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Shanghai Creative Superconductor

Ion Irradiation Effect on the In-Field Performance of MOD-REBCO Coated Conductors

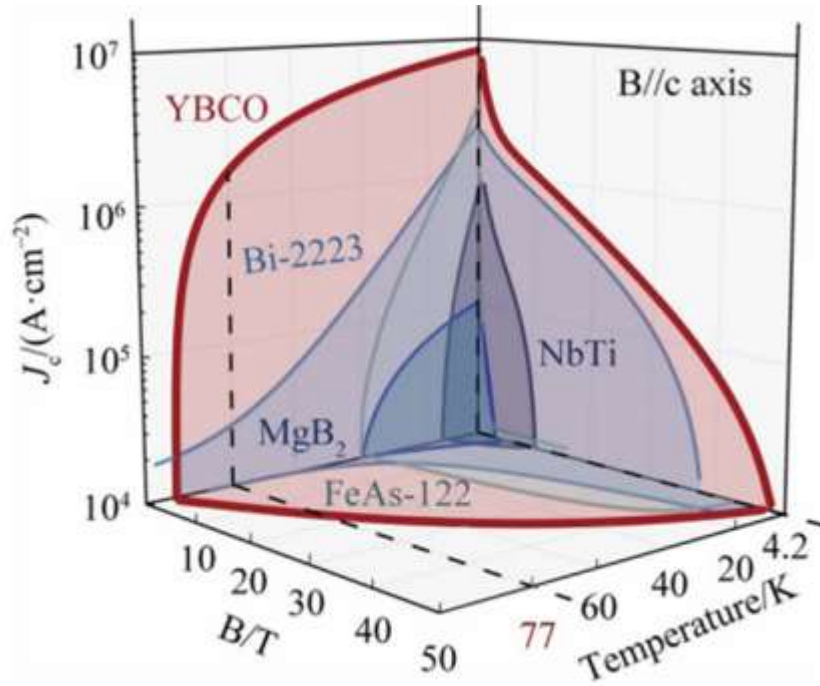
C. B. Cai; N. ZHANG; Z. Y LIU; R. T. HUANG; Y. LI

Shanghai Key Laboratory for High Temperature Superconductors,
Shanghai University

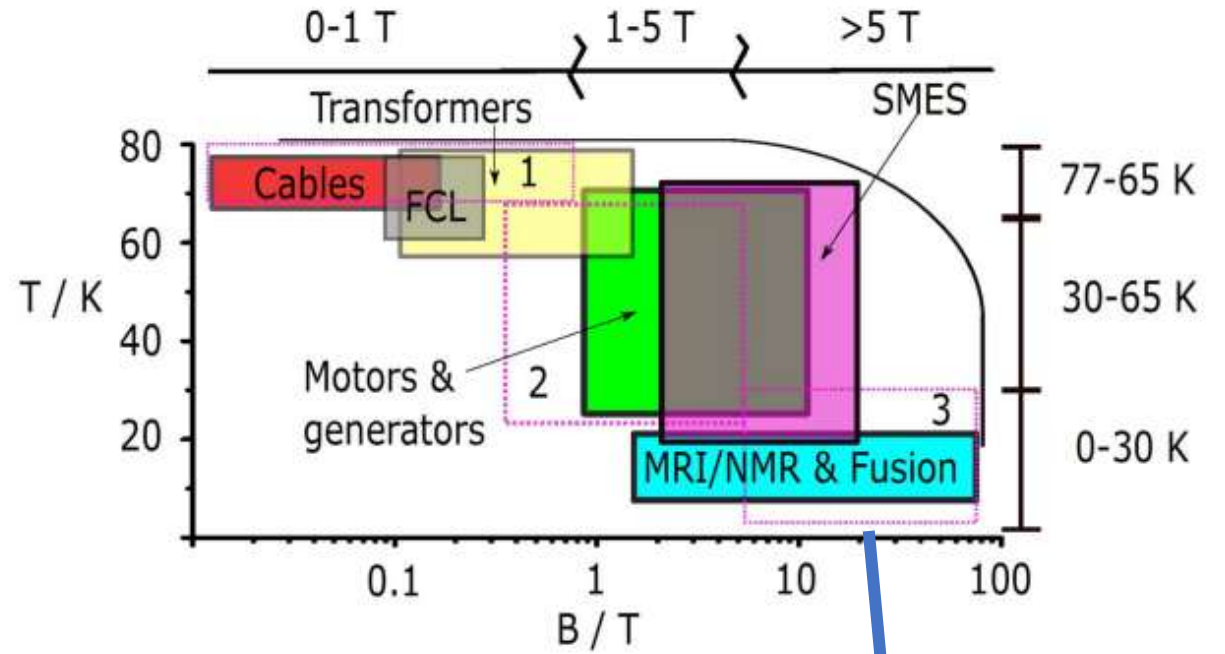
Shanghai Creative Superconductor Technologies Co., Ltd



Introduction



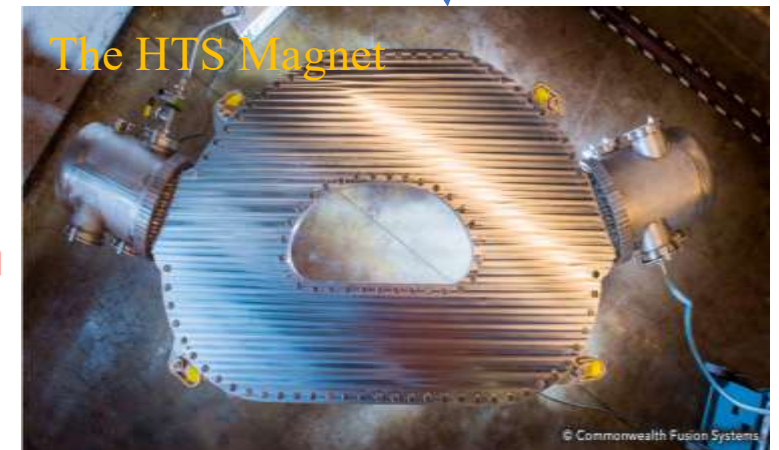
D.X. Wang., et al. ADV MANUF. 11.3 (2023): 523-540.



Characteristics of REBCO:

- High T_c
- High H_{irr}
- High J_c

**High research value
& Broad application prospects**



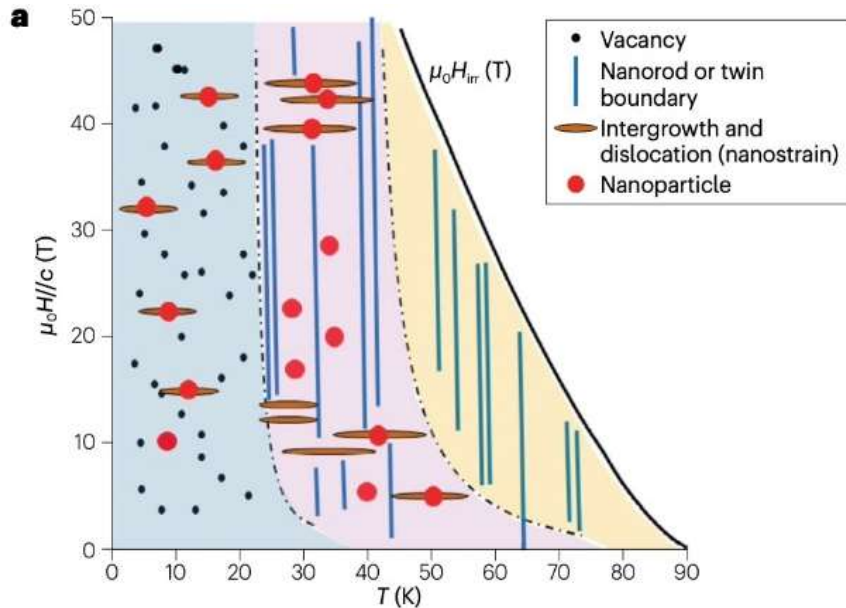
SPARC, MIT Plasma Science & Fusion Center

