**Supplementary Material for**

**Development of low-fluorine solution route and UV photolysis process for YBa2Cu3O7-x coated conductors**

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1. **Experimental details**

The YBCO precursor solution with F/Ba=2 was synthesized by mixing the Y-Ba-Cu solution and Ba-TFA solution. The Y-Ba-Cu-solution was prepared through dissolving yttrium, barium, and copper acetates in the mixture solution of propionic acid and methanol. The Ba-TFA solution was prepared by dissolving Ba-TFA gel into methanol. In the YBCO precursor solution, the metal ion ratio was controlled at Y:Ba:Cu=1:2:3, and the total metallic ion concentration was controlled at 1.5mol/L.

By adjusting the amounts of Y-Ba-Cu solution and the Ba-TFA solution, YBCO precursor solutions with F/Ba=1, 1.5, 1.8, 3 and 4.5, were also synthesized. The YBCO gel films derived from these precursor solutions were produced by the dip-coating method. After the gel films were coated on LaAlO3 substrate, they were pyrolyzed at 400oC in a humidified oxygen atmosphere. In order to increase film thickness, the coating-pyrolysis process was repeated for several times. Subsequently, the pyrolyzed thick films were annealed at 775℃and post-annealed at 450℃, obtaining the superconducting YBCO films.

For the films prepared by UV-assisted method, the YBCO precursor solution with concentration of 0.75mol/L and F/Ba=2 was used. The propionic acid is substituted by acrylic acid. The solution was dip-coated on the LaAlO3 substrates. After being dried in 130oC for 10 minutes to remove the redundant solvents, the YBCO gel films were placed on a hot plate with a temperature of 150oC and kept a distance of 10 centimeters away from the low-pressure mercury lamp. During the irradiation process, the low-pressure mercury lamp emitted rays with wavelengths of 253.7 nm (90%) and 184.9 nm (10%). During the UV irradiation process, air with or without 4.2vol.% H2O was continuously injected into the chamber at the flowing rate of 200L/h. In order to increase the film thickness, the coating-irradiation processes were repeated for four times. Finally, the photon-activated precursor films were directly heated to 785oC under a humidified nitrogen gas with 500ppm oxygen.

The films were analyzed using Thermo Fisher X-ray photoelectron spectroscopy (XPS). A standard X-ray source, 15 kV, 150 W, Al Kα (1486.6 eV), was used for measurements. Survey and multiregion spectra were recorded at the Y 3d, Ba 3d, Ba 4d, Cu 2p, O 1 s, F1 s, and C 1 s photoelectron peaks. A depth profiling was conducted using a 2 KeV Ar+ bombardment at a current density of 2 μA/cm2. A crater of 2 mm diameter was examined. Magnetization behaviors of the YBCO films were investigated by the Multi-function Vibrating Sample Magnetometer (VersaLab-VSM, Quantum Design). YBCO films were cut into small pieces with size of 2.1mm× 2.5mm. The *Jc* related to the magnetic strength (H) of the films were calculated from the M-H curves according to the Bean Model, as given by the equation: Jc =20ΔM/[a(1- a/3b)V]. In the Bean Model, ΔM is calculated according to the vertical width of M–H loops at zero field, and a and b are the length and the width of the film respectively. The applied field, with magnetic strengths of 0–3 T, was perpendicular to the film surface during the magnetization measurement. The obtained YBCO superconducting film was also patterned to be a micro-bridge with a width of 150 μ m. The V-I curve of the YBCO micro-bridge was measured at 77 K to determine Ic with a criterion of 1 μV/cm. The Jc of the YBCO films thus was calculated by Jc=Ic/td, where t=150μ m, and d is the thickness of the YBCO film. Measurements of resistance versus temperature were taken at the temperature of liquid nitrogen using a standard four-probe method.

1. **Reaction during the UV irradiation process**

In order to clearly understand photochemical solution deposition method, we should make clear the underlying mechanism about it. First, in the process of UV irradiation without water vapor, the O2 was irradiated by UV light of 185 nm and the radical oxygen atoms (O) were produced, as shown by reaction (1). The radical oxygen atom would further combine with the O2, forming the ozone gas (O3), as denoted by reaction (2). However, if the water vapor was provided during this process, the hydroxyl radical (\*OH) would be further produced instead of ozone gas under the irradiation of 254nm ray, as denoted by reaction (3) and reaction (4).

O2 + hv → O + O λ = 185 nm Reaction (1)

O2 + O → O3 Reaction (2)

O3 + hv → O2 + O\* λ = 254 nm Reaction (3)

O\* + H2O + hv → 2\*OH λ = 254 nm Reaction (4)

It is a well-known fact that the hydroxyl radical (\*OH) features a strong oxidizing ability in nature (only inferior to the oxidant of fluorine) with an oxidation potential value of 2.8 eV, which is even higher than that (2.07 eV) of ozone gas. In addition, it is also a non-selective and reactive oxidant, and can lead to the quick degradation of organics. Therefore, it could drastically oxidize the carbon-related by-products to small molecule gases rapidly, and effectively promote the film densification and the partial formation of M-O-M network.

1. **Figures**

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**Figure S1** Surface morphologies of single-layer YBCO thin films prepared using solutions with (a) TFA/Ba=0.33; (b) TFA/Ba =0.5; (c) TFA/Ba =0.6; (d) TFA/Ba =0.68; (e) TFA/Ba =1.0; (f) TFA/Ba =1.5.

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**Figure S2** XRD patterns of YBCO single-layer films prepared using solutions with (a) TFA/Ba=0.33; (b) TFA/Ba =0.5; (c) TFA/Ba =0.6; (d) TFA/Ba =0.68; (e) TFA/Ba =1.0; (f) TFA/Ba =1.5.

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Figure S3 XRD patterns of five-layer YBCO thick films derived from solutions with TFA/Ba ratio of (a) 0.33~0.6, and (b)0.68~1.5.

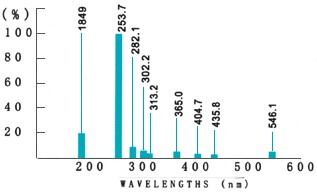


Figure S4 Spectral distribution of the low-pressure mercury UV lamp.



Figure S5. (a-e) are the FT-IR spectra of YBCO gel films irradiated at 150°C under UV light for different times, and (f) is the FT-IR spectrum of a sample heat at 150oC for 100min.

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Figure S6 (a) SEM images of the film irradiated under UV light for 100min without water gas; (b-d) are the surface morphologies of the films irradiated under UV light with water gas for 30min, 60min, and 100min respectively. (e) shows the Jc-H curves of the YBCO films processed under different UV-irradiation conditions.