Supplementary Information

Ultra-high Critical Current Density and Pinning Force in REBCO-based, Nanostructured, Superconducting REBCO-based, Coated Conductor

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This file includes:

Supplementary figures S1 to S16.

Details of Hall measurements.

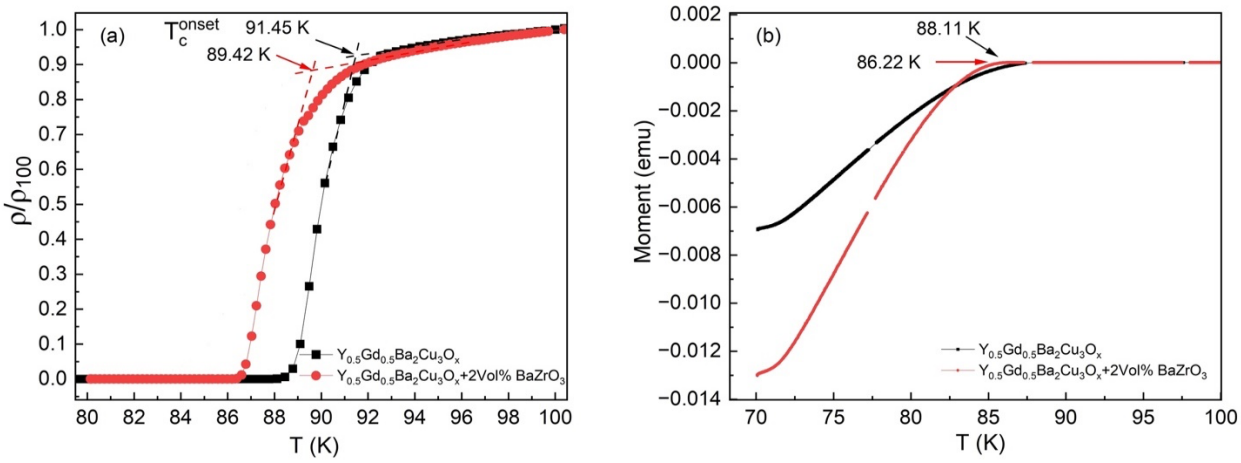

Fig.S1. Normalized resistivity versus temperature for $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ and $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2 vol%$BaZrO_3$ films. **(a)** The resistive T_c onset for the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ film is 91.45K and the T_c (zero) is 88.11K. The resistive T_c onset for the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2 vol%$BaZrO_3$ film is 89.42K and the T_c (zero) is 86.19K, both films having a transition width of ~ 3K. **(b)** The magnetic T_c defined as the maximum temperature were the film shows diamagnetism was observed to be 88.11K and 86.22K for the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ and $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$ films respectively.

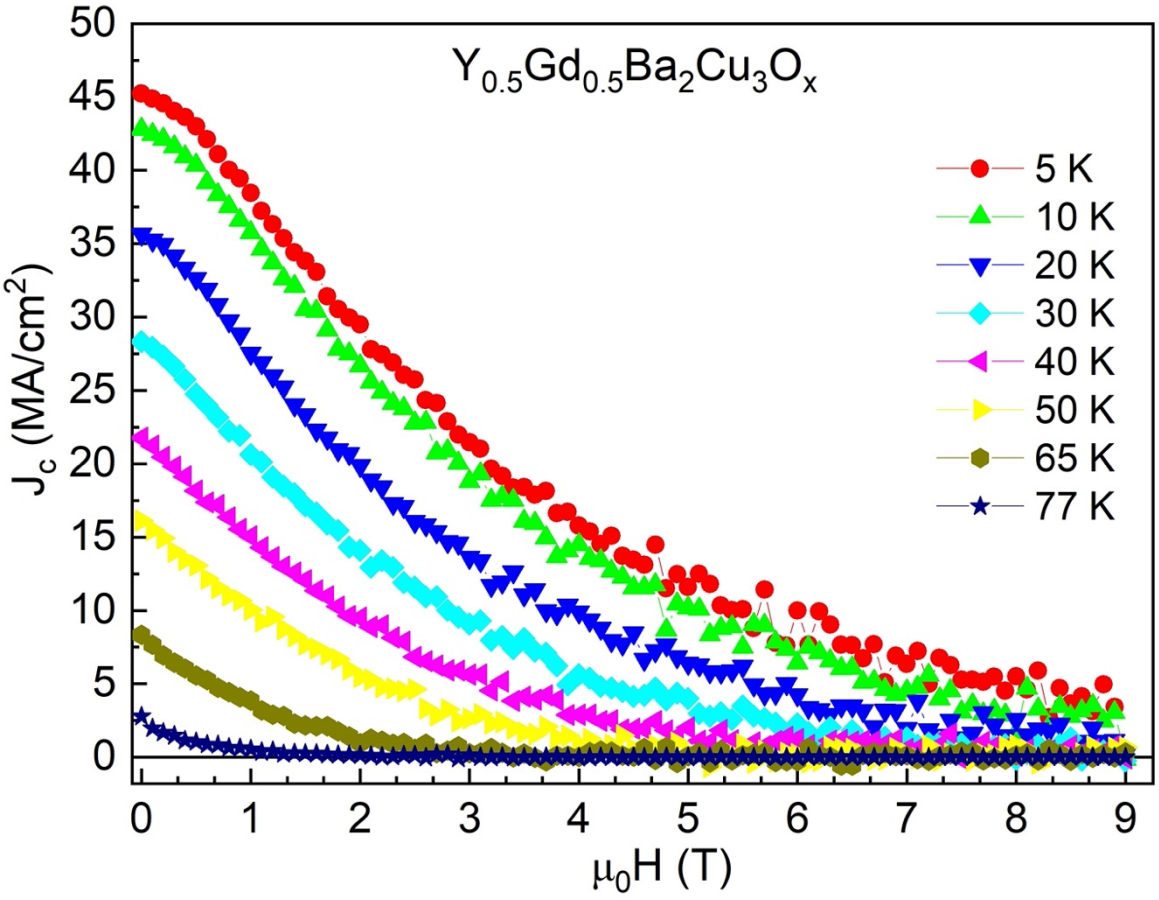

Fig.S2. J_c versus H on $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ measured at the Università di Salerno using the ACMS method.

