Levitation Force of Bulk YBaCuO and GdBaCuO under a Low-Pressure Environment

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Background

Fig. 1. The photo of HTS Maglev-ETT test system.

The HTS Maglev-ETT System

(The combination of high temperature superconducting maglev technology and evacuated tube transport)

parameters

Length: 45m

Load capability: 300 kg @ 20 mm, 1000 kg @ 10 mm

Maximum speed: 25 km/h (normal pressure); 50 km/h (low pressure)

Vacuum degree: 1-0.1 atm

Conclusion

- The experimental results further proved the phenomenon that a low pressure environment is helpful to increase levitation force of HTS bulks, which is exactly an extra advantage of the combination of HTS Maglev and evacuated tube.
- Moreover, it is interesting to found that the same sized YBaCuO bulk is more sensitive to the pressure variation compared with GdBaCuO above the PMG. In the low pressure condition, the levitation characteristics of YBaCuO bulk were superior to those of GdBaCuO, Attributed to the increasing critical current density *Jc* and *Tc* difference.
- This study finds a universal phenomenon and gives a better understanding of HTS bulks working under low pressure, which is meaningful for the application of the HTS Maglev-ETT system.

Abstract

The high temperature superconducting (HTS) bulk is the core component of HTS maglev systems. For the potential application to evacuated tube transportation (ETT), it is necessary to recognize the loading capacity of the bulk under a low-pressure environment. Based on a home-made pressure-reducing platform, we investigated the levitation force of two kinds of typical bulks, that is, the same sized YBaCuO and GdBaCuO, above a Halbach permanent magnet guideway under different pressure conditions. The levitation force in the cases of zero-field-cooling (ZFC) and field-cooling (FC) were measured and analyzed. Experimental re-sults show that the reduced air pressure can significantly improve the levitation force of the two kinds of bulks. The levitation force of YBaCuO and GdBaCuO has increased by 11.6% and 4.4% in the FC case, 20.3% and 13.7% in the ZFC case under 20 kPa compared with the atmospheric pressure (100 kPa), respectively. This universal phenomenon was explained by the increasing critical current density Jc of HTS bulks due to cooler liquid nitrogen under the low-pressure condition. It is interesting to find that the YBaCuO bulk was more sensitive to the pressure variation compared with the GdBaCuO bulk. This difference reflects the improvement extent of levitation force of HTS bulks with different Jc performance working in a low-pressure environment.

Keywords: Levitation force, YBaCuO, GdBaCuO, Low pressure, Evacuated tube transportation

Experiment

Sample

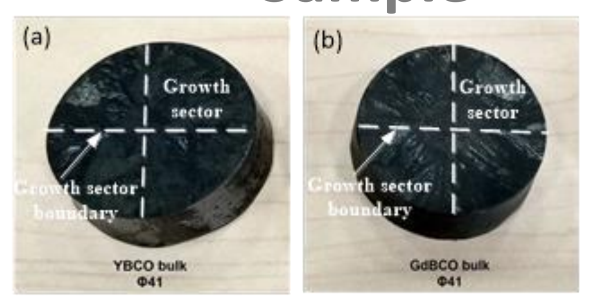

Fig. 2. Top views of the experimental HTS bulk samples. (a) YBaCuO, (b) GdBaCuO, both of which are divided to the four-fold growth sectors by two orthogonal growth sector boundaries.

•**Diameters:** 41mm

•**Height:** 15mm

Fabricated by TSMG processing

The maximum trapped magnetic fields: GdBaCuO(1.47 T); YBaCuO(0.94 T)

Measurement process

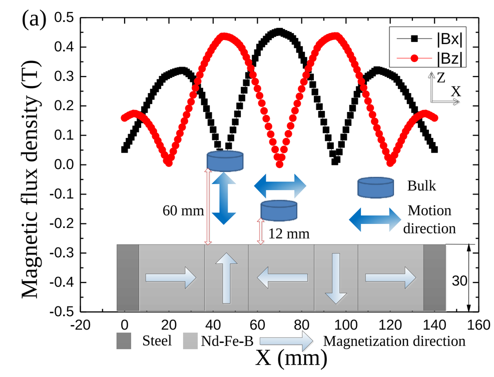

Fig. 3. The magnetic flux density distribution of the applied PMG along its transverse direction at a height of 12 mm and the schematic diagram of the measurement position and motion direction of the bulk in the experiments.