Mixed pinning landscape

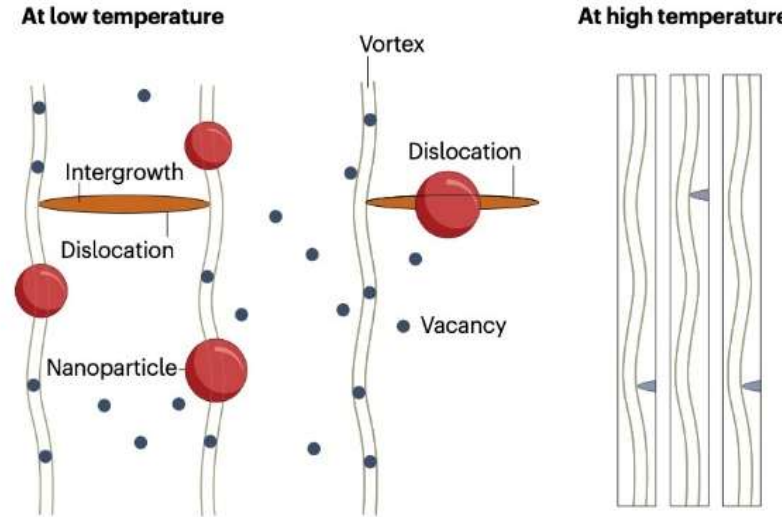


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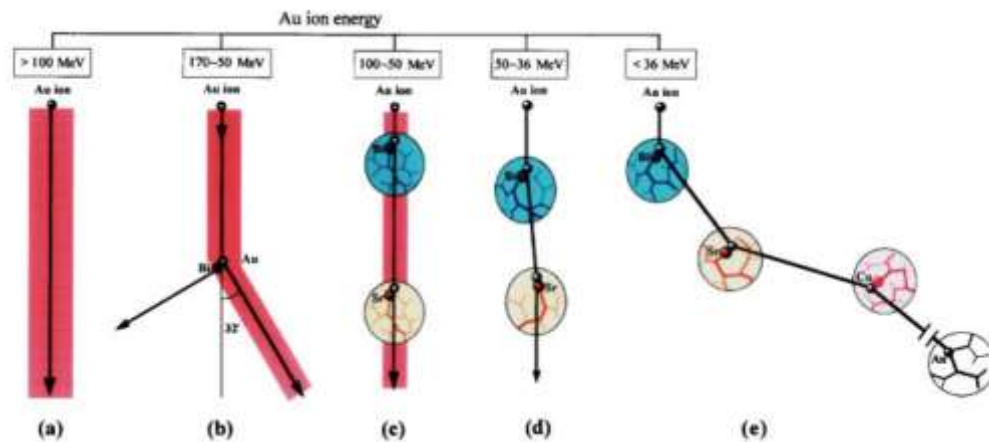
b Effective pinning landscape



a. H - T phase diagram, defects of different dimensions form different vortex states; b. effective pinning landscapes at high and low temperatures.

P Tuig, J Gutierrez, and X Obradors. "Nat. Rev. Phys. 6.2 (2024): 132-148.

Defects of different dimensions can improve the in-field performance of REBCO in various temperature and magnetic field ranges.



Pro of ion irradiation:

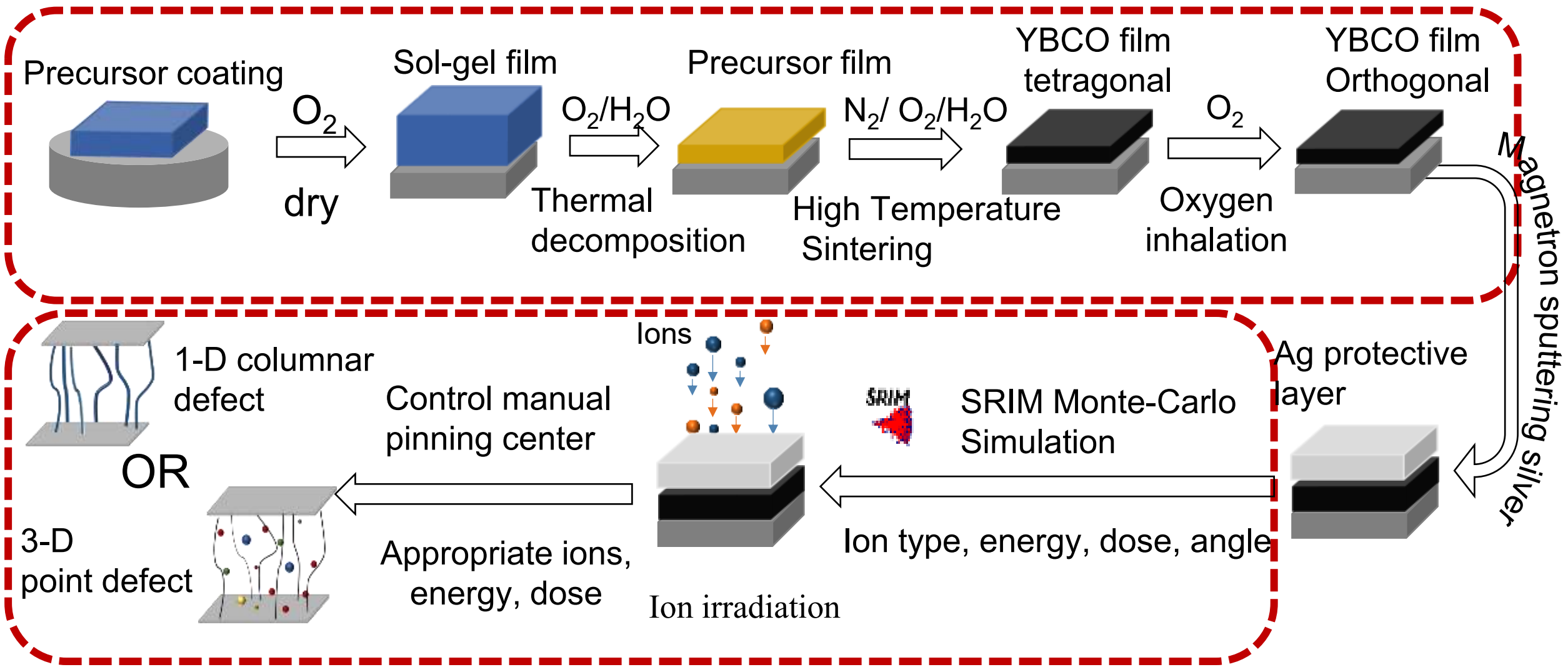
- Easy to control the size and distribution of defects

D. X. Huang* and Y. Sasaki, et al. Phys. Rev. B. vol.57 No.21 (1998)

Experimental process



The whole process: (Preparation for REBCO + Ion irradiation)

