Study of the Metal Operating Losses (MOL) in Pt-Rh alloy used for glass fibre fabrication

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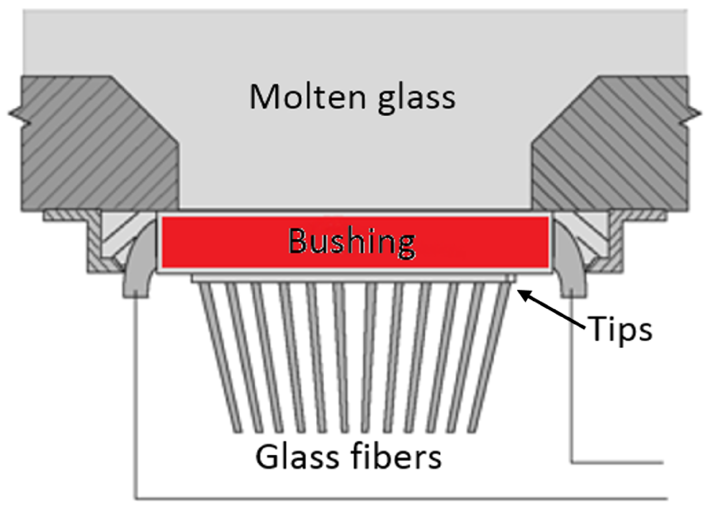
Introduction

The fibre glass industry uses Platinum-Rhodium alloys for their excellent mechanical and chemical properties at high temperature. Theses alloys are used for the bushing to pull glass fibres from molten glass.



There are two different kinds of problem which limit the lifetime of a bushing:

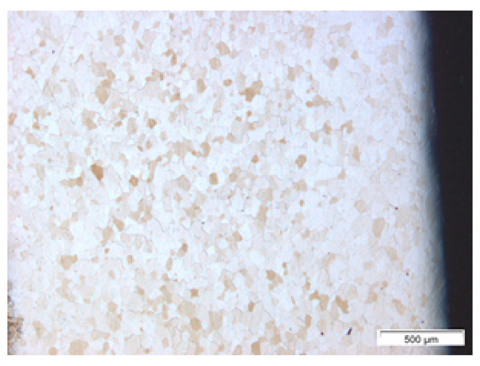
1. the **damage propagation problem:** the bushing tends to failure until its decommissioning
2. the **metal operating losses:** the high level of temperature (1300°C) induces the creation of volatile oxide and so loss of mass.

It can be estimated that the lifetime of a bushing is only a few months and the weight losses may reach until 1 kg. Pt-Rh alloys are amongst the most expensive materials. The price is comprised between 40 and 80 €/g.
The goal of this project is to increase the lifetime and reduce these metal operating losses. A first step is the understanding of the physico-mechanical behaviour of the matter during the process.

Microstructural analysis

The analysis of the microstructure provides us some preliminary informations on the characteristic of the metal as mean grain size (MGS), Hardness Vickers (HV), microstructure, ...

Base metal

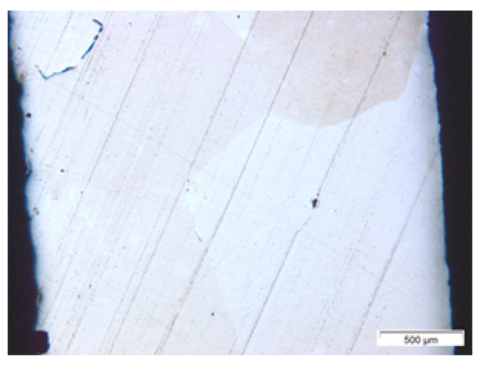


→ MGS ~ 60 μm
→ 110 HV

Welded area (critical zone)