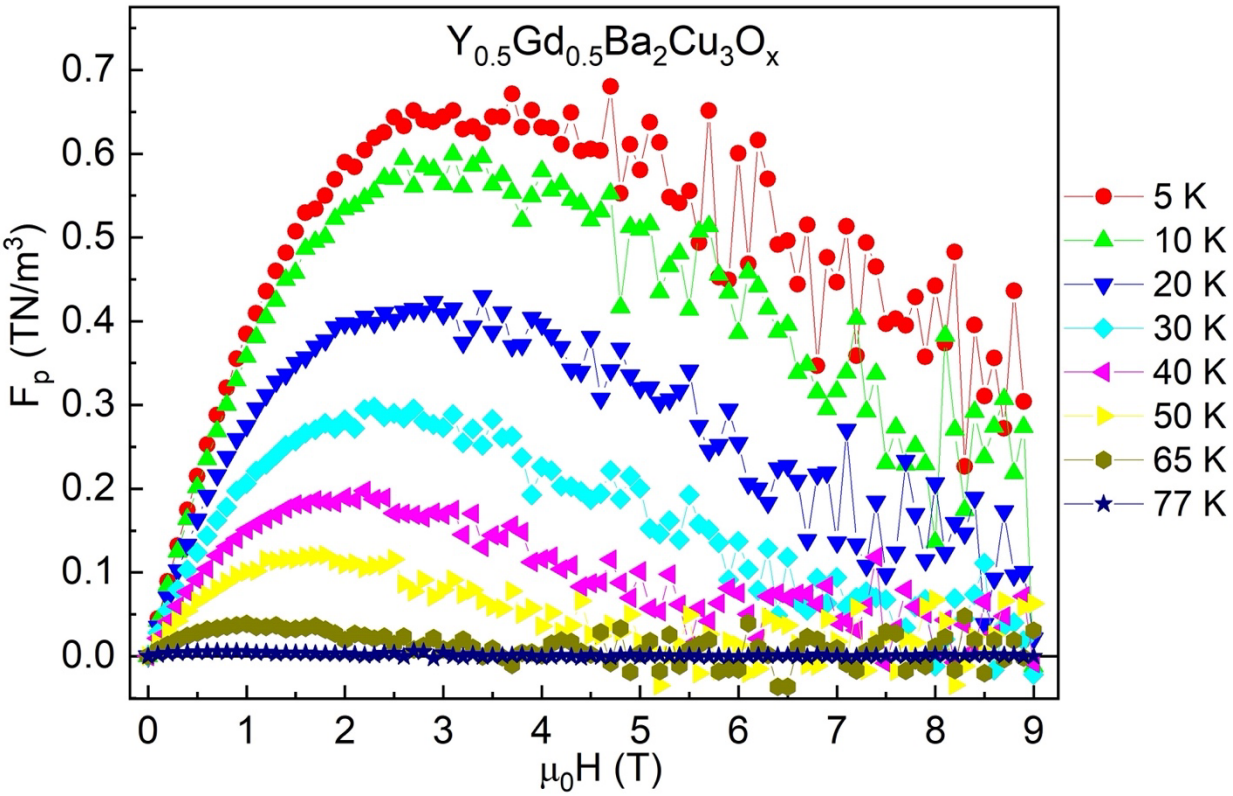

Fig.S3. F_p versus H on $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ on same sample as in Fig.S2 measured at the Università di Salerno using the ACMS method.

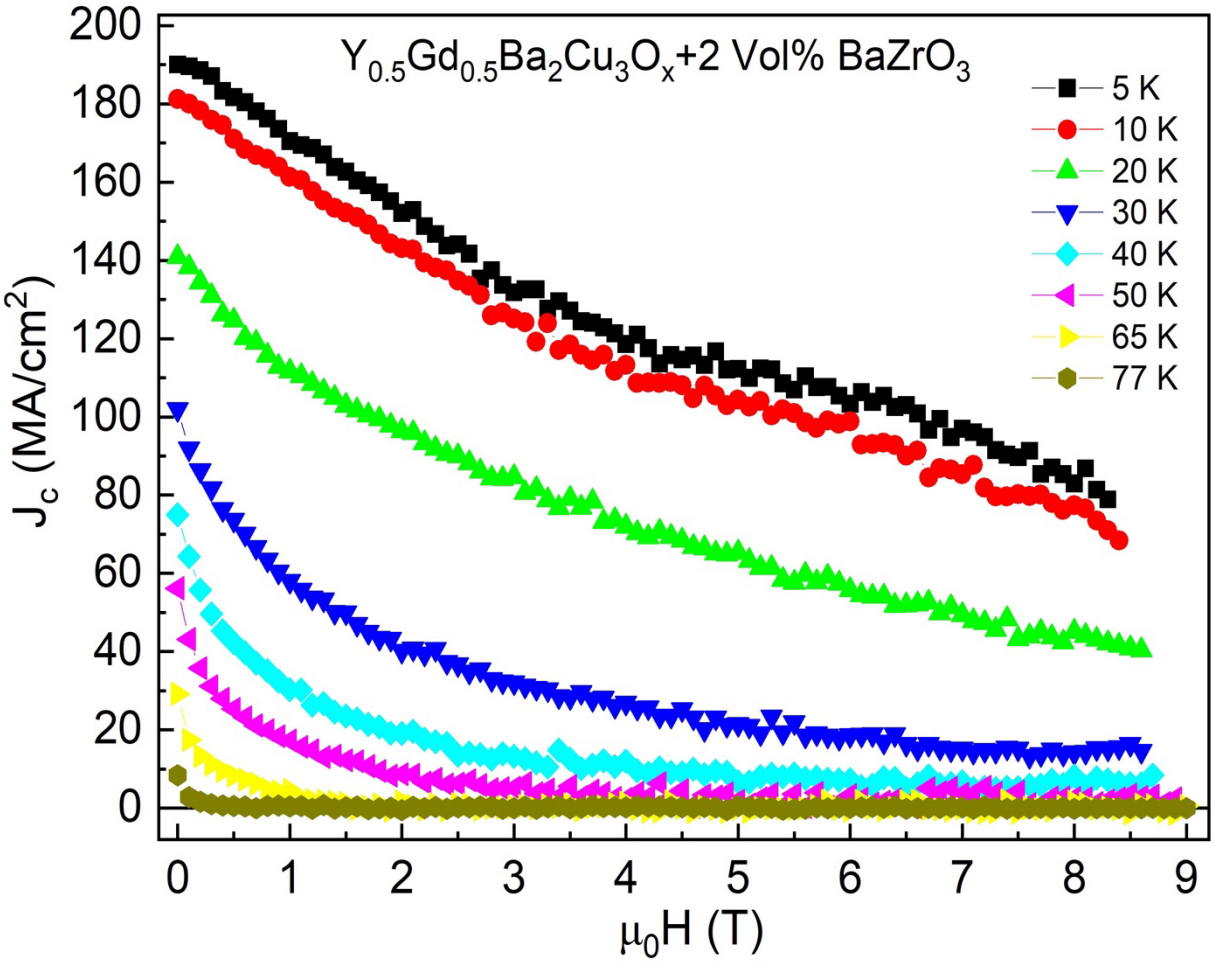

Fig.S4. J_c versus H on another $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2 vol%$BaZrO_3$ sample measured at the Università di Salerno using the ACMS method.

