Modification of the trapped field in bulk HTS as a result of the drilling of a pattern of artificial columnar holes

Gregory P. Lousberg, J.-F. Fagnard, M. Ausloos, P. Vanderbemden, and **B. Vanderheyden**

SUPRATECS Research Centre, Montefiore Institute, University of Liège, B-4000, Liège, Belgium

Motivation

Drilling holes in bulk HTS samples favors the oxygen annealing process but impacts on its magnetic properties. Numerical studies have already revealed that the presence of holes in the sample influences the current stream lines. The trapped magnetic flux of a drilled sample has been shown to drop as compared to that of a plain sample having the same superconducting properties [1-2]. In particular, the arrangement of the holes may be optimized so as to minimize this drop of trapped flux. This study aims at demonstrating experimentally that the hole pattern indeed affects the trapping properties of the samples.

Numerical modeling

Bean model
Calculation of the travelling distance of the flux front, according to [1]

2D finite-element
Flux creep effects with E-J power law (n=25)
Trapped flux simulated in two time-steps
GetDP environment [2]

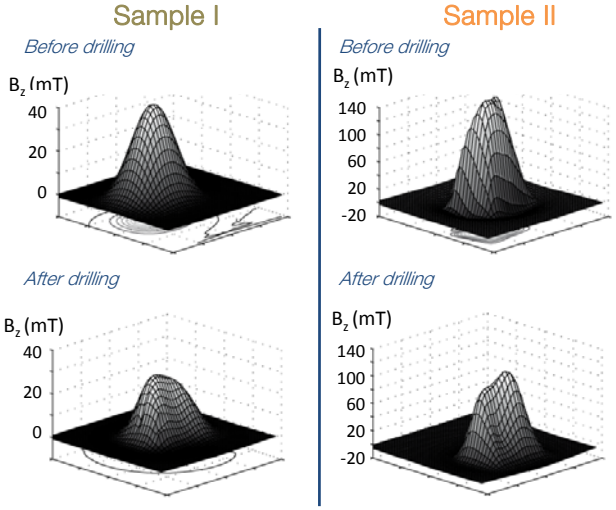
Neglect finite height effects

Simulation in the median plane only

3D finite-element
Finite height of samples taken into account
Flux creep effects with E-J power law (n=25)
Trapped flux simulated in two time-steps
GetDP environment [2]

Simulation in the median plane and on the top surface

Hall probe mapping of the trapped flux above the sample top surface



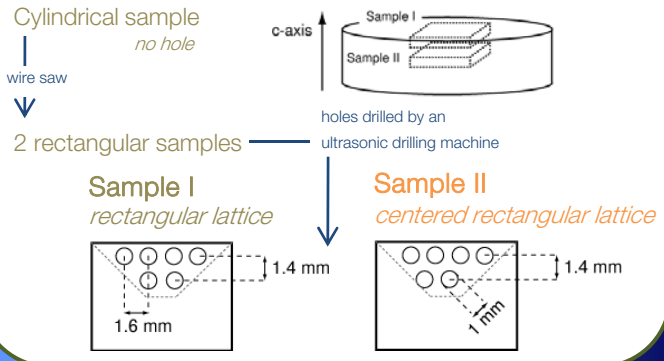
Field-cooled magnetization process. Ba = 300 mT during 5 min. Wait 15 min before mapping. Mapping at 0.5 mm above surface

Conclusion

We have shown with experiments and modelling that the arrangement of the holes in a drilled sample influences the trapped magnetic flux. Sample II with the centered rectangular lattice has the lowest drop of trapped flux, with value in agreement with simulations. This result is consistent with the analysis in [1]-[2]

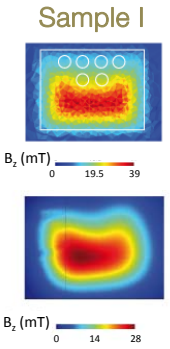
References [1] Lousberg G P *et al*, Supercond. Sci. Technol. 21, 025010, 2008
[2] Lousberg G P *et al*, Supercond. Sci. Technol. 22, 055005, 2009

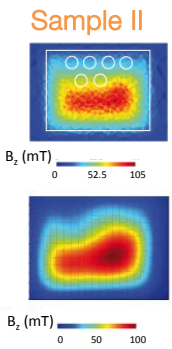
Sample preparation



Discussion

Comparison of the trapped flux profiles





3D FEM simulation
0.5 mm above the top surface

Jc is determined such that the 3D FEM simulations of the trapped flux at the top surface of the samples before drilling reproduce well the measured values.

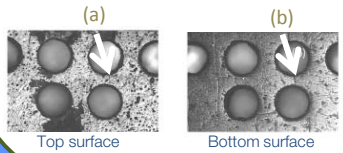
Hall probe mapping
0.5 mm above the top surface

Maximum trapped flux density

Sample I	MEDIAN PLANE			TOP SURFACE	
J_c = 4.1 10^7 A/m²	Bean	2D	3D	3D	Meas.
Before drilling	169 mT	137 mT	95 mT	61 mT	60 mT
After drilling	126 mT	104 mT	75 mT	46 mT	33.7 mT
Relative drop	25 %	24 %	21 %	**25 %**	**44 %**

Sample II	MEDIAN PLANE			TOP SURFACE	
J_c = 8.8 10^7 A/m²	Bean	2D	3D	3D	Meas.
Before drilling	358 mT	310 mT	244 mT	154 mT	155 mT
After drilling	291 mT	253 mT	207 mT	130 mT	120.7 mT
Relative drop	19 %	18 %	15 %	**16 %**	**22 %**

Micrographs of the surfaces of sample I



Crack between holes at both surfaces *arrows (a) and (b)*

➡ drop in sample I is larger than predicted by simulations

Acknowledgments

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