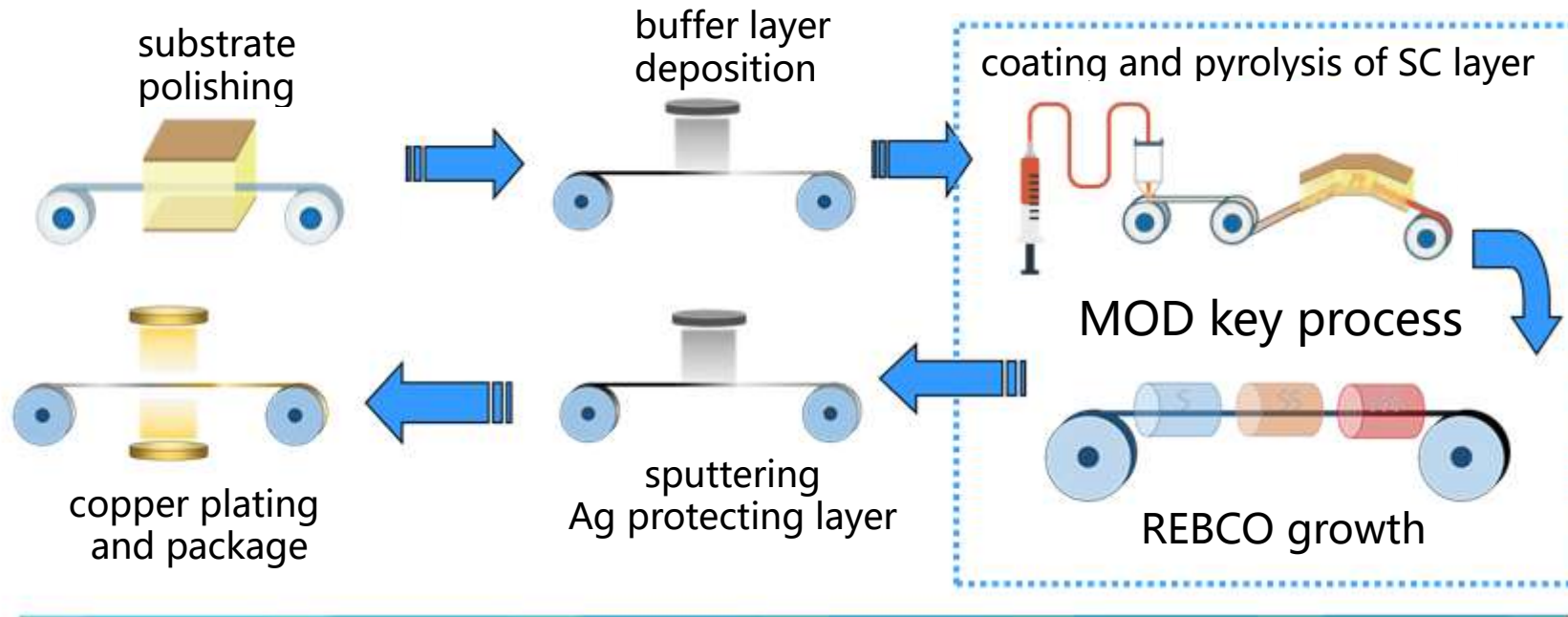


SCSC: industrial production lines



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Low-cost MOD route

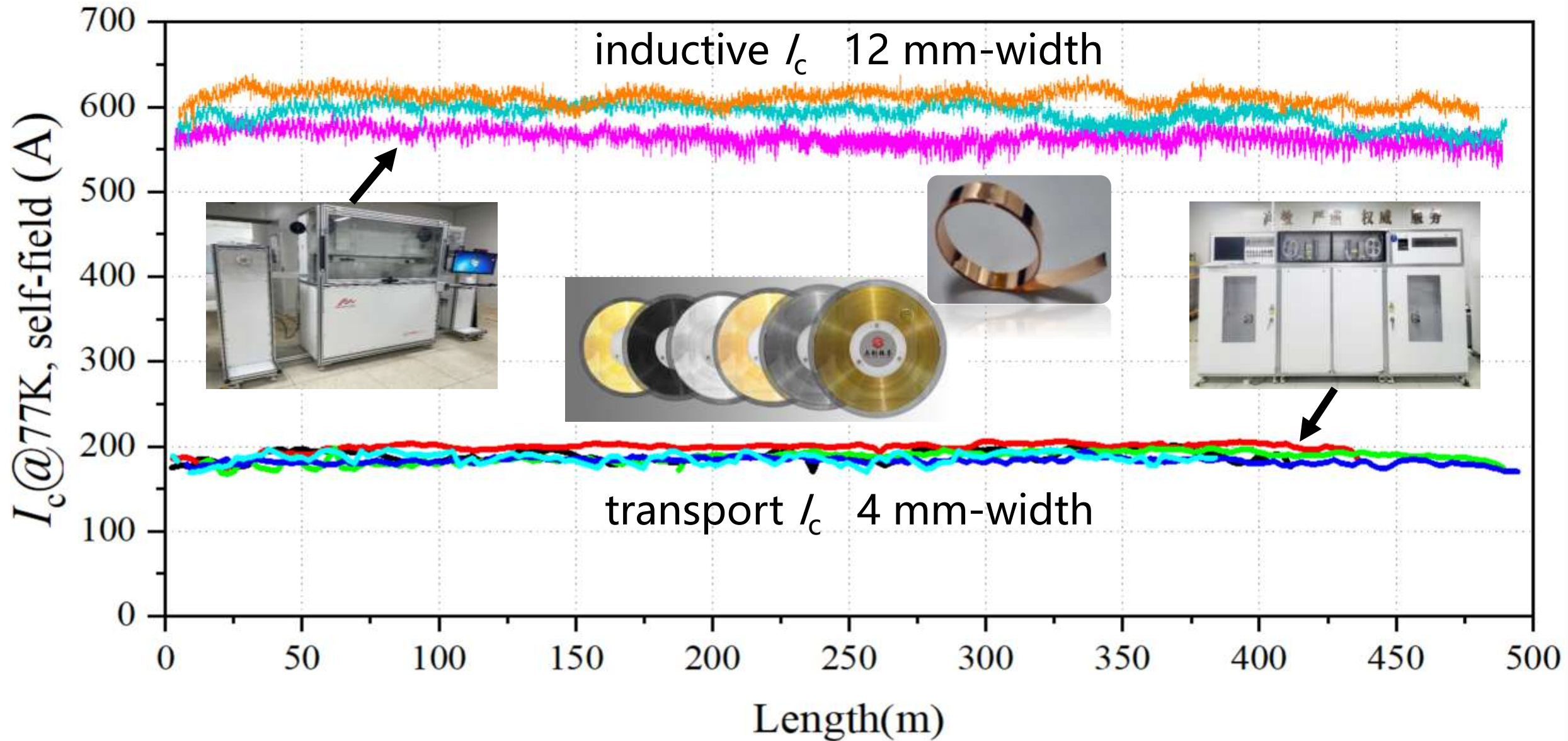
- **No high vacuum**
- **Easy control of composition**
- **100% utilization of solution**
- **Wider tape & thicker HTS**
- **Large scale production**

- Substrate polish
- Texture formation of buffer layers
- Coating and growth of HTS layer
- Sliting & Package