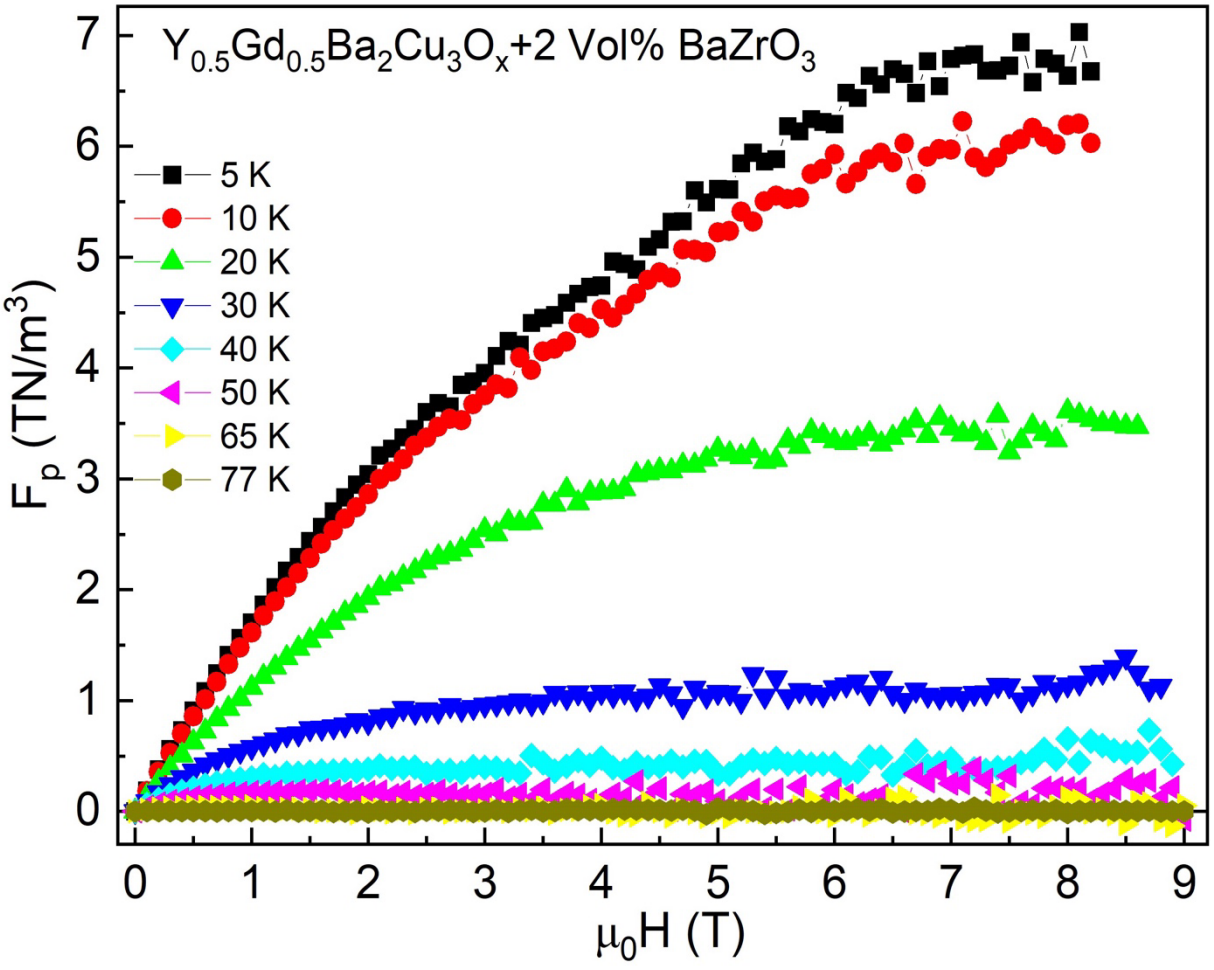

Fig.S5. F_p versus H on $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2 vol%$BaZrO_3$ sample for which J_c versus H was shown in Fig.S4, measured at Università di Salerno using the ACMS method.