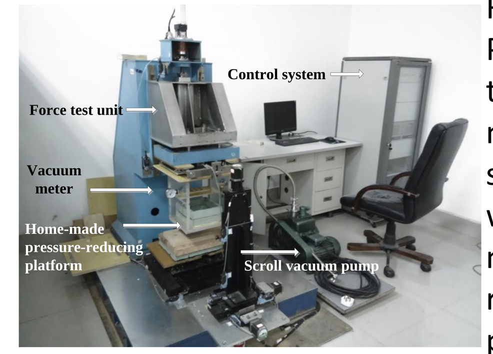

Fig. 4. Photograph of the HTS maglev measurement system together with a home-made pressure-reducing platform.

The levitation force of the bulk sample was measured under 100 kPa, 60 kPa and 20 kPa, respectively. The measurement of levitation force was conducted both in the case of ZFC and FC. In ZFC, the HTS bulks were immersed in LN2 at a height of 60 mm. This is the first step and called as “the cooling of bulk”. Then, the scroll vacuum pump was used to evacuate the chamber to one of the expected pressure. This is the second step and it will last about 5 minutes. Finally, the HTS bulk was moved at a speed of 2 mm/s from a 60-mm height to a 12-mm height above the PMG, and then returned to the height of 60 mm. The levitation force measurement in the FC condition is similar, except that the cooling height was changed to a 20-mm height above the PMG.

Results and Discussion

Levitation force in ZFC and FC condition

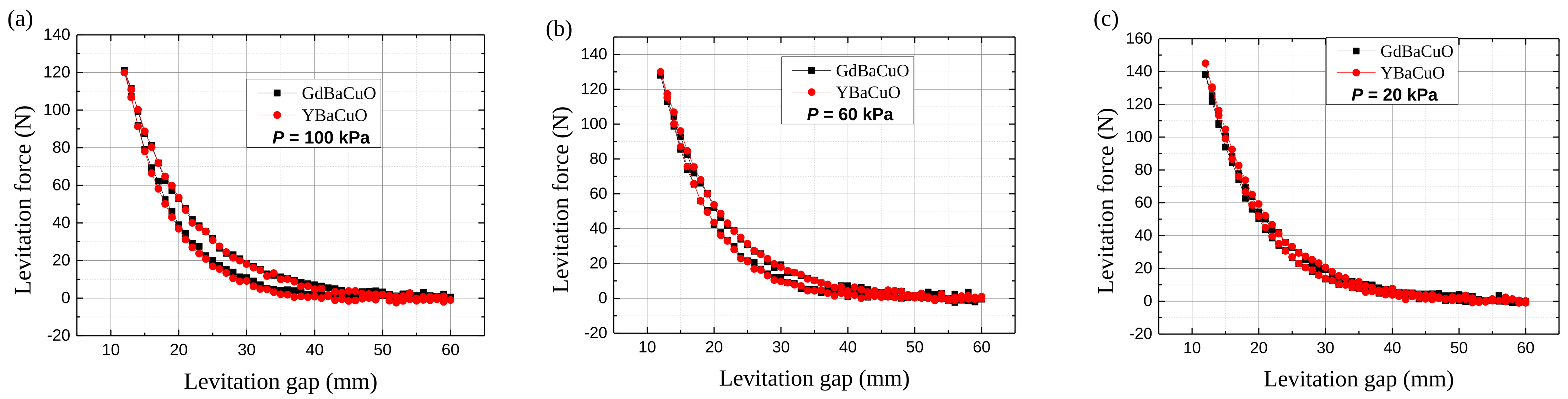

Fig. 5. Levitation force curves of the YBaCuO bulk and GdBaCuO bulk under the pressures of (a) 100 kPa, (b) 60 kPa, and (c) 20 kPa in the case of ZFC.

