Numerical Modelling of Iron-Pnictide Bulk Superconductor Magnetization

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Modelling Framework

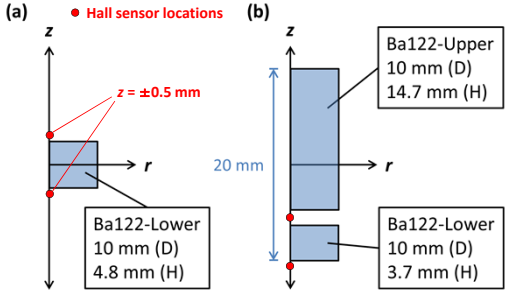
2D axisymmetric ***H***-formulation
COMSOL Multiphysics 5.2a
Isothermal conditions, no thermal model
Slow ramp rate (1.5 T/min)
Flux creep relaxation +10 min

$$\nabla \times \boldsymbol{E} + \left(\frac{d\boldsymbol{B}}{dt}\right) = \nabla \times \boldsymbol{E} + \frac{d(\mu_0 \mu_r \boldsymbol{H})}{dt} = 0$$

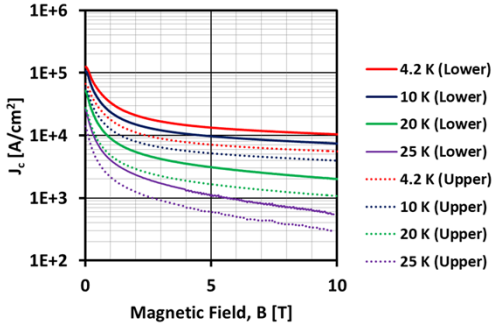
$$\nabla \times \boldsymbol{H} = \boldsymbol{J}$$

$$\boldsymbol{E} = \frac{E_0}{J_c(B,T)} \left| \frac{J}{J_c(B,T)} \right|^{n-1} \boldsymbol{J}$$

$E_0 = 10^{-4}$ V/m, $n = 50$

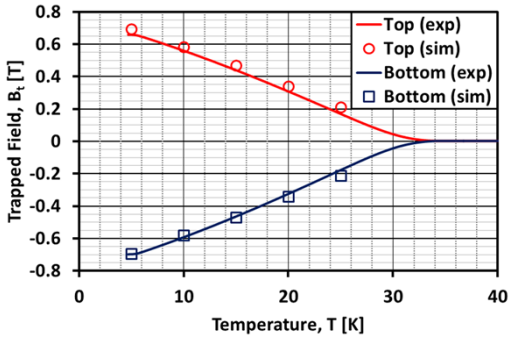


2D axisymmetric models for numerical simulation of iron-pnictide (Ba122) bulk superconductors; a 1.6 mm spacer (not modelled) exists between the two bulks to accommodate a Hall sensor

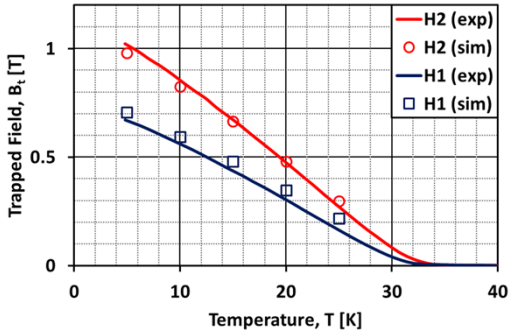


$J_c(B, T)$ characteristics for the lower bulk, "Ba122-Lower," measured at 4.2, 10 and 20 K in fields up to 20 T; the $J_c(B, T)$ characteristics for the upper bulk, "Ba122-Upper," are estimated from remnant trapped field data

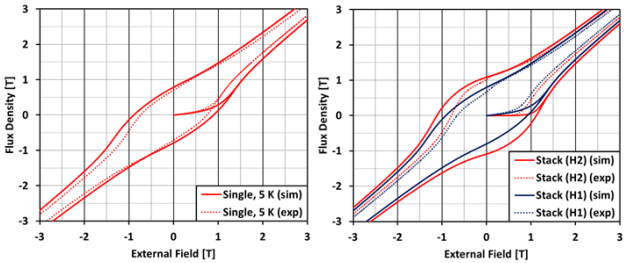
Modelling Results



Comparison of experimental & numerical simulation results for the single Ba122 bulk: "Ba122-Lower."