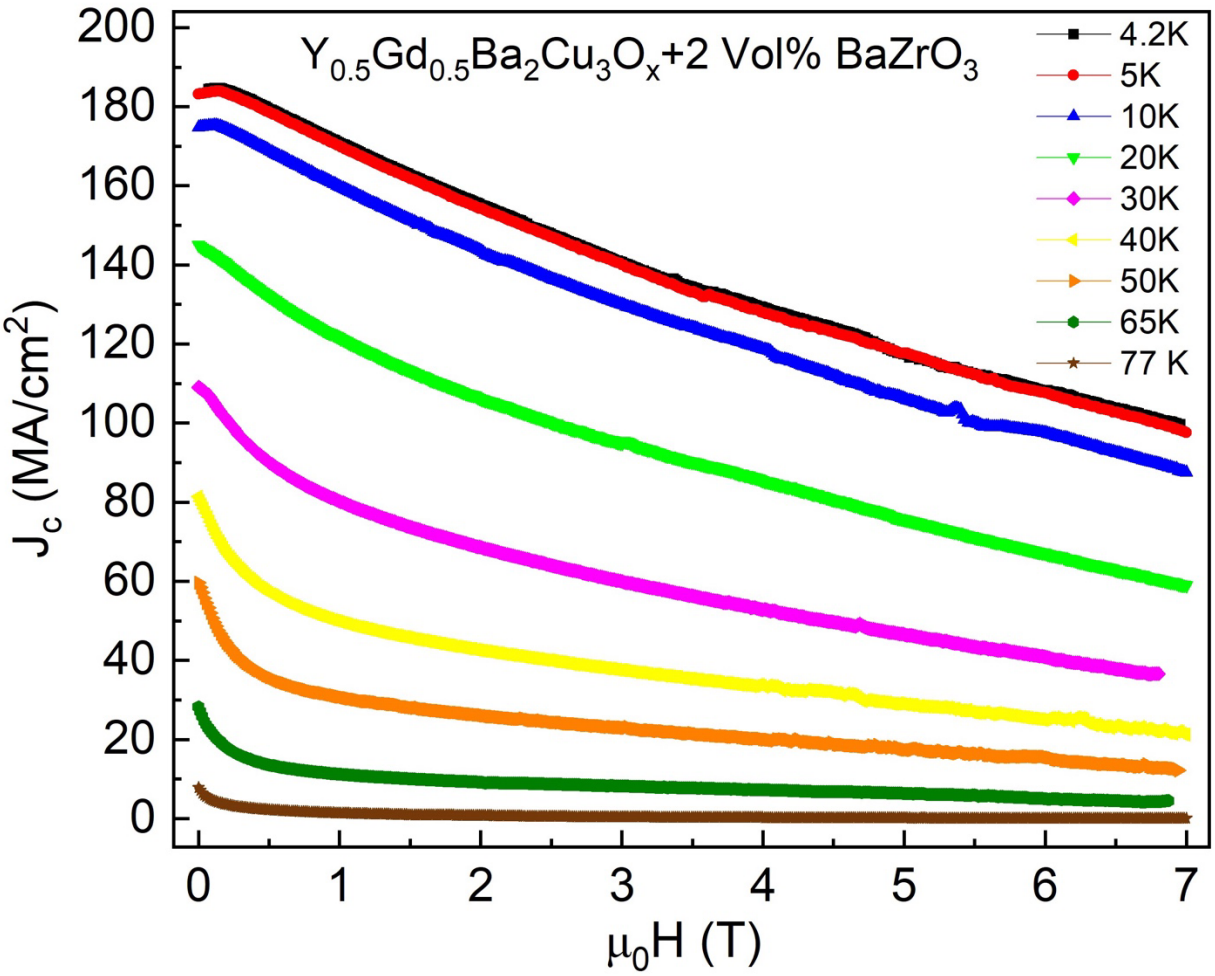

Fig.S6. J_c versus H shows reproducibility on another sample measured at the University of Buffalo using the VSM method.

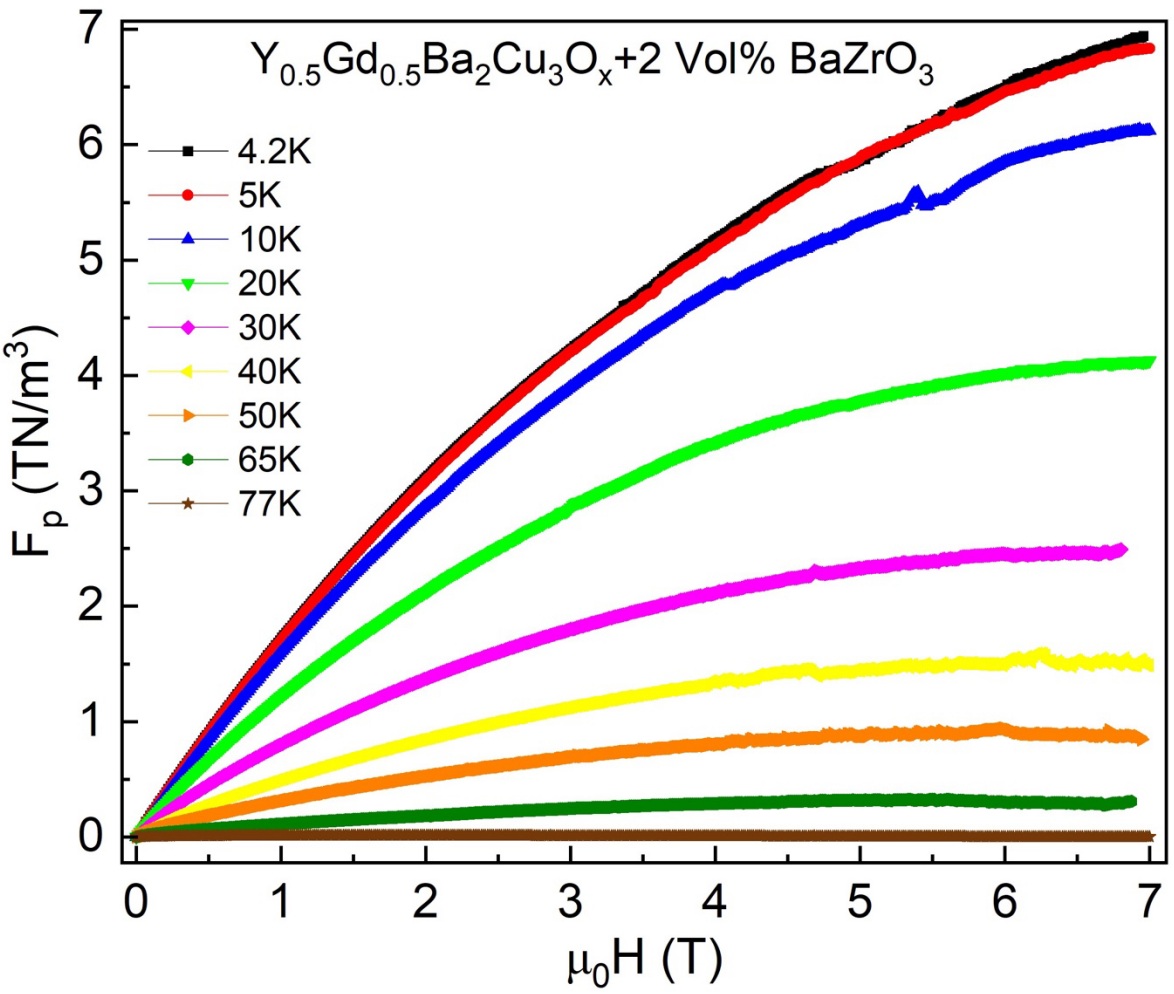

Fig.S7. F_p versus H shows reproducibility on another sample measured at the University of Buffalo using the VSM method.