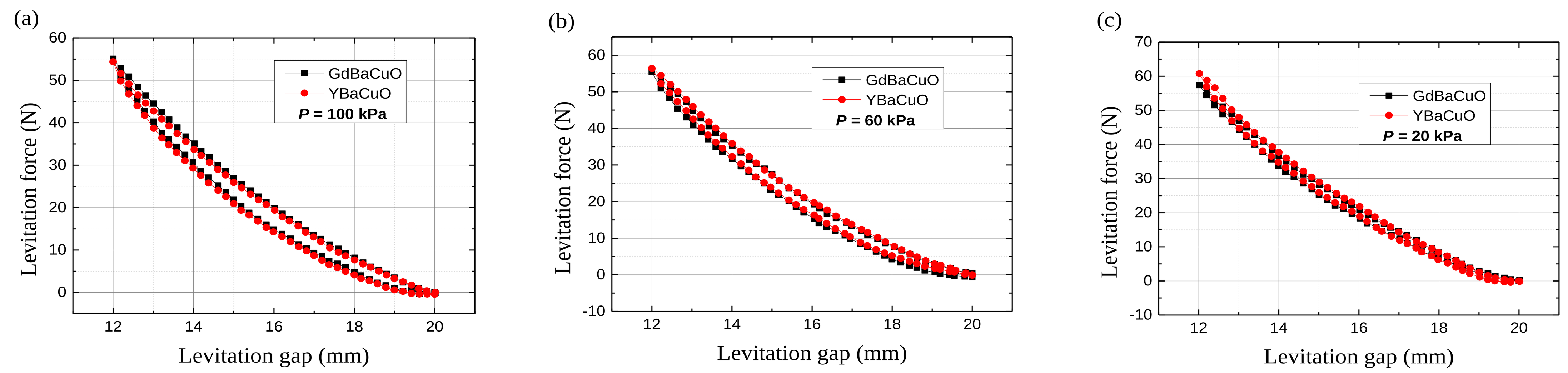

Fig. 6. Levitation force curves of the YBaCuO bulk and GdBaCuO bulk under the pressures of (a) 100 kPa, (b) 60 kPa, and (c) 20 kPa in the case of FC.

Changes in Levitation force under low pressure environment

TABLE I

CAMPARISON OF THE MAXIMUM LEVITATION FORCE OF YBACUO AND GDBACUO IN DIFFERENT PRESURE AND THE INCREASE RATIO OF THE MAXIMUM LEVITATION FORCE COMPARED WITH 100 KPA CONDITION IN THE CASE OF ZFC AND FC

Pressure	100 kPa		60 kPa		20 kPa	
	YBCO	GdBCO	YBCO	GdBCO	YBCO	GdBCO
ZFC (N)	120.5	121.7	130.4	128.2	145.2	138.4
Increase ratio	—	—	8.2%	5.3%	20.3%	13.7%
FC (N)	54.4	55.0	56.4	55.4	60.7	57.4
Increase ratio	—	—	3.8%	0.7%	11.6%	4.4%

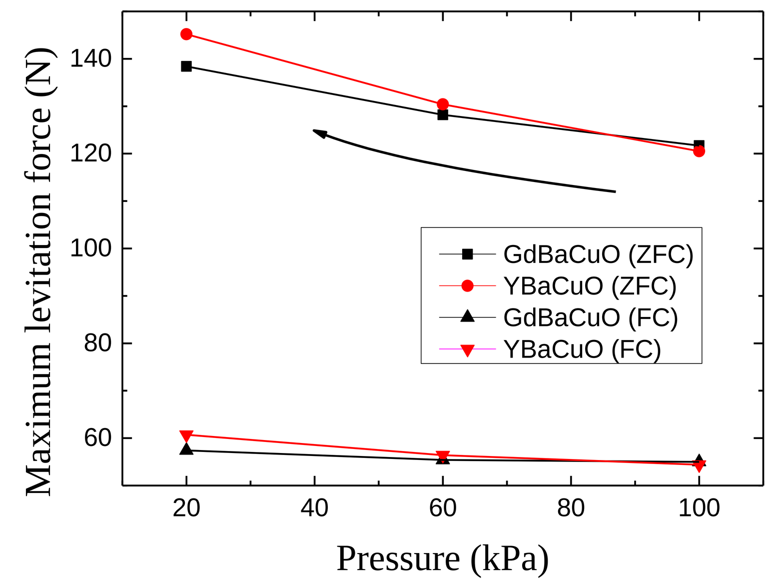

Fig. 7. Maximum levitation force of the YBaCuO bulk and GdBaCuO bulk at different pressures of 100 kPa, 60 kPa, and 20 kPa in the case of ZFC and FC.

Acknowledgements

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