→ MGS ~ 150 μm
→ 100 HV

In-service metal



→ MGS ≥ 500 μm
→ 100 HV

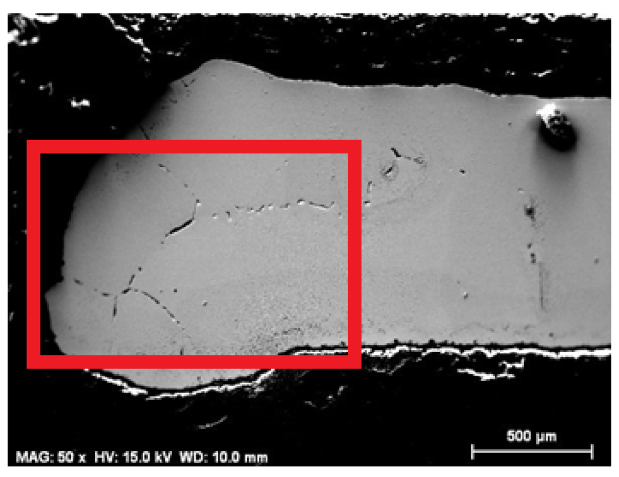
Observations:

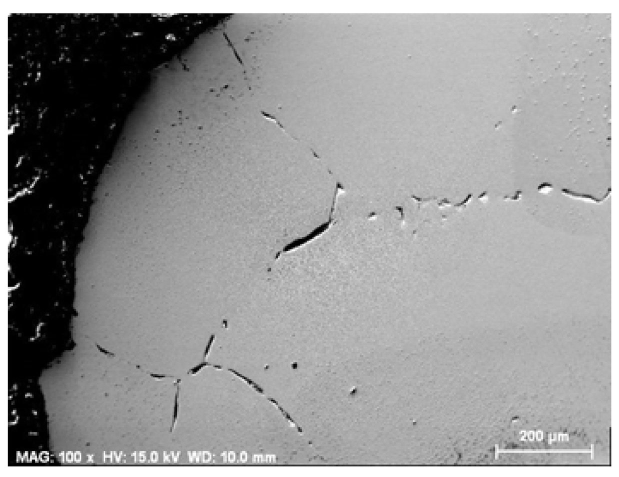
- mean grain size is multiplied by a 2-3 factor compared to the base metal and welded area
- mean grain size of in-service metal is far above 500 μm
- no significant difference for Hardness Vickers values
- equiaxed grain morphology for the base and in-service metals
- columnar morphology in the welded zone: the grain are oriented along the thermal gradient during welding

Cracks and internal defects

Deeper analysis made by electronic microscope highlights internal failure at grains boundaries.

In-service metal

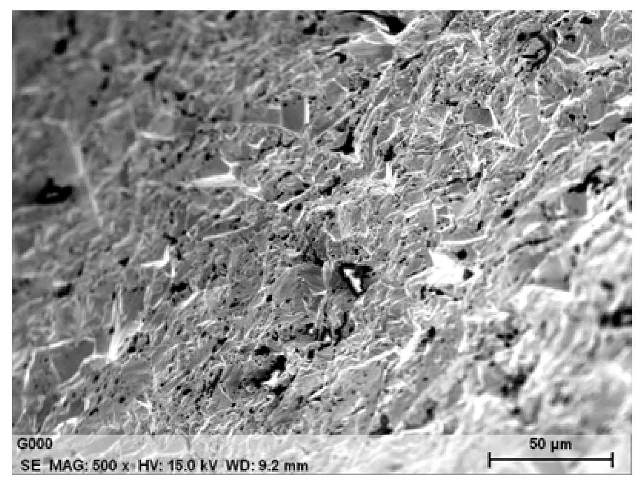




→ Coarsed grains have intergranular cracks resulting from the interconnection of adjacent voids or holes located at the grains boundaries.