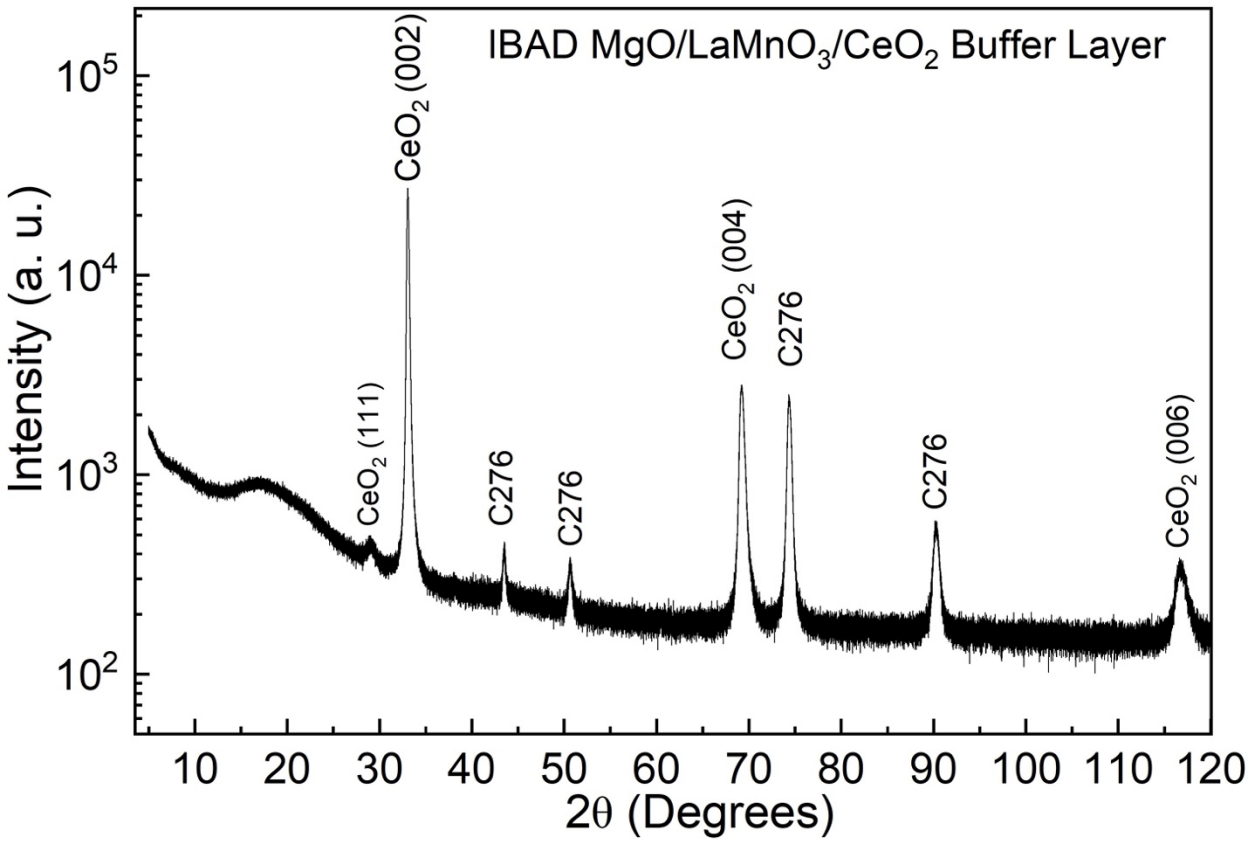

Fig.S8. X-ray diffraction (XRD) data for coated conductor substrate used in this work. a High-resolution θ-2θ XRD scan for the film. All the substrate peaks are identified and marked.

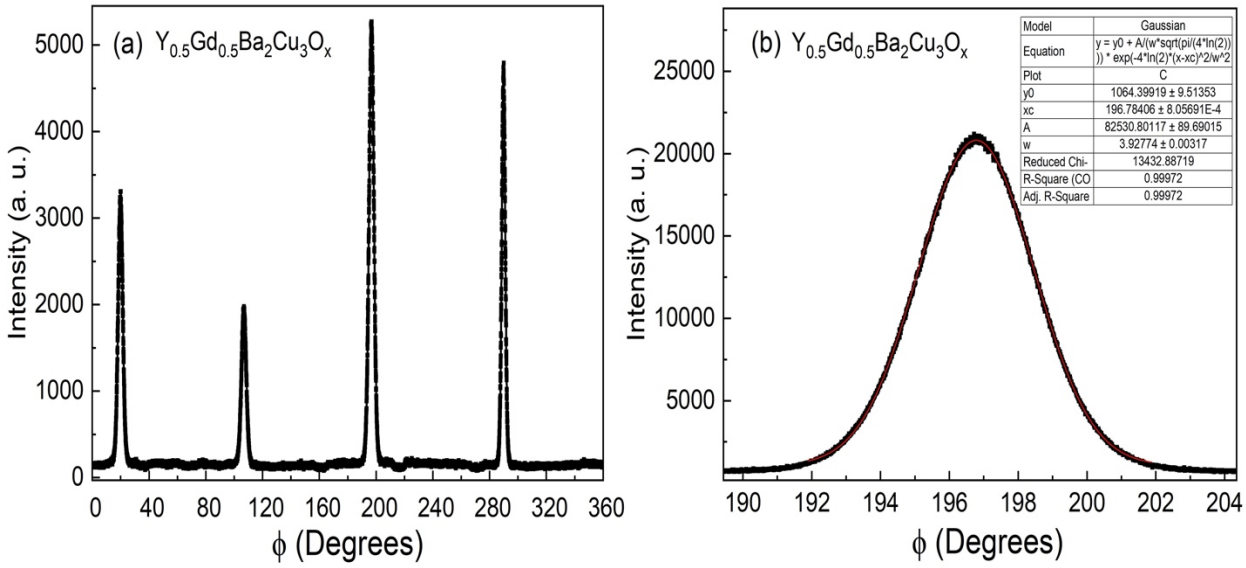

Fig.S9. (a) In-plane texture determined via a Phi scan of (103) peak from the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ film and (b) Curve-fitting and full-width-half-maximum (FWHM) of 3.9°.