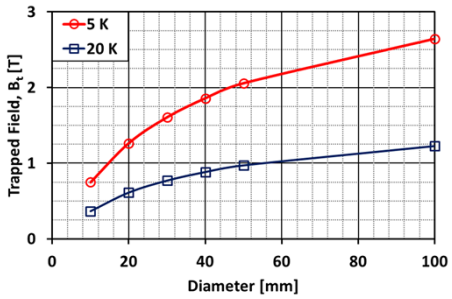
Comparison of experimental & numerical simulation results for the stack of Ba122 bulks: "Ba122-Upper" and "Ba122-Lower"



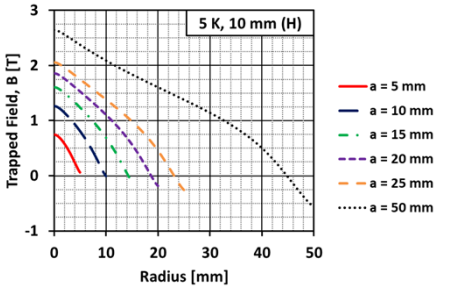
Experimental & simulated hysteresis loops

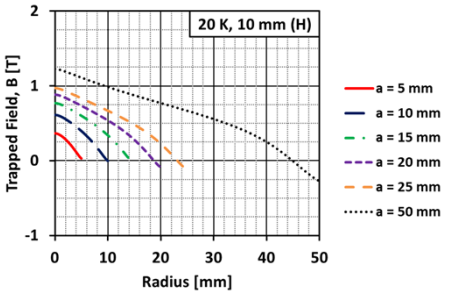
Influence of Geometric Parameters

Diameter Dependence



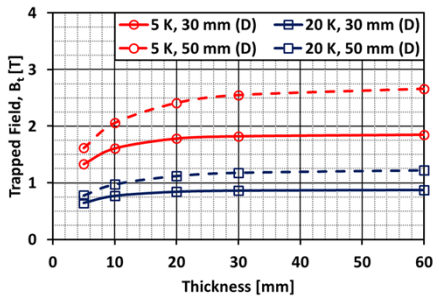
Numerical simulation of the diameter dependence of the trapped field (centre, +0.5 mm above top surface) for "Ba122-Lower" for a fixed thickness of 10 mm & operating temperatures 5 and 20 K



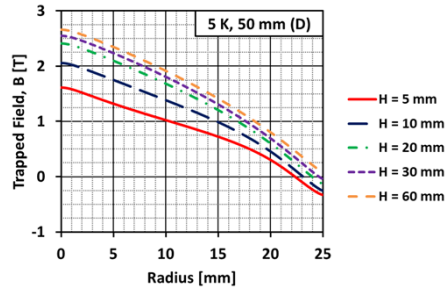


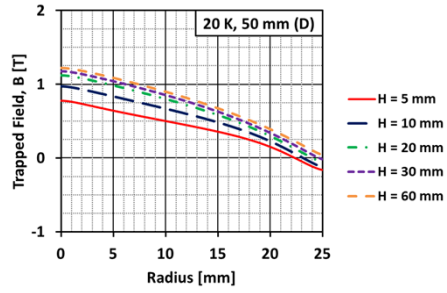
Diameter dependence of the trapped field across top surface (z = +0.5 mm); thickness = 10 mm

Thickness Dependence



Numerical simulation of the thickness dependence of the trapped field (centre, +0.5 mm above top surface) for "Ba122-Lower" for fixed diameters 30 & 50 mm & operating temperatures 5 & 20 K





Thickness dependence of the trapped field across top surface (z = +0.5 mm); diameter = 50 mm

- A 2D axisymmetric finite-element model implementing the H-formulation was used to investigate the magnetisation properties of iron-pnictide (Ba122) bulk superconductors
- The experimentally measured trapped fields are reproduced well for a single bulk, as well as a stack of bulks, using the measured $J_c(B, T)$ characteristics of a small sample
- With current state-of-the-art superconducting properties, surface trapped fields > 2 T could readily be achieved at 5 K (and > 1 T at 20 K) with a sample diameter of 50 mm
- An aspect ratio between 1-1.5 (radius : thickness) would be an appropriate compromise between the accessible surface trapped field and volume of superconducting materials