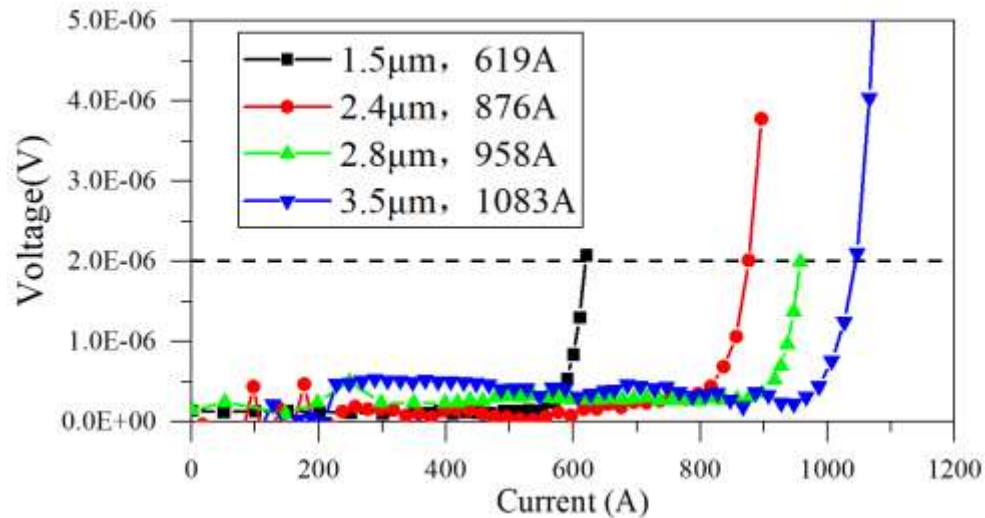
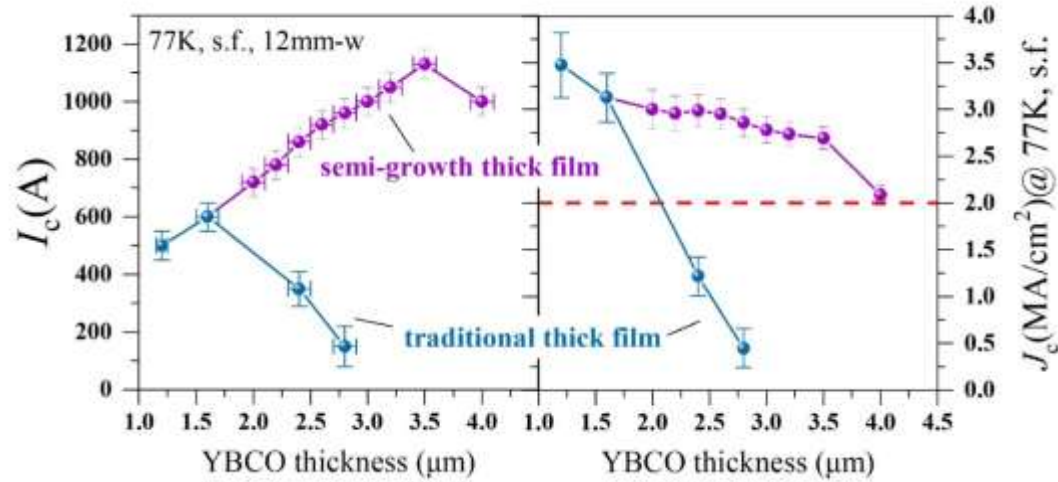
Performance of conventional thin tape in SCSC



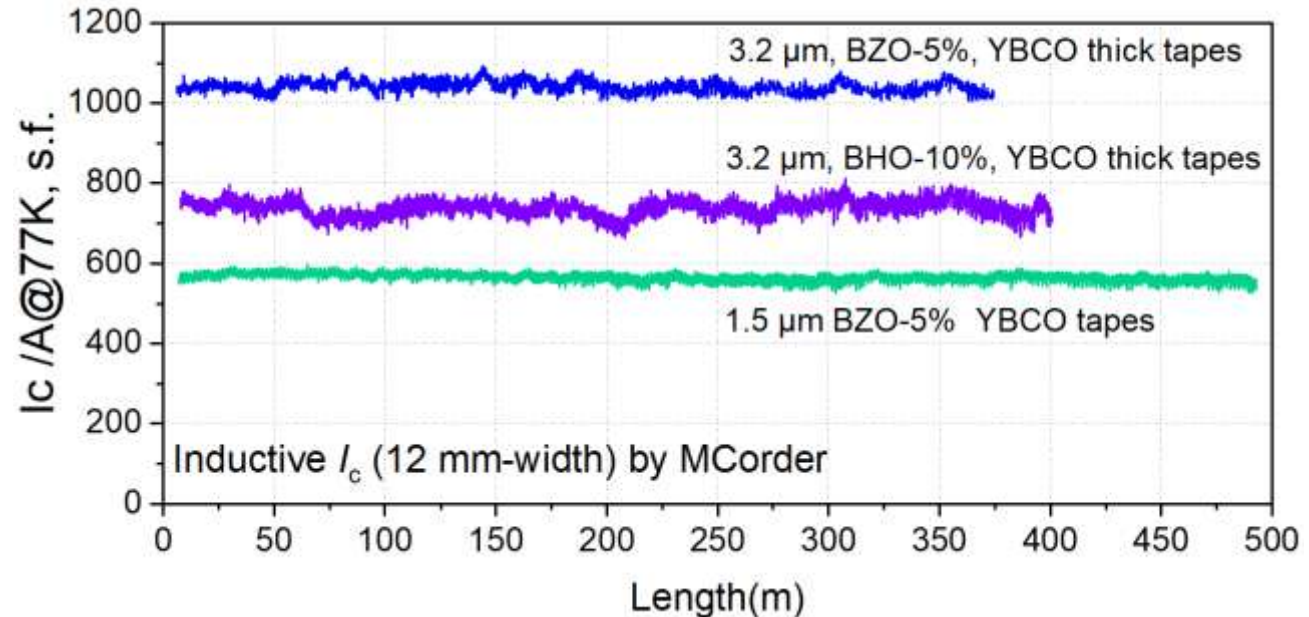
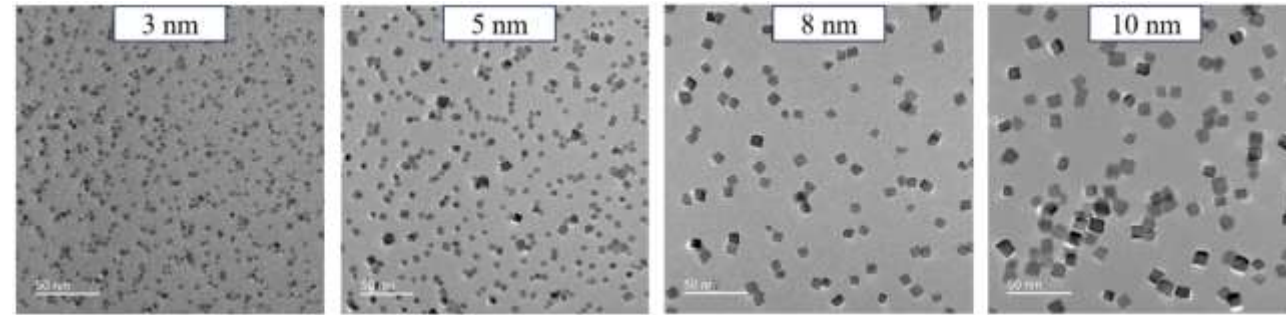


