Basalt Fibres under heat treatment

Introduction

- Today, only time-consuming and cost intensive produced ceramic fibres are used for high temperature applications around 1100 °C
- The most widely used oxide ceramic fibres cannot be obtained from a melting process. First, fibre precursors a fabricated by melt spinning of a polymer or by dry spinning of ceramic dispersion in water or sol-gel. Further, the fibres go through a stabilisation / pyrolysis process and a following sintering step.
- The differences of the fibres types are shown in table 1. The are not comparable in terms permanent application temperature (T_{ap}) and Young's Modulus.

Fibres	Price	T_{ap}	Young's Modulus
Basalt fibres	2-3 €/kg	800 °C	91 – 110 GPa
E-Glass fibres	1-6 €/kg	600 °C	72 – 74 GPa
Ceramic fibres	500 €/kg	1200 °C	430 – 460 GPa

Table 1: comparison of different fibres

Experimental

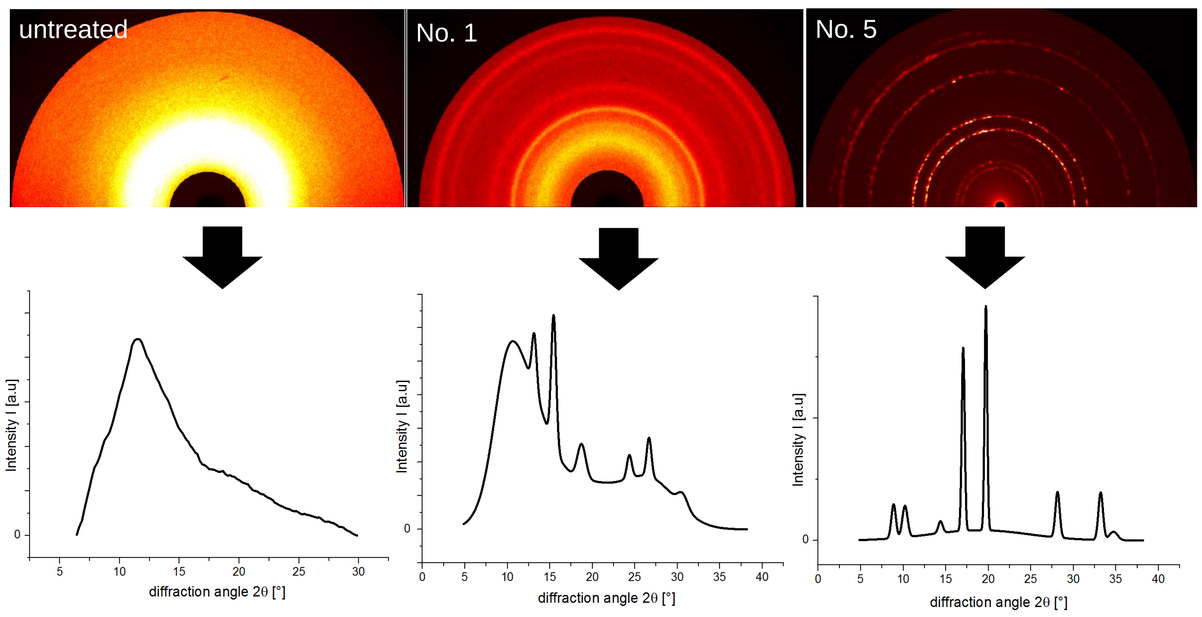
1. The fibres were exposed to high temperatures as shown in Table 1.
2. The Structure of fibres was measured using wide angle x-ray diffraction (WAXD).
3. The WAXD images and the resulting diffraction pattern were interpreted and the density of the fibres was determined

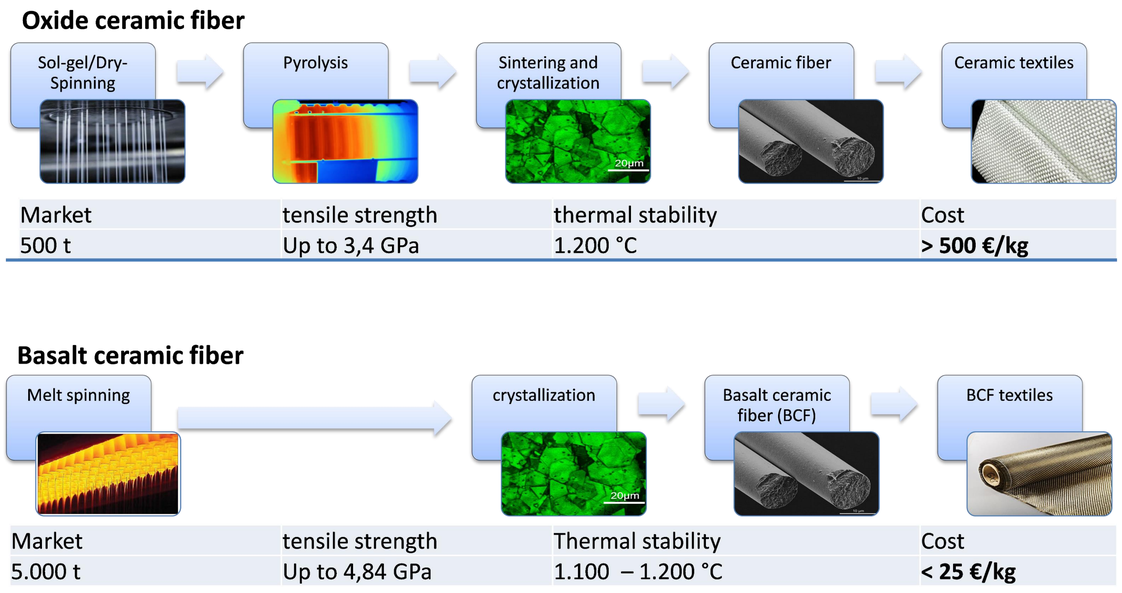
The Image-Plate Detection System II, STOE & Cie GmbH was used.

No.	T_n	retention time at T_n	T_{cg}	retention time at T_{cg}
1	650 °C	30 h	750 °C	90 h
2	650 °C	45 h	750 °C	90 h
3	650 °C	30 h	750 °C	120 h
4	700 °C	30 h	800 °C	90 h
5	700 °C	45 h	800 °C	90 h
6	700 °C	30 h	800 °C	120 h

Table 2: basalt fibres' heating profiles

Results & Discussion





- Nucleation time has to be at least 45 minutes at 700 °C
- All other heat treatments cause nearly no changes in crystallinity
- Only fibre No. 5 can be called ceramic based on the definition (30% value threshold between glass and ceramic)

No.	X_C
1	6,79 %
2	8,37 %
3	8,17 %
4	9,92 %
5	66,10 %
6	5,42 %

- No. 1 is partially crystalline due to amorphous silicon oxide
- No. 5 shows a discrete rings, a good example for crystalline materials
- Visible change from amorphous to crystalline structure
- The untreated fibre is clearly amorphous with its wide ring
- Principle is confirmed by the production of monolithic ceramics
- Manufacturing process chain of oxide ceramic fibres and basalt ceramic fibres

Conclusion

- research is a promising approach for new materials, basalt ceramic fibres and their applications
- Crystallisation is possible without destruction of the fibre integrity
- For better structure results a longer nucleation time of at least 45 minutes is needed
- Fibre's brittleness prevents further research. It is important to find solutions to keep the fibres save after the heat treatment

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