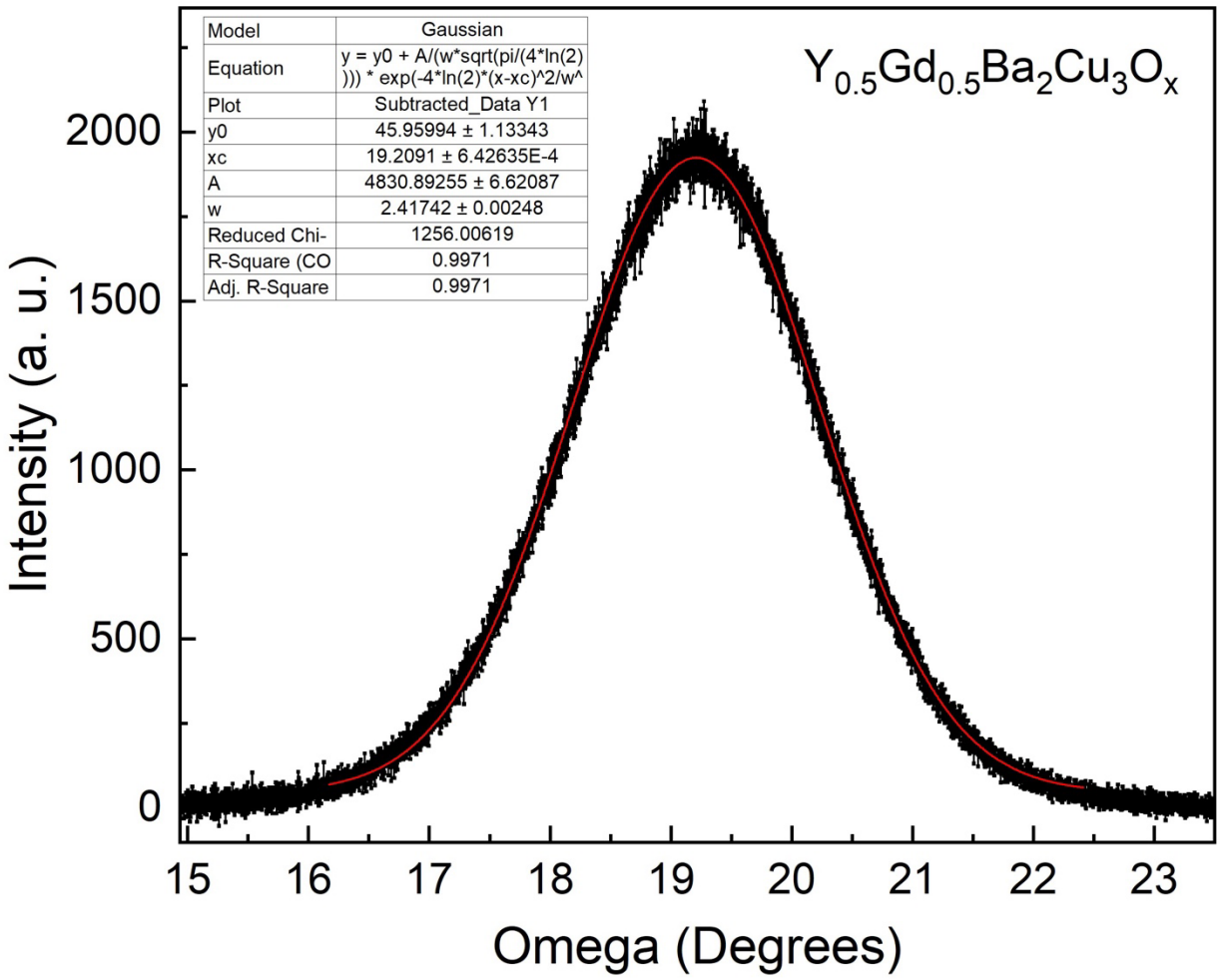

Fig.S10. Out-of-plane texture determined via an Omega scan of (005) peak from the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ film with full-width-half-maximum (FWHM) of 2.4°.

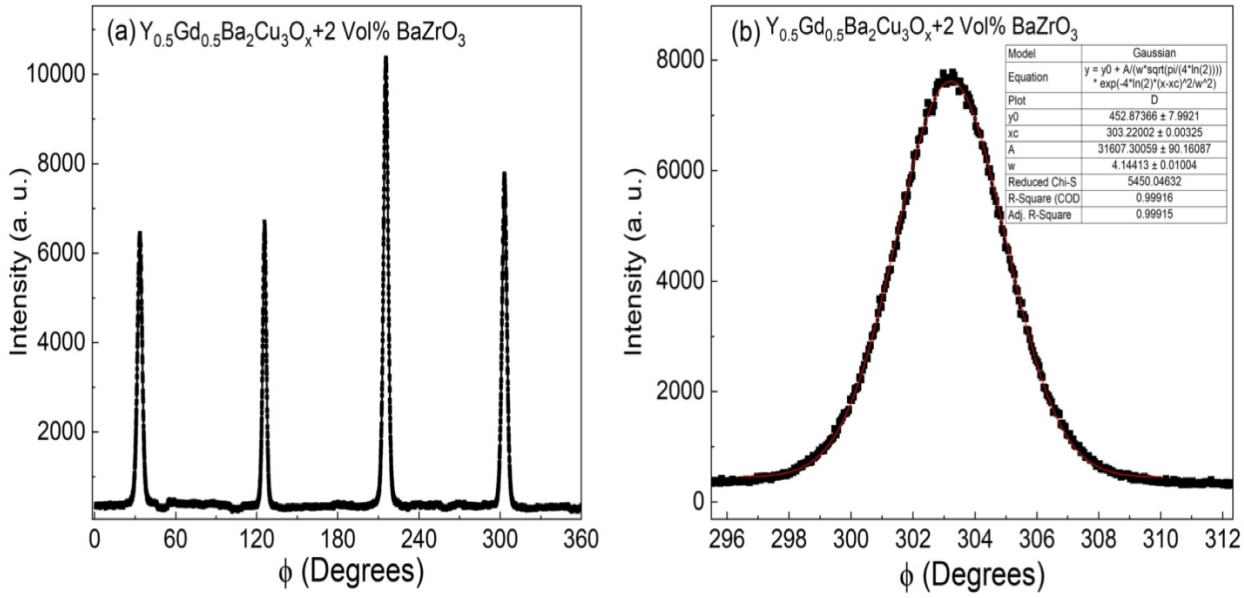

Fig.S11. (a) In-plane texture determined via a Phi scan of (103) peak from the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$ film and (b) Curve-fitting and full-width-half-maximum (FWHM) of 4.1°.