REBCO: thickening and nanocrystal

✓ Significantly improve the J_c of YBCO



Dispersion of BMO



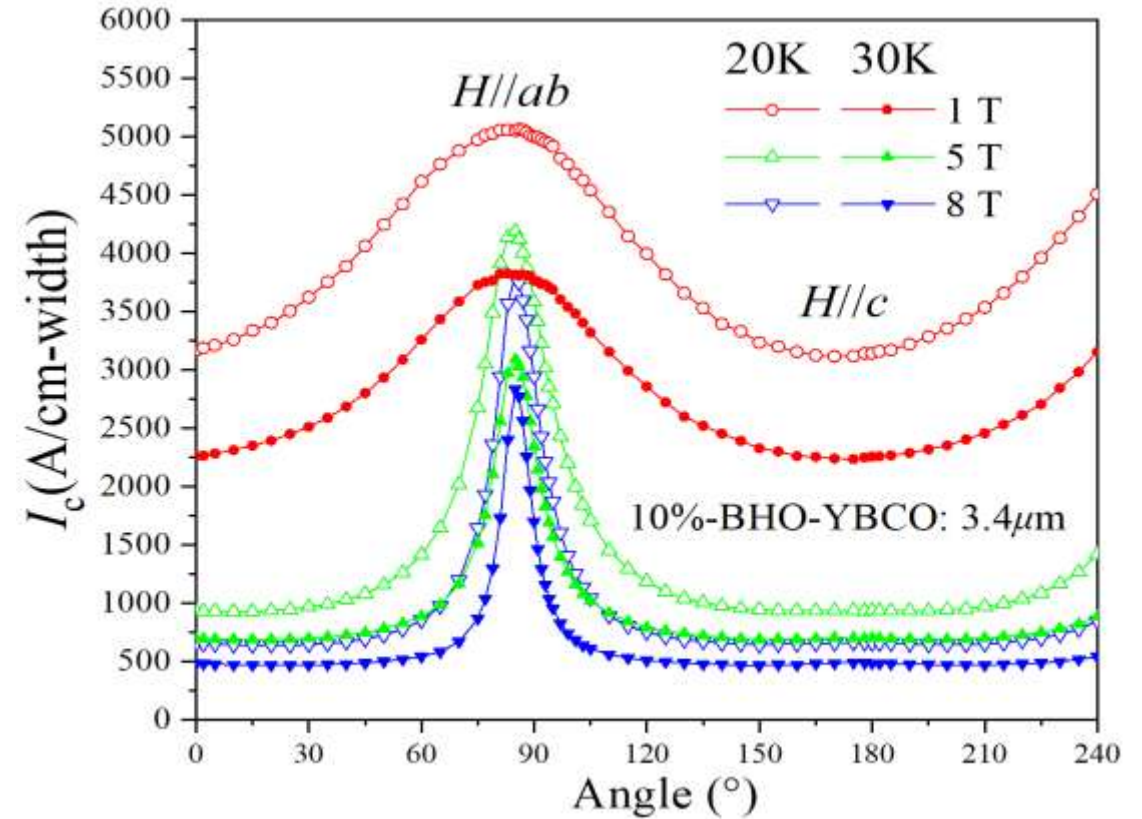
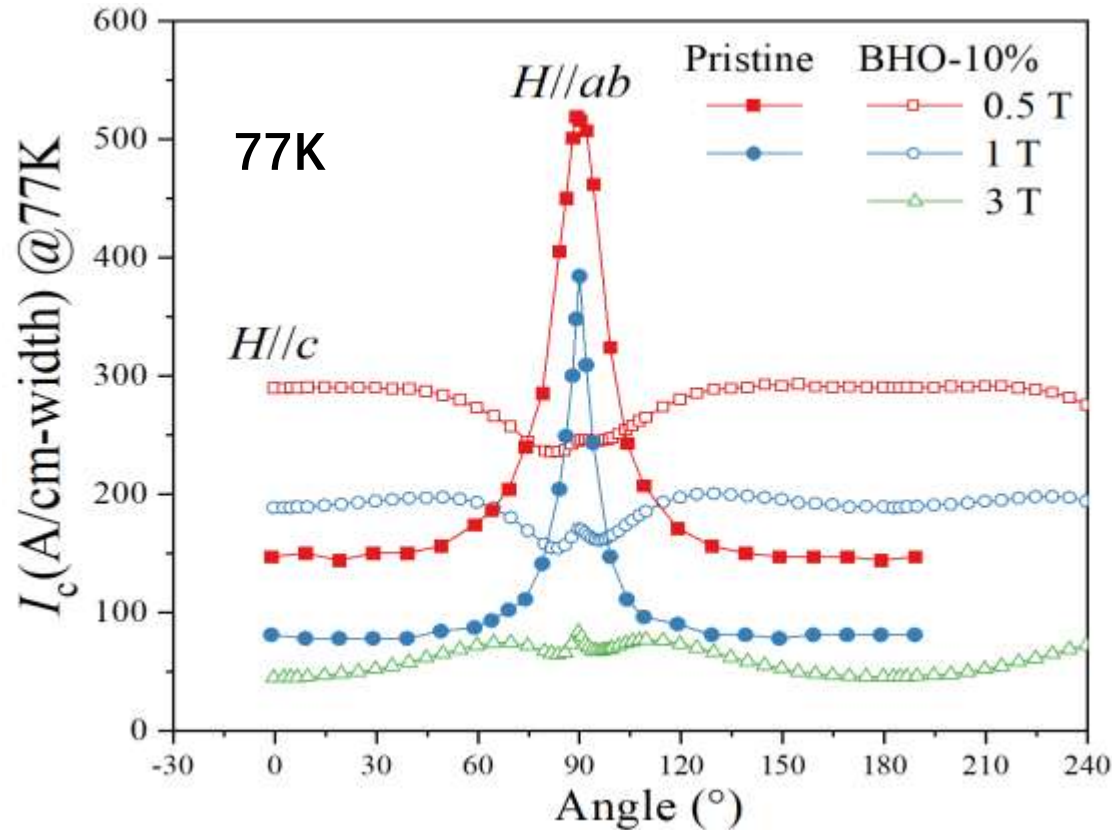
Anisotropic behavior with BMO additions



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- Measured by Robinson Research Institute, NZ



- ◆ Angular in-field I_c of BMO-added YBCO films at various high temperatures and low fields
- ◆ Competitive flux pinning effect between the intrinsic layers and the correlated 0D/3D pinning, both affected by effective vortex potential $U_{\text{eff}}(H, T)$
 - ◆ depending on the applied temperatures and magnetic fields

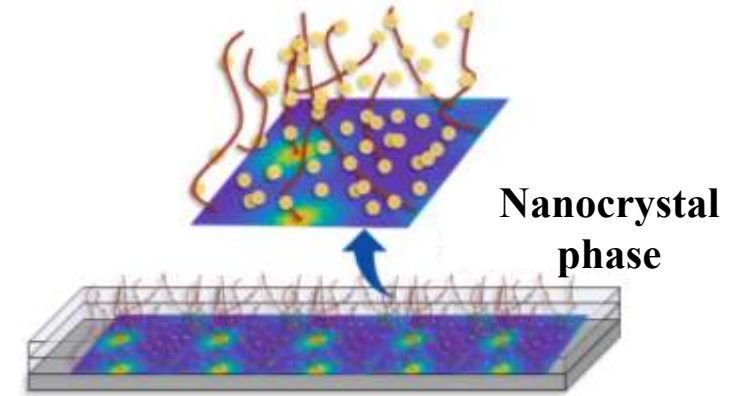
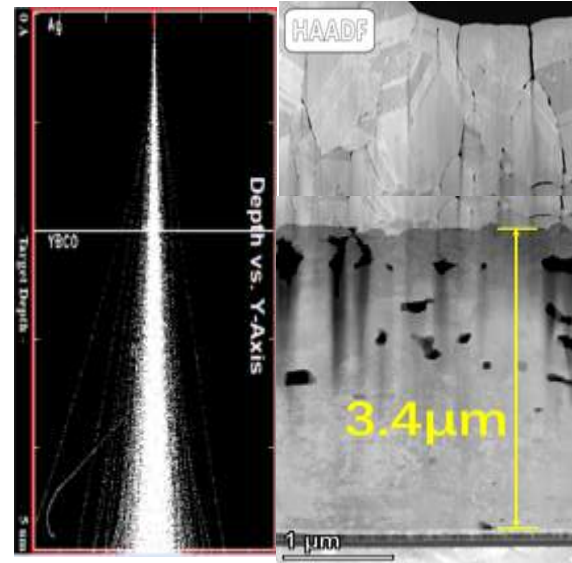
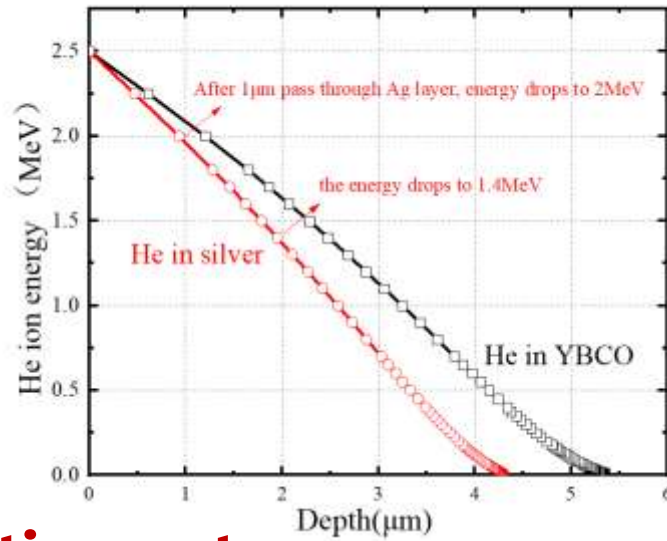
Experimental parameters



