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MODULAR EQUIPMENT FOR THERMAL ANALYSIS IN MAGNETIC DC FIELDS UP TO 5 TESLA

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ABSTRACT

We present modular equipment for the differential thermal analysis in homogeneous magnetic fields (M-DTA) with a magnetic flux density of up to 5 Tesla. The development of this measure equipment started in the frame of the Junior Research Group "Electromagnetic Processing of Materials". It served to investigate the crystallization processes and the phase transitions in glasses containing high amounts of iron oxide. Further we expect that the M-DTA is well suited for the investigation of the influence of the magnetic field to the crystalline structure of metal during solidification. Commercial software is used for the data recording, the storage and the analysis. The equipment is located at the laboratory of the department of Electro-Thermal Energy Conversion of the Ilmenau University of Technology.

1. INTRODUCTION

The influence of strong magnetic DC fields on crystallization behaviour of amorphous material in the ternary system BaO-Fe_2O_3-B_2O_3 was investigated by applying the glass crystallization technique [1]. A better understanding of the crystallization process of barium hexaferrite ($BaFe_{12}O_{19}$; BHF) by using the M-DTA is the goal of this work. The M-DTA equipment works in the following range:

- range of temperature: room temp. - 1400°C
- magnetic field: DC field up to 5 Tesla
- controlled atmosphere: air, O_2, N_2, CO/CO_2, Ar

2. CRYOGEN-FREE MAGNET

The magnetically assisted investigations were performed inside a supra-conducting, cryogen-free magnet (CRYOGENIC Ltd.) with a warm bore of 300 mm and a constant magnetic flux density of up to 5 Tesla. At 5 Tesla the obtained magnetic flux density is constant within 0.05 Tesla in the experimentally used volume.

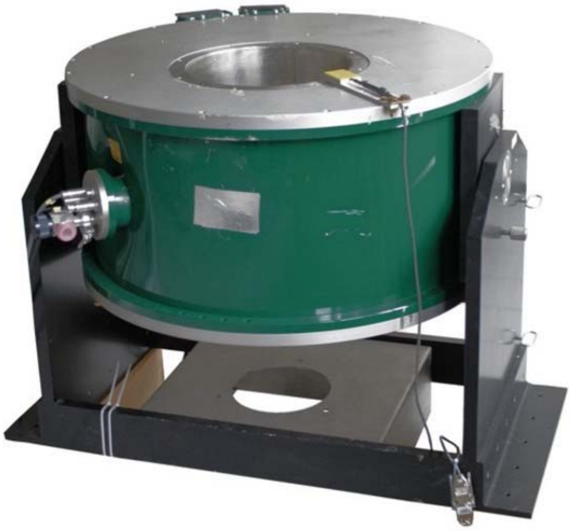

Figure 1: Cryogen-free magnet (CFM)

3. HIGH TEMPERATURE FURNACE

The high-temperature furnace (XERION GmbH) is specially designed for the insertion into the warm bore of the CFM. The outer surface of the furnace is cooled by a water jacket which keeps the maximum temperature of the outer furnace surface below 30 °C. Heating is done by a DC heater in order to minimize unwanted interactions between heating currents and magnetic field. With this furnace, a maximum temperature of up to 1500 °C can be obtained. The temperature profile over the area of maximum temperature corresponding to the experimentally used hot spot is very constant, with a maximum variation in temperature of set point ± 2.5 K. The hot spot maximum and area of maximum, constant magnetic flux density overlap in the center of the experimentally used region of 6 cm height and 5 cm diameter. Thanks to separately computer controlled devices, independent and precise control of magnetic field and temperature is possible.

Figure 2: High temperature Furnace

Figure 3: Mechanical positioning system

Figure 4: DTA *Figure 5: DSC*

Exchangeable measurement systems (sample holder)

4. CRYSTALLIZATION OF BARIUM HEXAFERRITE

The starting material are amorphous flakes of a composition of 39.6 BaO – 35.4 B_2O_3 – 25 Fe_2O_3 (mole-%), obtained by a rapid quenching process. To get information about the crystallization process thermal analytic measurements (DTA) were made. In subsequent systematic experiments the amorphous flakes were tempered at the four onset temperatures of the DTA peaks outside and within a magnetic DC field of 5 Tesla. The Obtained material was analysed using analytical technologies as XRD and SEM to characterize differences in the crystal structure [3].

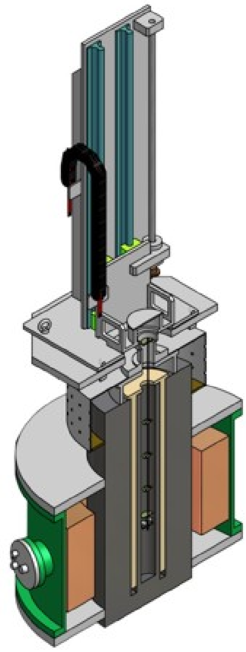

Figure 6: The modular equipment for thermal analysis in magnetic DC fields

5. CONCLUSIONS

First test measurements with quartz powder at magnetic flux density of 0 Tesla showed no difference between M-DTA and conventional DTA. The sample holder as well as the used crucibles are not influenced by the external magnetic DC fields and therefore do not affect the measurements at different magnetic flux densities. In principle the M-DTA is accessible for external user.
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