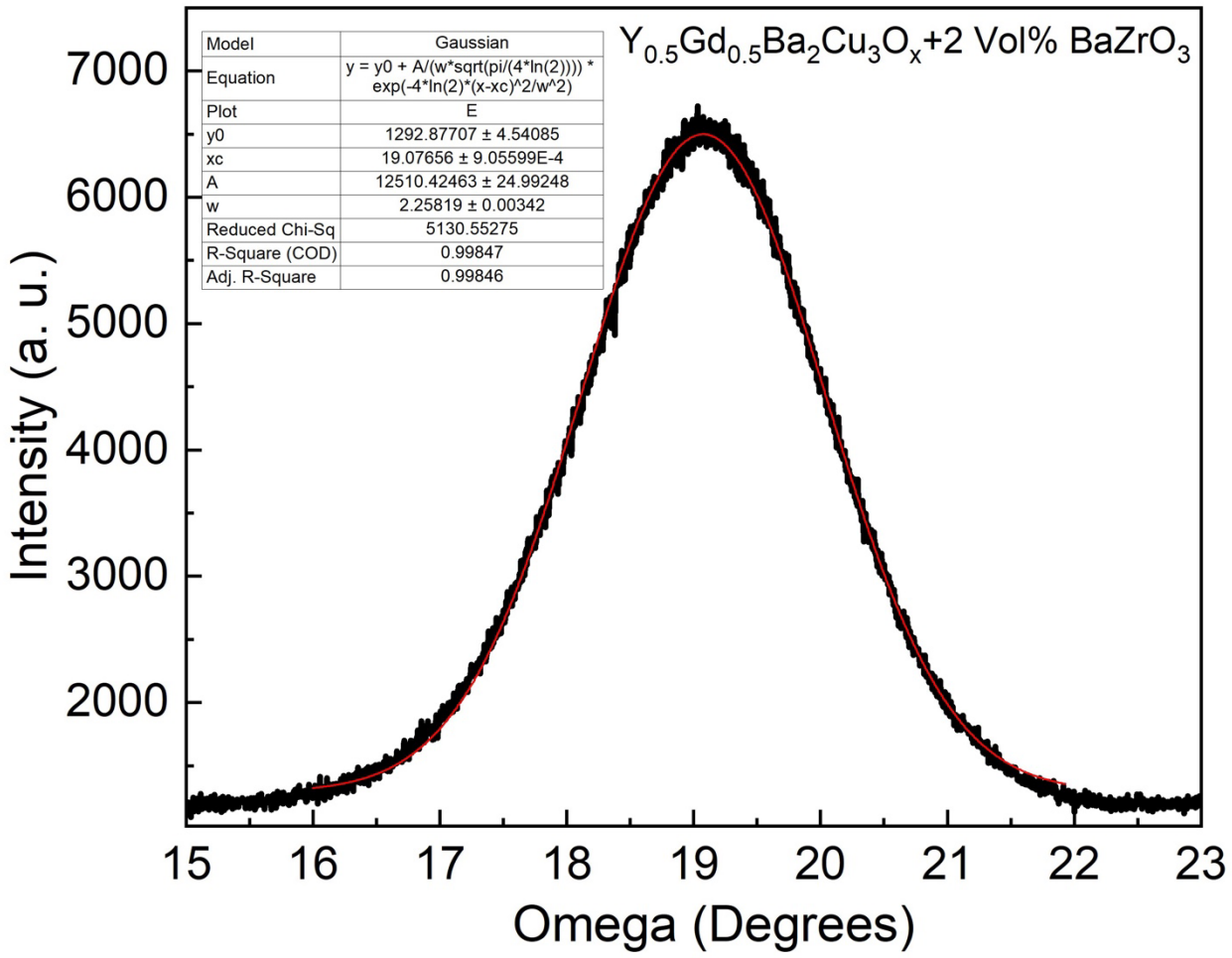

Fig.S12. Out-of-plane texture determined via an Omega scan of (005) peak from the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$ film with full-width-half-maximum (FWHM) of 2.25°.

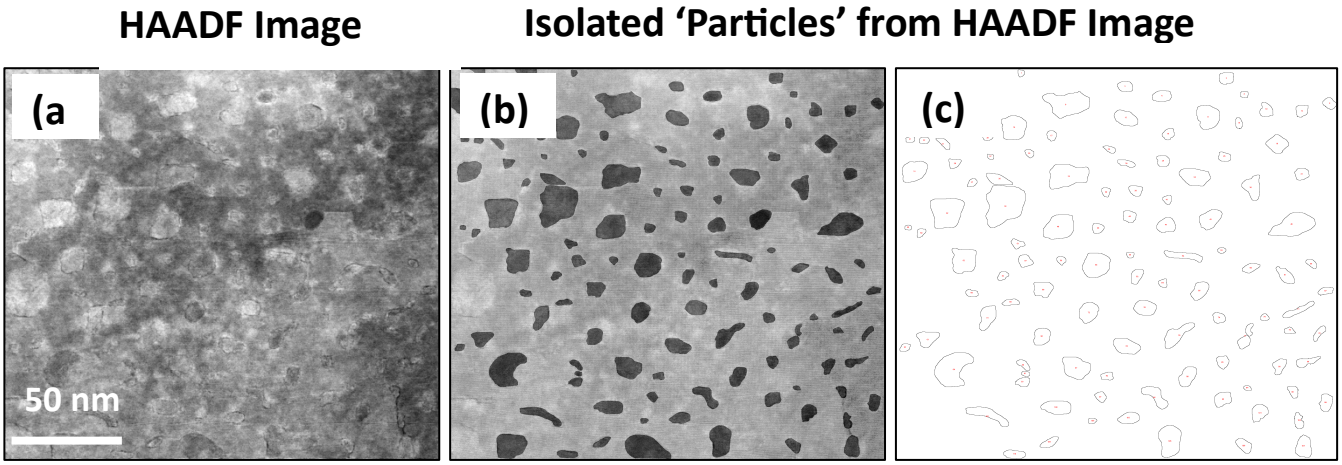

Fig.S13. $BaZrO_3$ (BZO) density is determined from HAADF images of plan-view TEM foils. The number density and average BZO separation is calculated using this methodology. Analysis performed in Fiji software, using Analyze function and BioVoxxel Toolbox (doi.org/10.5281/zenodo.10050002).