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SRIM Simulation:

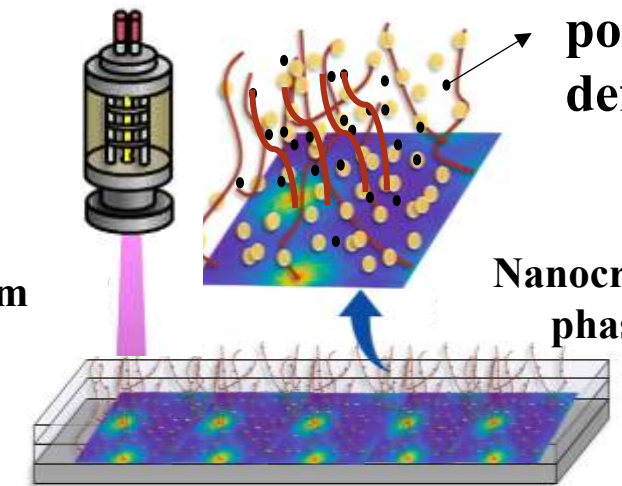


Ion Irradiation

Introducing point-like defects, etc.

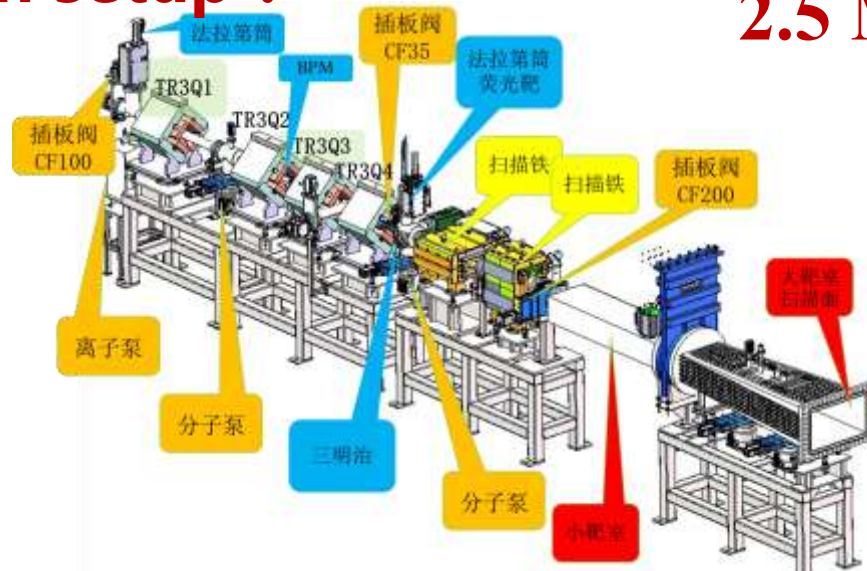
Ion beam

Nanocrystal phase



Irradiation setup :

2.5 MeV He

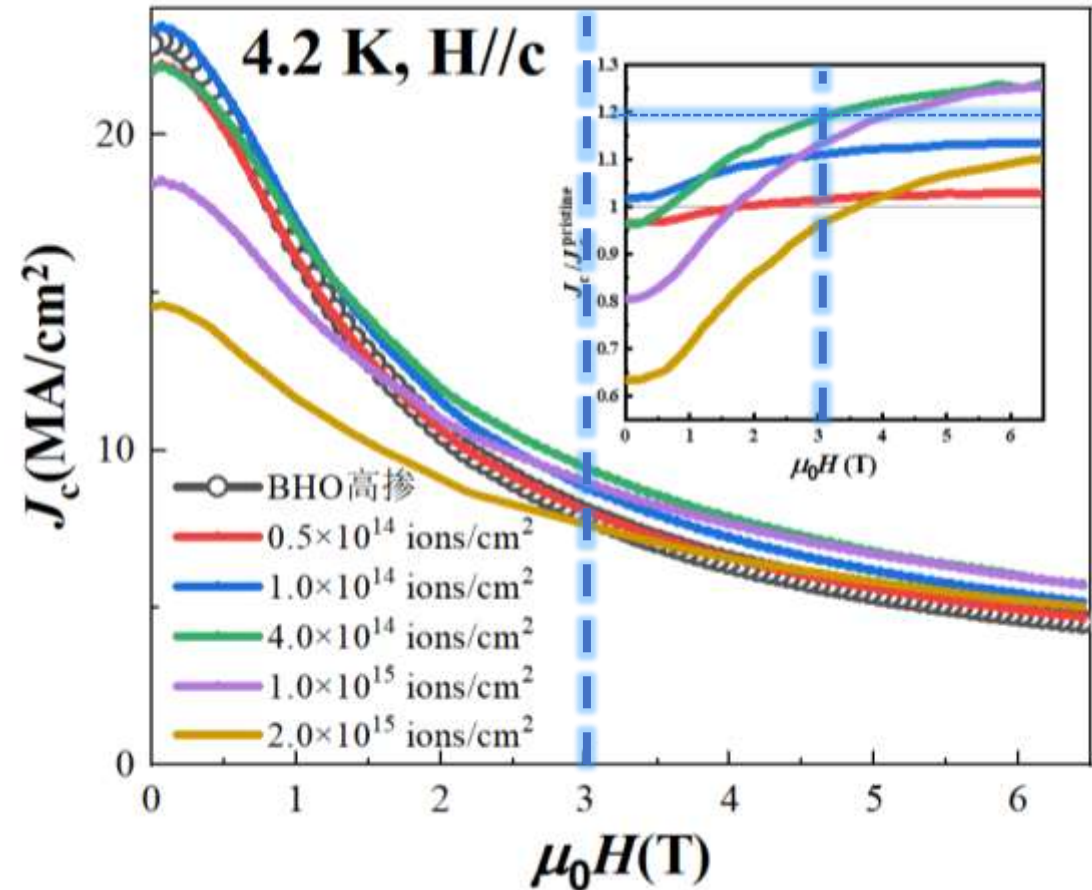
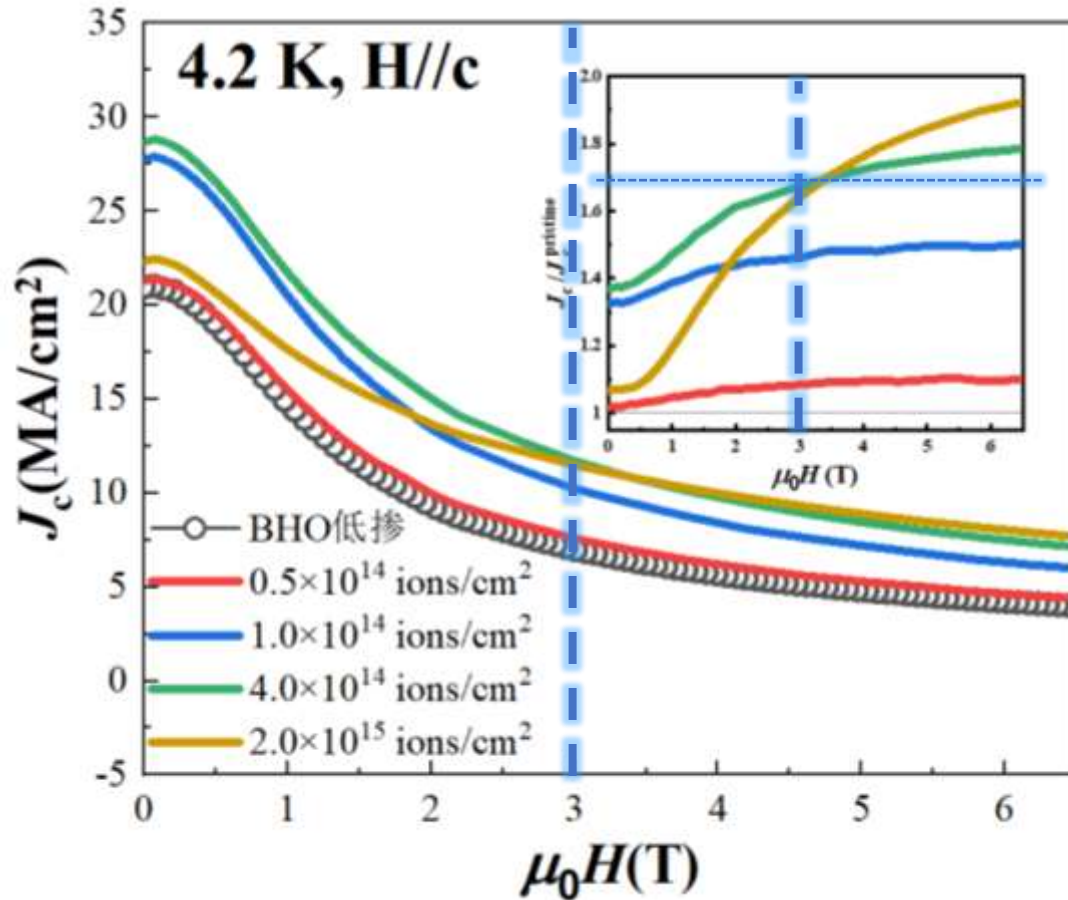


