Phase structure and superconducting properties of RHQT Nb_3Al wires fabricated by static and dynamic rapid heating

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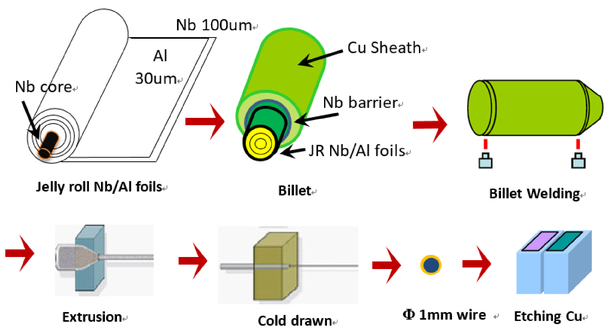
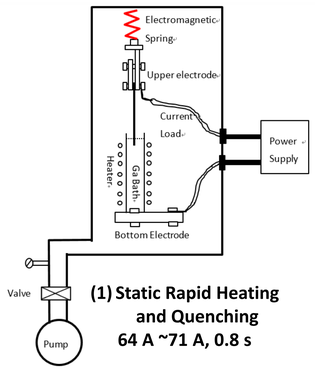
Introduction

- Nb_3Al prohibits higher T_c (18.9 K), higher B_{c2} (29.5 T@4.2 K) and better stress-strain tolerance than Nb_3Sn.
- Bronze process cannot fabricate Nb_3Al phase for non-superconducting of Nb-Al-Cu compounds, stoichiometric Nb_3Al can only be formed beyond 1900 ºC.
- Rapid heating, quenching and transformation (RHQT) process can fabricate stoichiometric Nb_3Al with fine grain size, exhibiting excellent J_c over whole magnetic fields.
- Right now, it is still lack of the comparison between phase structure and superconducting properties of RHQT Nb_3Al wires fabricated by static and dynamic rapid heating and quenching.

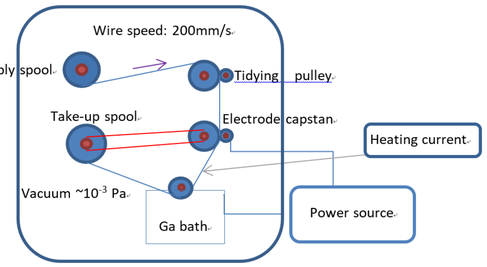
Single filament JR Nb_3Al



Rapid heating and quenching (RHQ)

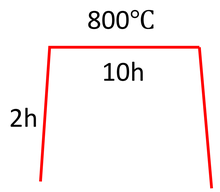


(1) Static Rapid Heating and Quenching
64 A ~71 A, 0.8 s



(2) Reel to reel Dynamic Rapid Heating and Quenching
120 A~124 A, 0.5 s

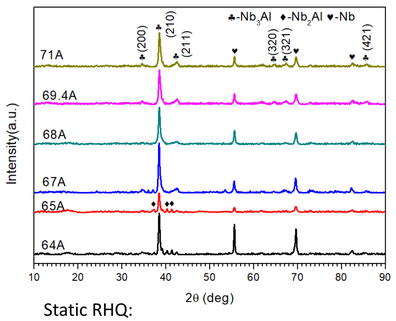
Transformation (T)



Characterization:

✓ XRD ✓ M-T ✓ M-H

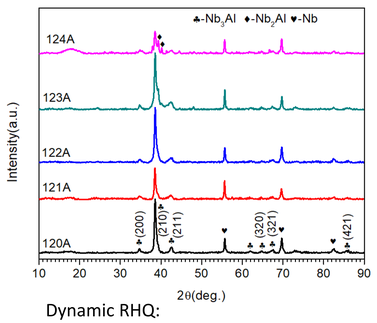
XRD of static and dynamic RHQT Nb_3Al wires



Static RHQ:

ϵ I_{RHQ} ≤65A, brittle, Nb_2Al+A15 after 800 ℃ 10h

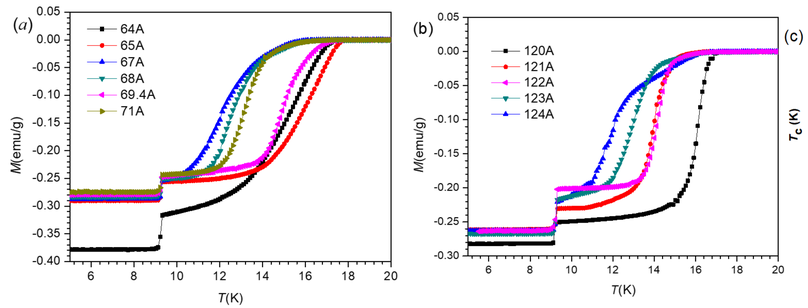
ϵ I_{RHQ} =67~71A, ductile, A15 after 800 ℃ 10h



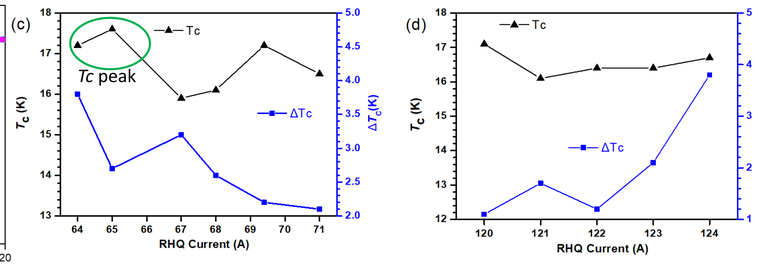
Dynamic RHQ:

ϵ All ductile, A15 after 800 ℃ 10h, but Nb_2Al+A15 for 124 A RHQT sample

M-T curves of RHQT Nb_3Al wires



Tc-onset and ΔTc of RHQT Nb_3Al wires



♠ Static RHQ

Tc peak: 65 A, 17.5 K;

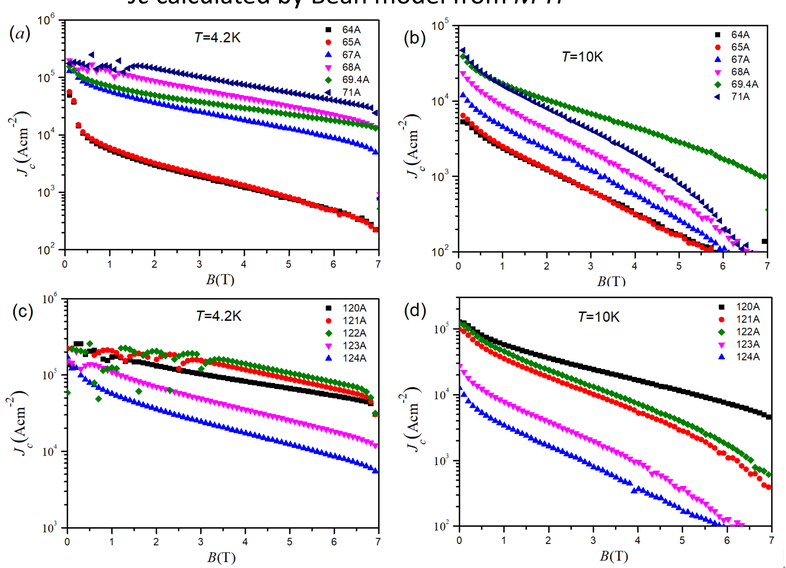
Smallest ΔTc: 71 A, 2.1 K

♠ Dynamic RHQ

Tc peak: 120 A, 17 K;

Smallest ΔTc: 120 A, 122A; both ~1.1 K

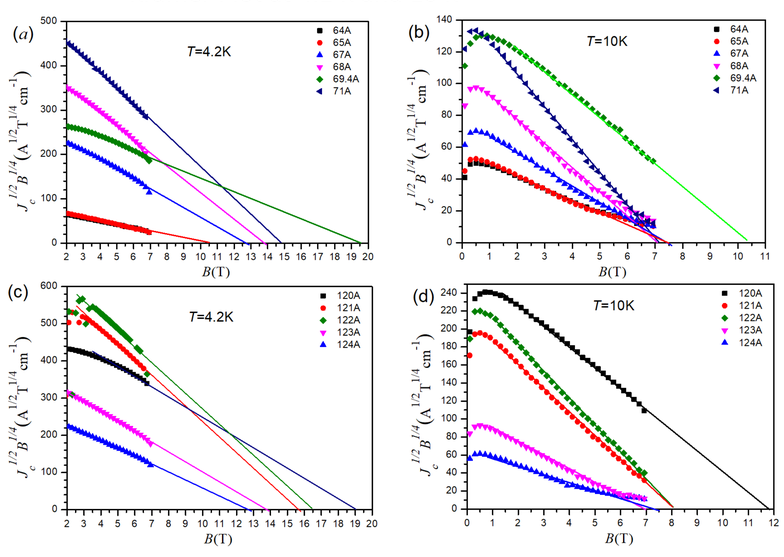
Jc calculated by Bean model from *M-H*



♠ Best *Jc*@4.2 K: static RHQ is 71 A; Dynamic RHQ is 122 A, 120 A~122A is *Jc* plateau

♠ Best *Jc*@10 K: static RHQ is 69.4 A; Dynamic RHQ is 122A.

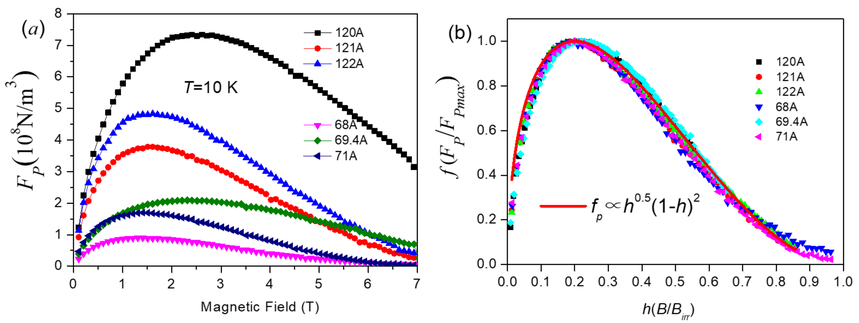
Kramer Plot at 4.2 K and 10 K



♠ Best *Birr*@4.2 K: static RHQ is 69.4 A, Dynamic RHQ is 120A

♠ Best *Birr*@10 K: static RHQ is 69.4 A, Dynamic RHQ is 120A

Fp and pinning mechanism



♠ best *Fp*@10 K in all Nb_3Al samples Dynamic RHQ: 120A

♠ Surface pinning mechanism: Grain boundary and Stacking faults

Conclusion

♠ Static RHQT Nb_3Al wires have wider ΔT_c (>2.1 K) than dynamic RHQT Nb_3Al (~1.1 K).

♠ At 4.2 K, 6.5 T, J_c range of dynamic RHQT Nb_3Al is 4.7~6.9×10^4A/cm^2, much narrower than the static RHQT samples of 1.8~3.4×10^4A/cm^2.

♠ Nb_2Al impurity phase formed when I_{RHQ} deviated from optimism condition: static RHQ of 64A~65A (lower I_{RHQ}) and dynamic RHQ of 124A (higher I_{RHQ}).

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