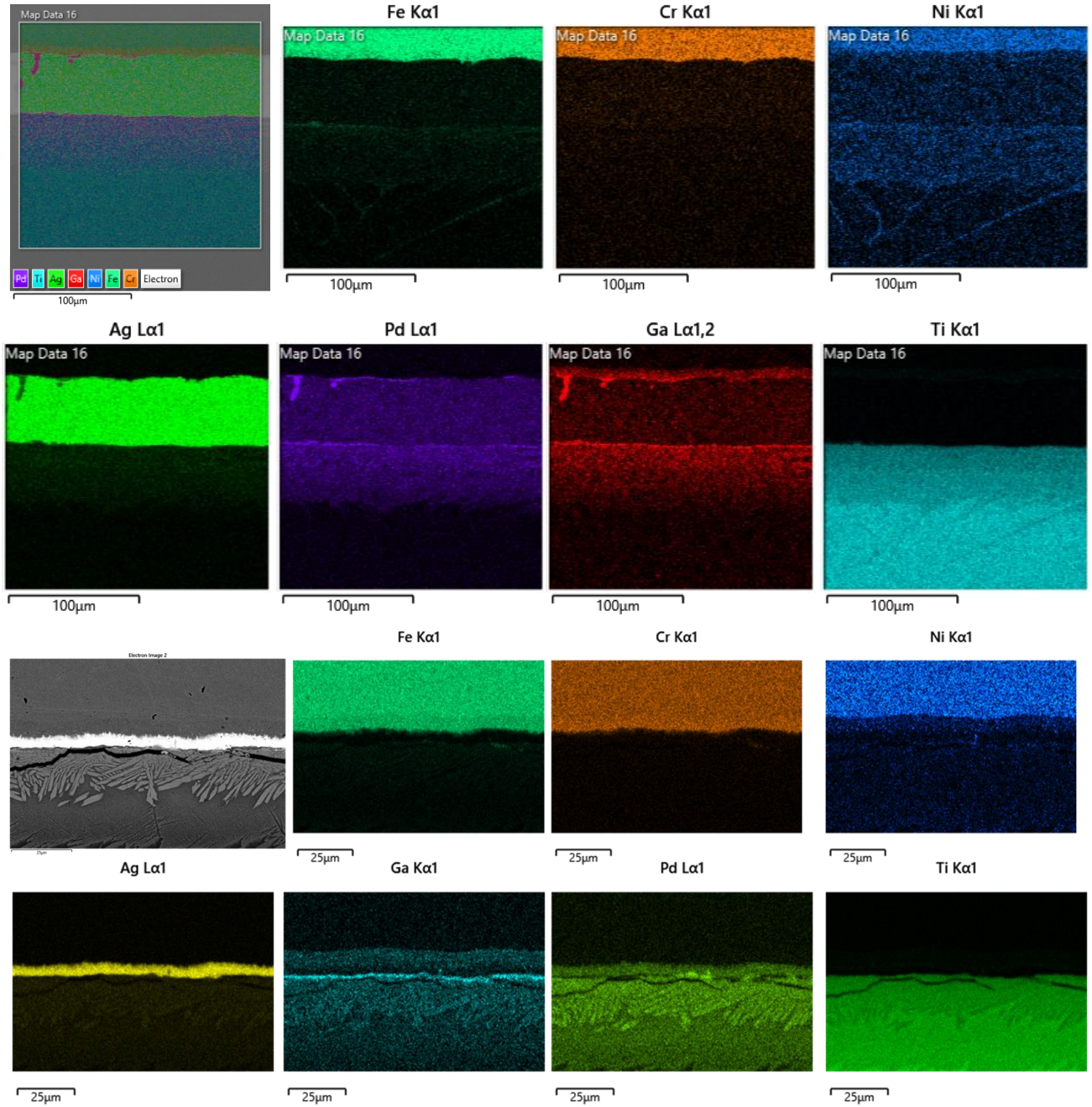
- CERN does stress relief of the SS-tube and applies a Ni-plating of 1µm in all the brazing area.
- Is the Ni-plating forming less brittle IMCs due to diffusion towards the Ti-parent material?
- Is there a chemical composition difference of the IMCs between CERN and ZANON procedure?

Brazing procedure CERN vs ZANON:

CERN	ZANON
SS tube is stress relieved at 950°C	NOT SPECIFIED/MENTIONED (?)
Surface treatment and cleaning: - Ti tube is degrease/etch - SS tube is degrease/etch + **Wood's strike of Ni** (1 um) on brazing surface (both shear lap and toe region) - Tubes are pack with Al foil and stored in PE bags	NOT SPECIFIED/MENTIONED (?) - Ni strike in SS tube???
Vacuum brazing: - Filler material 'Gapasil-9' - Load applied during brazing in Ti-tube >10kg, insert>2kg - Atmosphere: vacuum < 5x10-6mbar - Program: 820°C (300°C/h), dwell for 60min, goes up to 915°C (500°C/h), **dwell until T reaches 905** (+10°C) then 915°C to 700°C (600°C/h), dwell for 1h, cool down in furnace	**Vacuum brazing:** - Filler Gapasil-9 diameter of 1mm - Load apply ?? - Atm vacuum: ? - Program: 820°C (300°C/h), dwell for 120min, goes up to 915°C (500°C/h), No dwell, then goes down to 700°C (600°C/h) dwell for 1h, furnace cooling

CERN / ZANON

CERN
(Shear lap region)



- Diffusion of Ni to the Ti region
- IMCs of Pd-Ga-Ni-Fe

ZANON
(Shear lap region)

- NO or minimal diffusion of Ni to the Ti region
- IMCs of mostly Pd-Ga-Ti
- Strong formation of α-phase → very fragile → more stress concentration when stress relief by cutting

Remarks:

- ZANON Brazing 2024:
  - Based in BPQR:
    - No Stress relieved was applied to SS
    - No Ni-plating was applied
  - Based on EDX maps
    - The are abundant IMCs of Pd-Ga-Ti, which are believe to be more brittle than Ga-Pd-Ni
    - The brittle IMCs **(Pd-Ga)** near the Ti region makes that area more constrain → promotes crack initiation → will propagate through the Ti.

  - The observation of cracks only after metallographic cut, might be induced due to the stress relief and the high presence of the brittle Pd-Ga-Ti IMCs and the presence of α-phase → Very brittle/fragile regions

Recommendations

- To reduce the brittle IMCs and the strong presence of α-phase, we strongly recommend:
  - ➢ Apply Ni-plating
  - ➢ For the brazing cycle: to reduce the dwell time of 820 °C.