J_c Analysis of different-doped BHO-YBCO



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- At 4.2 K, 3 T, compared with the original sample, **He irradiation** can improve the J_c of **low-doped BHO-YBCO** by up to about **1.7 times**, while that of **high-doped BHO-YBCO** is only about **1.2 times**.

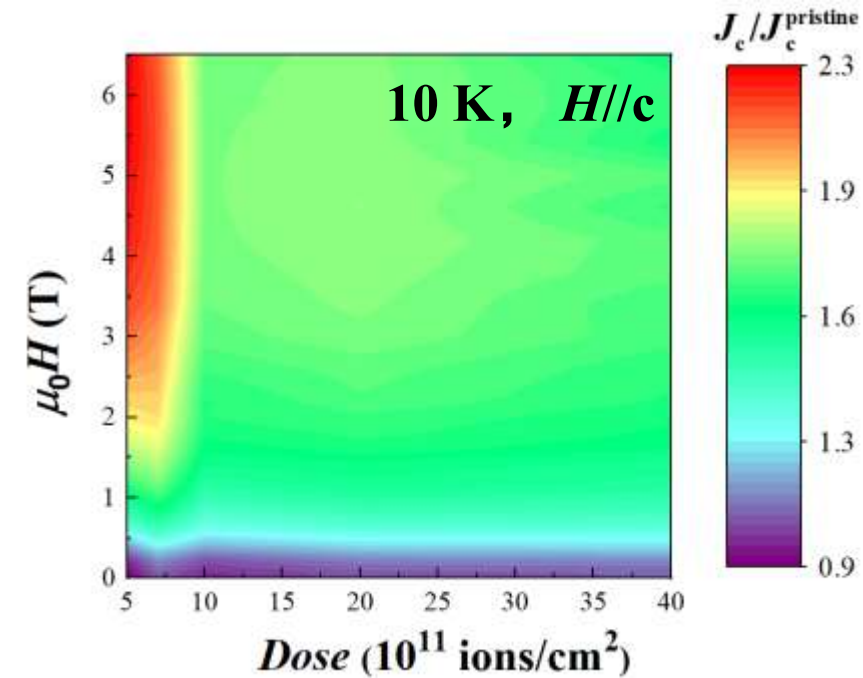
Other works: Ar ion VS He ion irradiation



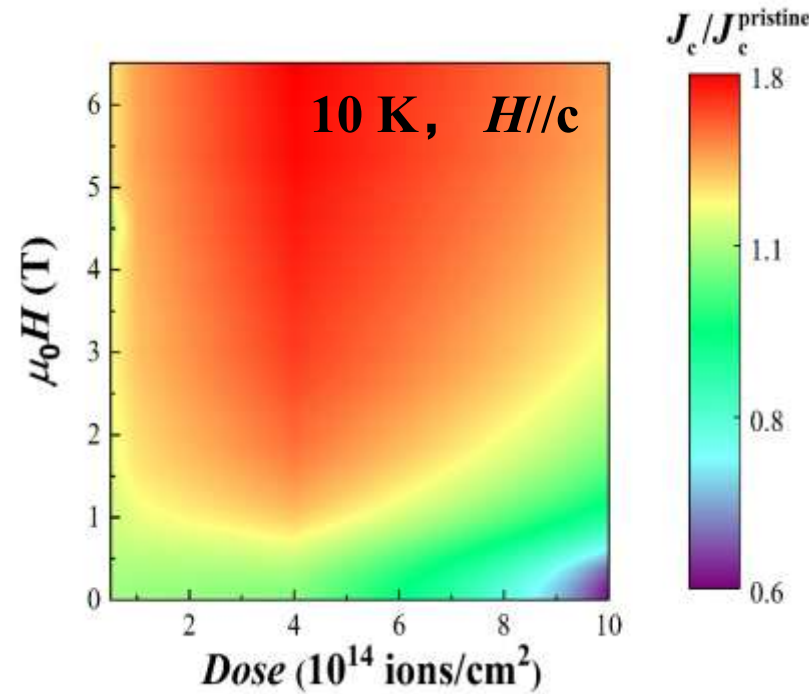
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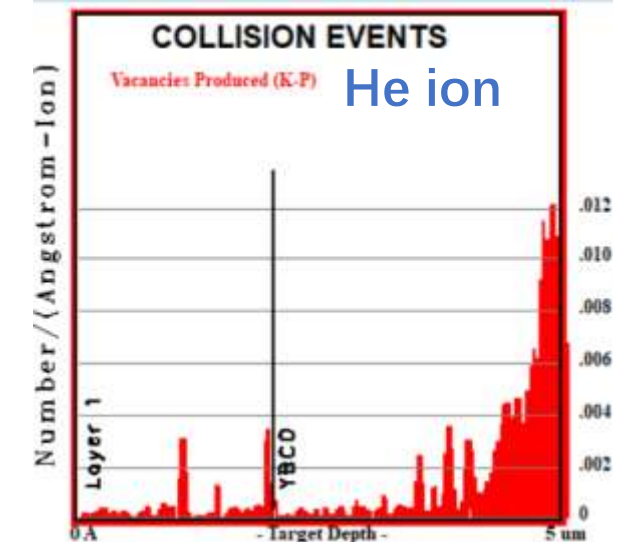
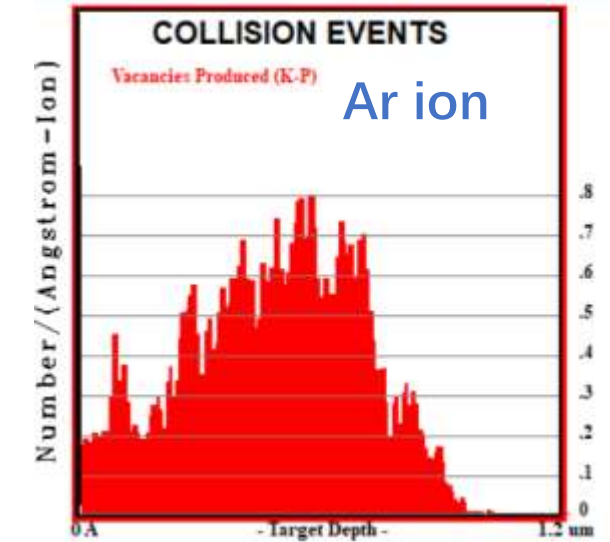
Ar ion irradiation



He ion irradiation



SRIM Simulation collision results :