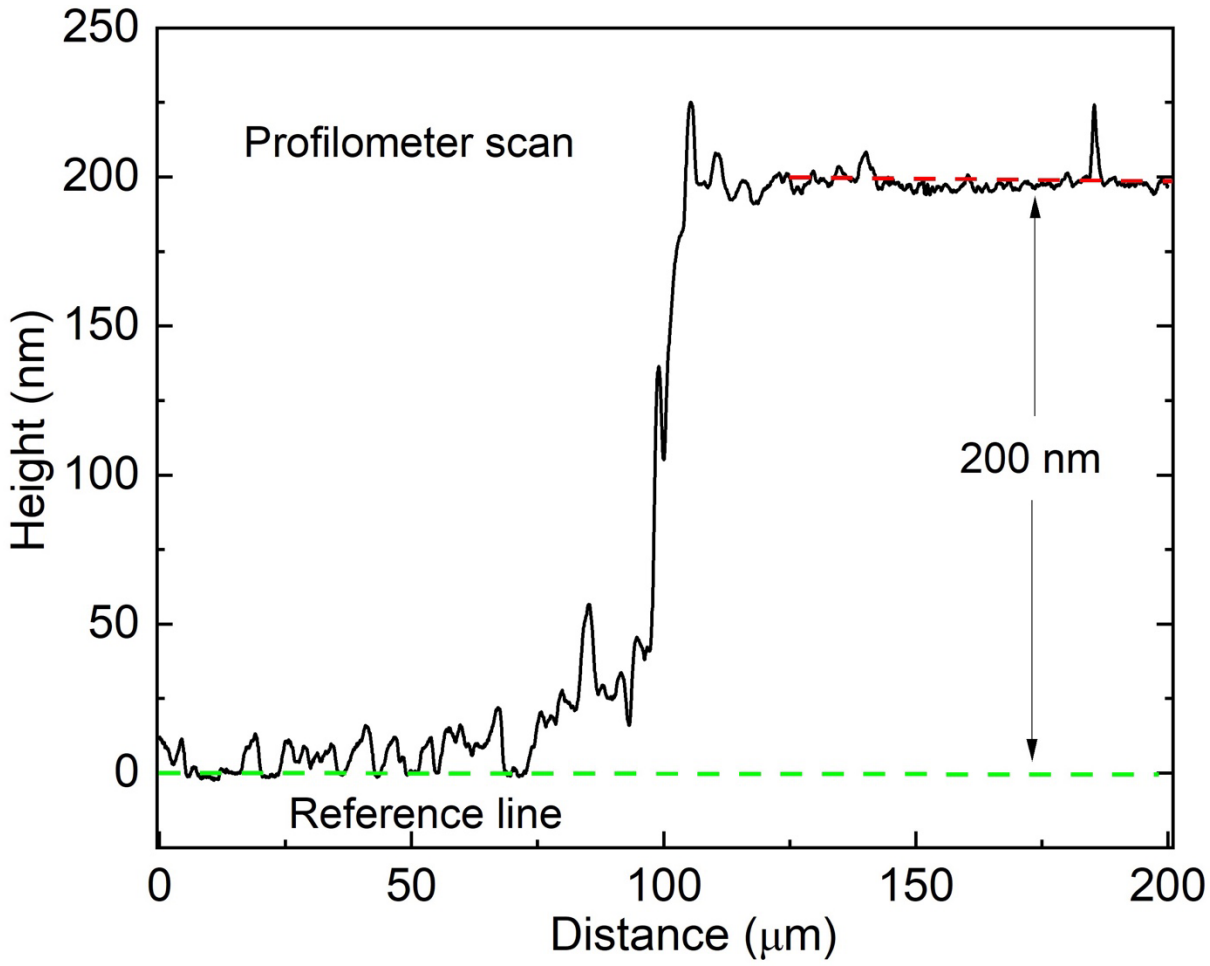

Fig.S14. Out-of-plane texture determined via an Omega scan of (005) peak from the $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$ film with full-width-half-maximum (FWHM) of 2.25°.

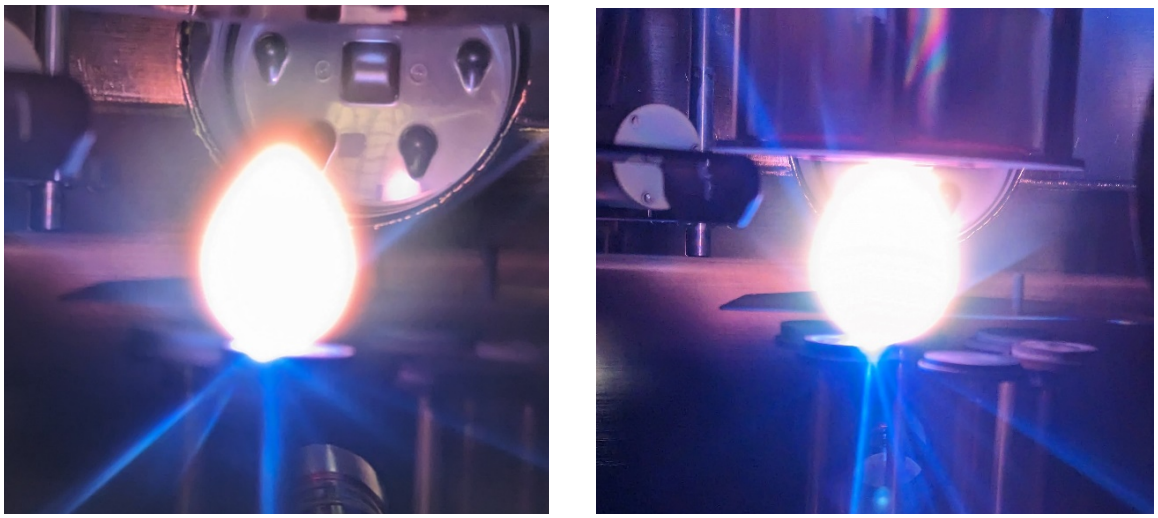

Fig.S15. Laser induced plasma plume generated by pulsed excimer laser (a) with no interaction with the substrate (b) with ~15 % of the plume intersection with the substrate during thin film deposition.

Details of Hall Measurements at 300K

The Hall measurements were performed using the **Hall (average configuration)**. Hall average configuration is the improved version of Hall RMFR configuration, in which Hall coefficient measured by two independent ways and averaged to achieve a modest reduction in the uncertainty. The whole procedure can be seen at Quantum Design, van der pauw Hall Option manual (https://www.depts.ttu.edu/phas/cees/Instruction/PHYS_5300-19/Activities/van_der_Pauw-Hall_Option_Users_Manual.pdf).

In order to calculate the carrier concentration of $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$, the slope of Hall voltage as a function of applied magnetic field was used.

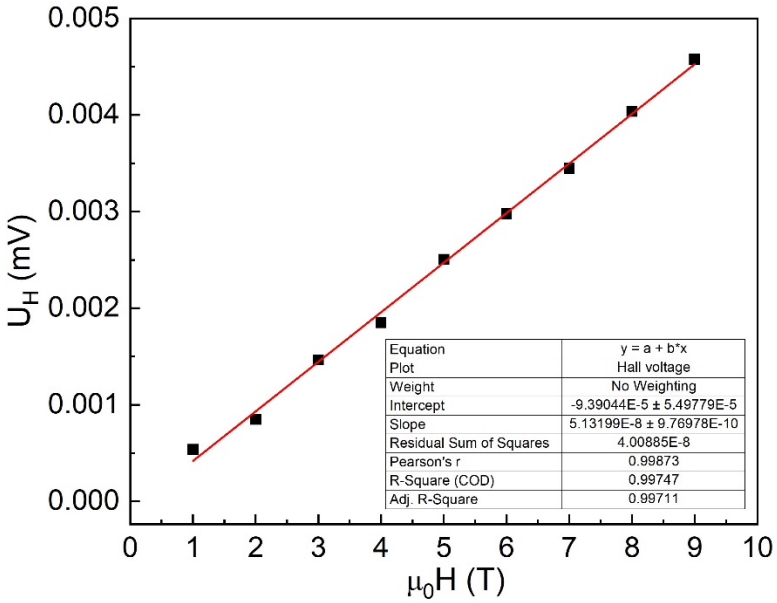

Fig. S16. Hall voltage as a function of applied field for $(Y_{0.5}Gd_{0.5})Ba_2Cu_3O_X$ + 2vol%$BaZrO_3$.