Electromagnetic Processing of Materials

at the department of Inorganic-Nonmetallic Materials, TU Ilmenau

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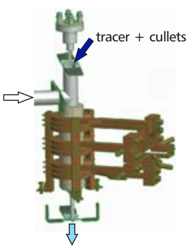
Electromagnetic Module for the Production of High-tech Glass (EMoGla)

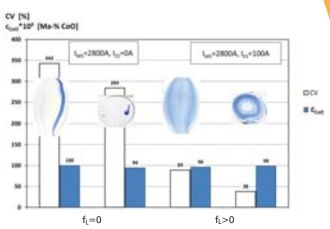
- Lorentz force f_L created by electric current density **j** and magnetic flux density **B**

$$\vec{f}_L = \vec{j} \times \vec{B}$$



outlet channel of a special melter (JSJ Jodeit GmbH)

- homogenization of CoO-doped glass
- flakes and droplets (cross section)
- concentrations c_{CoO} and coefficient of variation (CV) in dependence of Lorentz force



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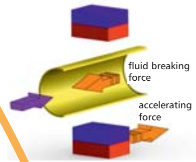
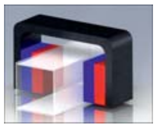
Lorentz Force Velocimetry

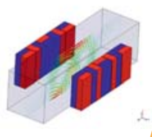


$$\vec{f}_L = \vec{j} \times \vec{B}$$

- design, test and optimization of sophisticated magnet systems for Lorentz Force Velocimetry in electrically low conducting fluids
- assembling using carbon fibre material
- optimization with automated FEM-Optimizers
- test on a first LFV-prototype for electrolytes



standard" design with two magnets (easy to construct)



set of Halbach arrays (3 times higher forces)

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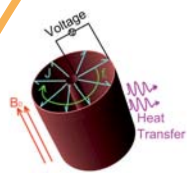
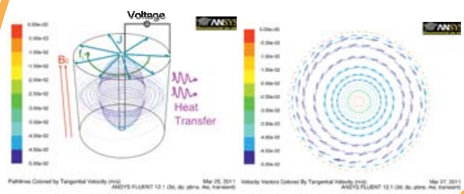
Numerical study of EM controlled flow in crystallizers of inorganic materials



$$\vec{f}_L = \vec{j} \times \vec{B}$$

- study of the fluid flow and temperature distribution for the crystallization process
- the Lorentz force produces a flow about 5 cm/s
- the heat dissipation created by the Joule's effect can be neglected



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flow manipulation, velocity measurement

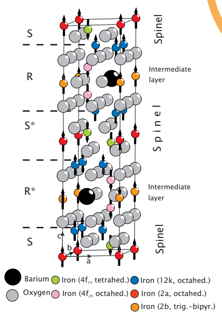
electro-magnetic absorption

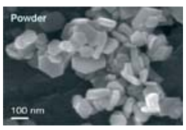
magnetic fields

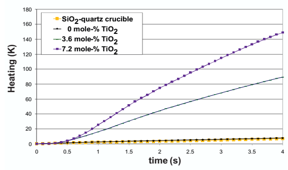
fine grinding

ion manipulation

- Partial substitution of Fe^{3+} by Ti^{4+} in Barium hexaferrite powders to absorb electromagnetic waves in the GHz range.







- heating of the undoped and Ti-doped Barium hexaferrite at the same tempering conditions in a microwave oven (2.45 GHz)

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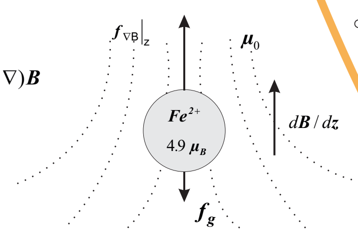
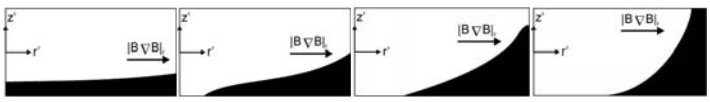
Magnetic gradient force density (Kelvin force)

$$f_{\nabla B} = \frac{\chi}{\mu_0} (\boldsymbol{B} \cdot \nabla) \boldsymbol{B}$$

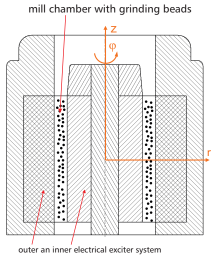


- influence of magnetic field gradients on the distribution of paramagnetic ions in aqueous solutions and glass melts
- creation of graded glasses or glass ceramics from glass melts
- e.g. tuning of the refraction index during the creation of glass fibres

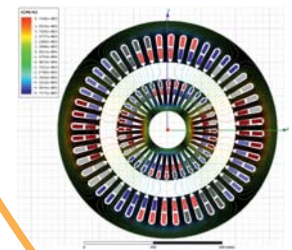


- schematics of solutions (black) with different Fe^{2+} concentrations - influence of magnetic (gradient) field (magnetic flux density B = 5)
- solutions move in the direction of the highest gradient
- surface of the solution forms characteristic shapes

mill chamber with grinding beads



- reduce the specific energy consumption during mechanical grinding:
  + direct movement of hard magnetic grinding beads with varying magnetic field
  + optimization of the design of winding
- fine milling of raw materials:
  + $d_{50,3}$ < 10 µm, >5,000 cm²/g (according to Blaine)



simulation of the magnetic field distribution

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DFG EFRE FG Leistungselektronik und Steuerungen in der Elektroenergietechnik JSJ JODEIT

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