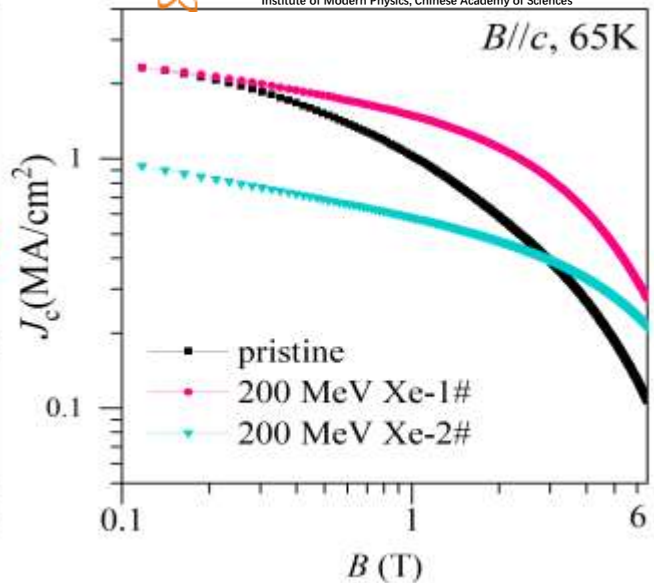
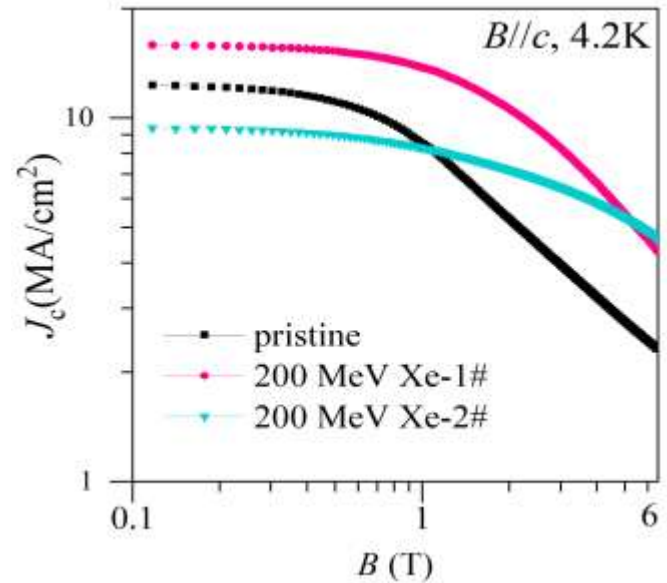
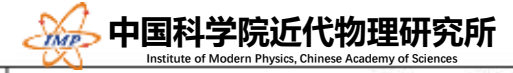
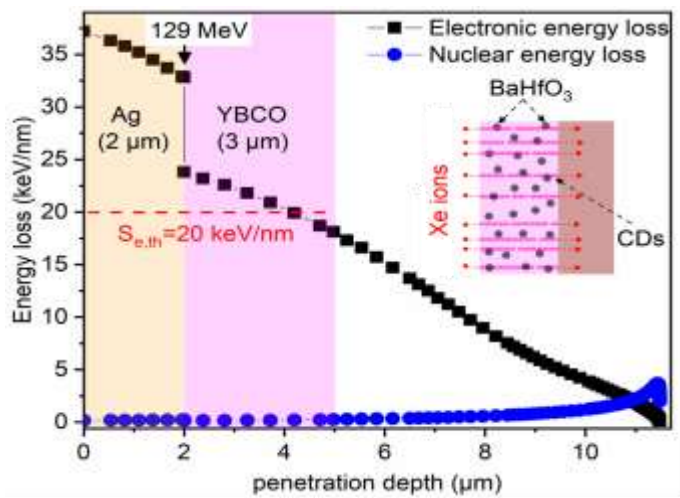
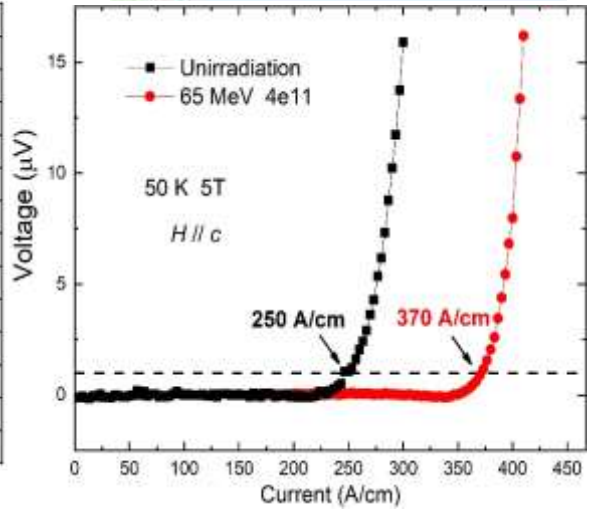
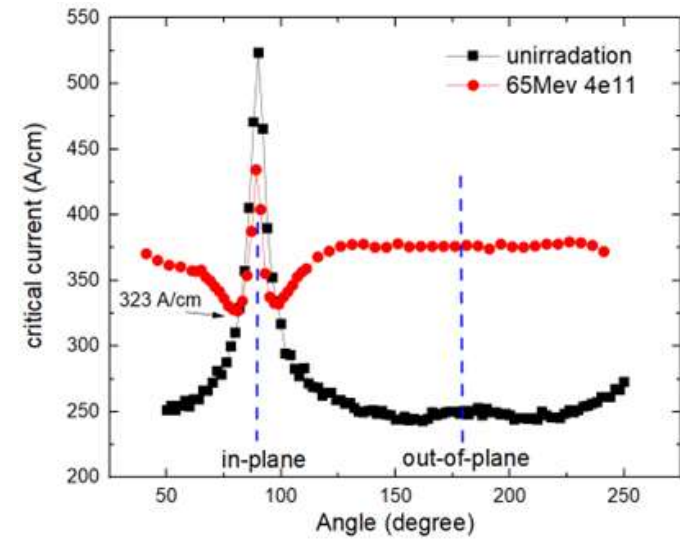
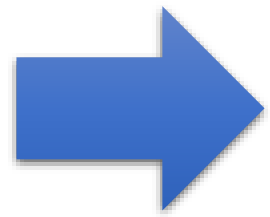
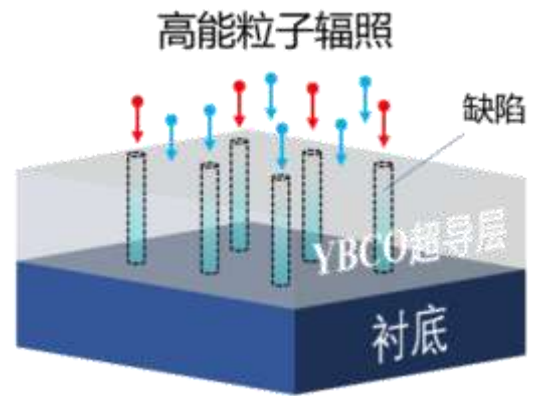


- ✓ Ar ion and He ion irradiation can significantly improve the in-field performance of YBCO at 10K ;
- ✓ The SRIM simulation collision results show that Ar ion irradiation produces more effective pinning centers than He ion irradiation.



Different energy irradiation effects of MOD REBCO

✓ Xe ion irradiation at different energies significantly improves the mid-temperature field performance of the MOD-REBCO.



Conclusion



- He ion irradiation can effectively improve the J_c of BHO-doped-YBCO tapes at low temperature and high field;
- At **4.2 K, 3 T**, compared with the original sample, He irradiation is **more effective** in improving the J_c of **low-doped** BHO-YBCO, about **1.7 times**, while **high-doped** BHO-YBCO is only about **1.2 times**;
- Under the same irradiation dose, the effective utilization rate of irradiation defects in high-doped BHO-YBCO is low (because BHO has occupied most of the pinning sites);
- Different ion irradiation (He, Ar, Xe) has different degrees of improvement on the in-field performance of REBCO tapes.



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Thanks a lot for your attention!



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