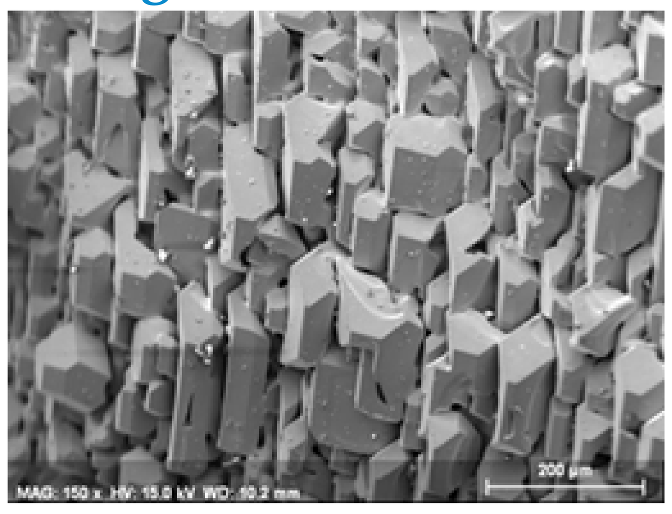
Fractography

Study of the fracture surface also gives us some informations. Unfortunately, in this specific case, the fracture surface is not the initial one but have been coated by condensated oxides during the manufacturing process.

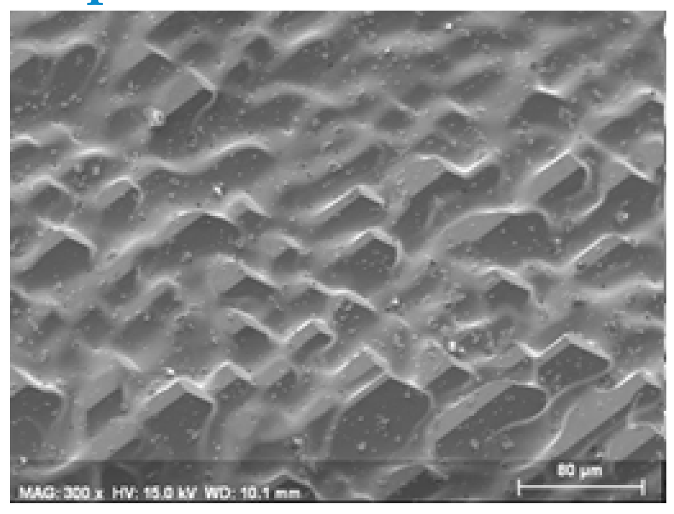


Two different kinds of coatings (Pt-Rh based oxides) are observed:

Hexagonal structure



Deposit veil



Dust Analysis

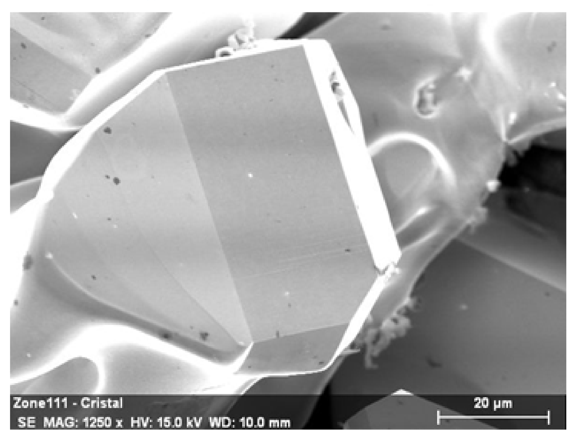
Dust particles can be found along the tips on the bushing.
Two possible origins:

- diffusion of metallic elements
- condensation and deposition of pre-evaporated oxides

Different kinds of dust are found

- As on fractography surface:

Hexagonal structure



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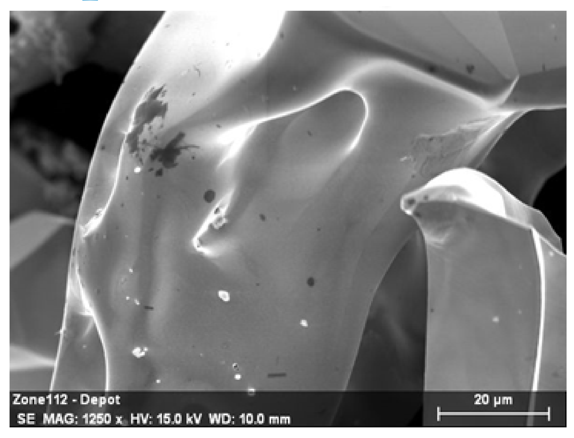
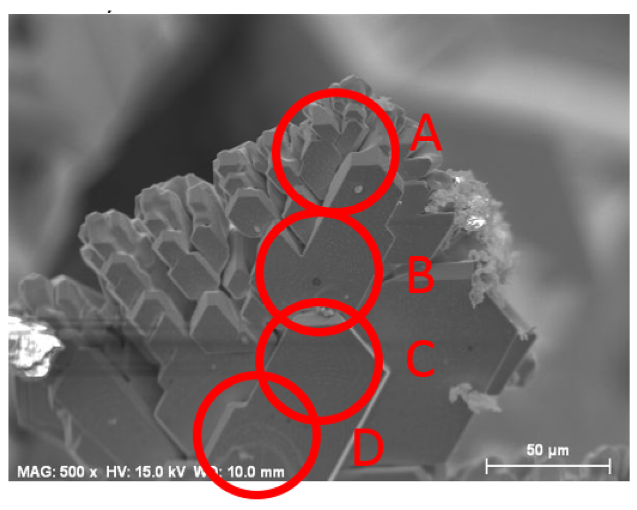
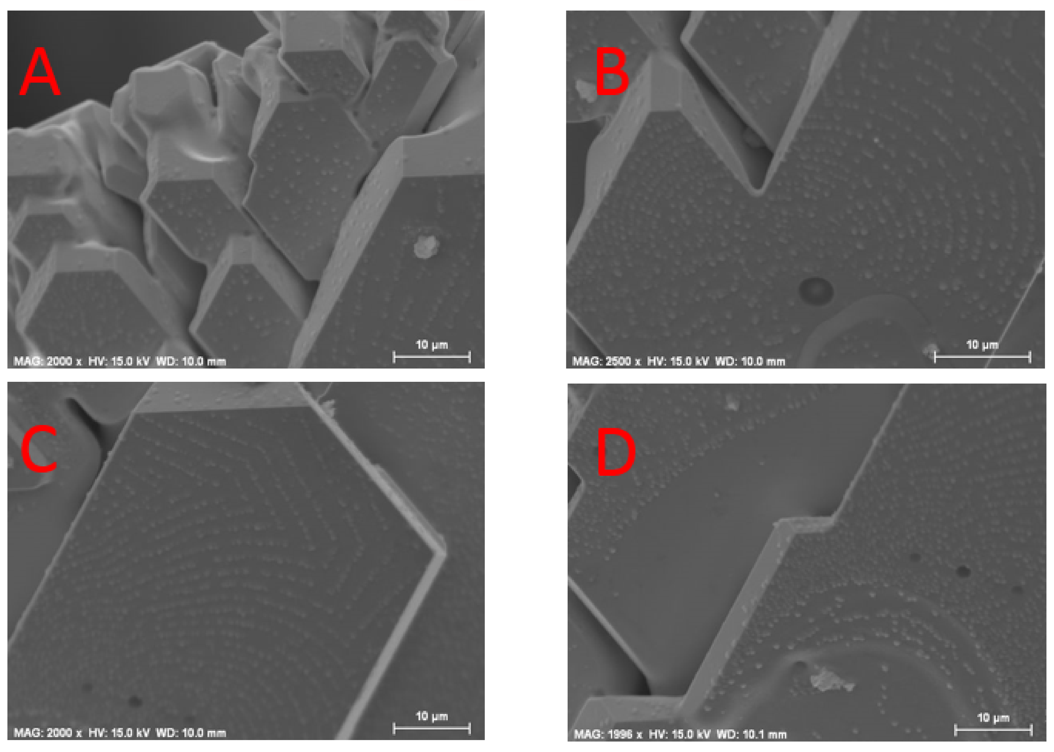


- with a faceted structure ...





→ multi scale crystal structure with ordered dots with a size around 1 μm