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Developing Nb_3Sn and Bi-2212 conductors for high field magnet applications

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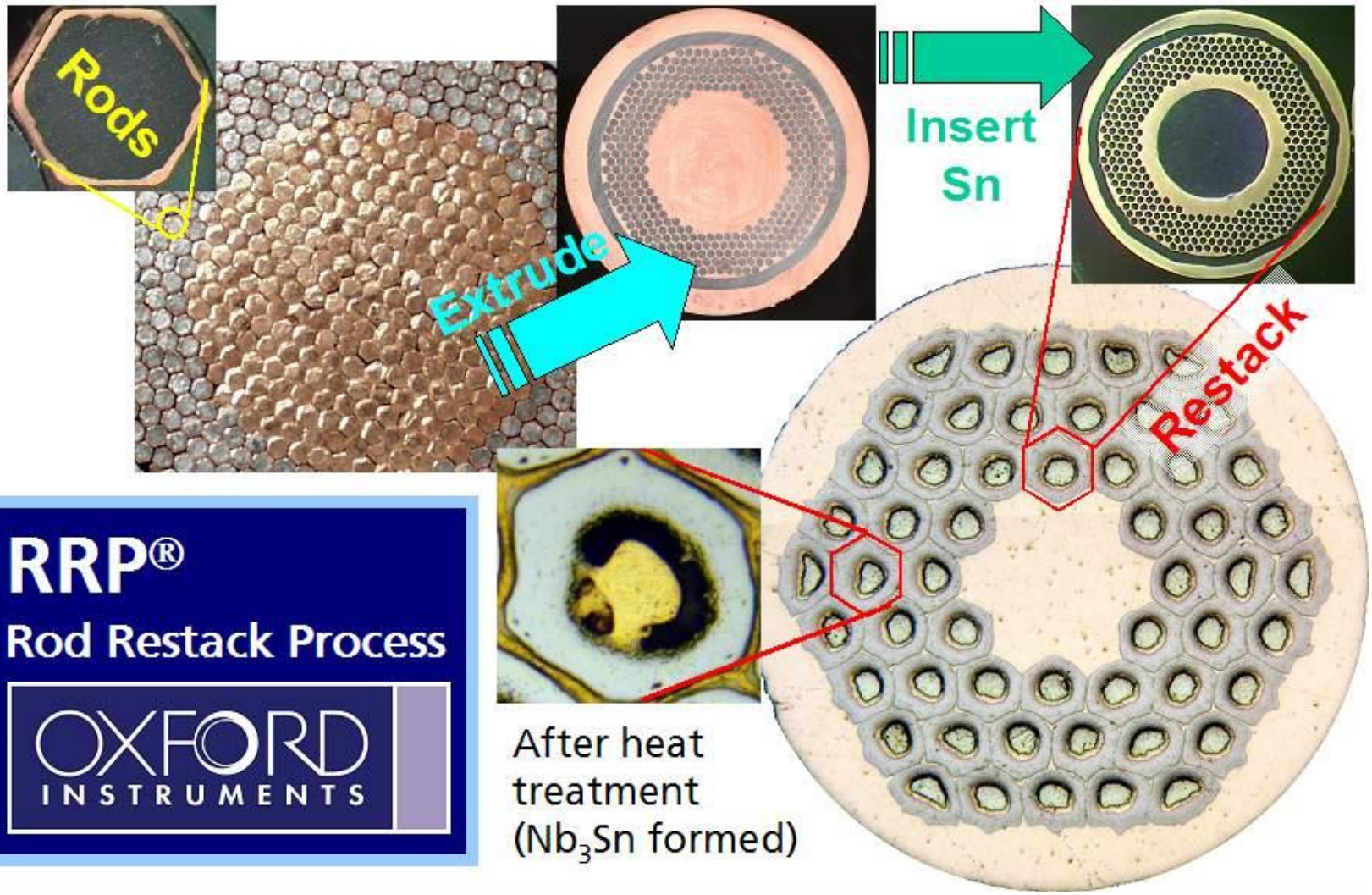
- ASC - Florida State University / NHMFL

- Thank you for your continued support

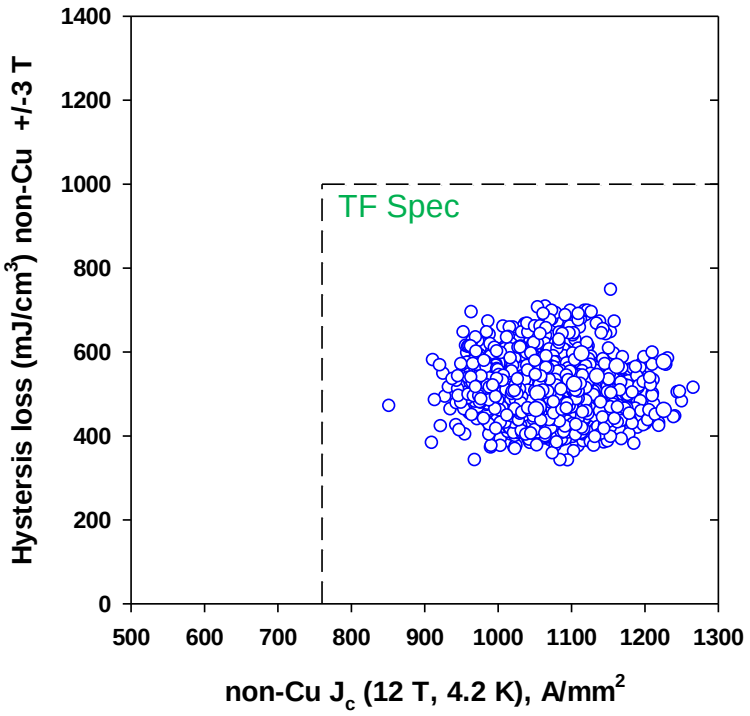
Outline

- Nb_3Sn
  - Proven, consistent, industrial process
  - Flexible process allows for tailored conductor designs for specific applications
    - Wide range of I_c and hysteresis loss properties are possible
    - Ongoing R&D to reduce the effective filament diameter
- Bi-2212
  - Unique material for high field applications
  - Performance improvements
  - Development horizon
- Conclusions

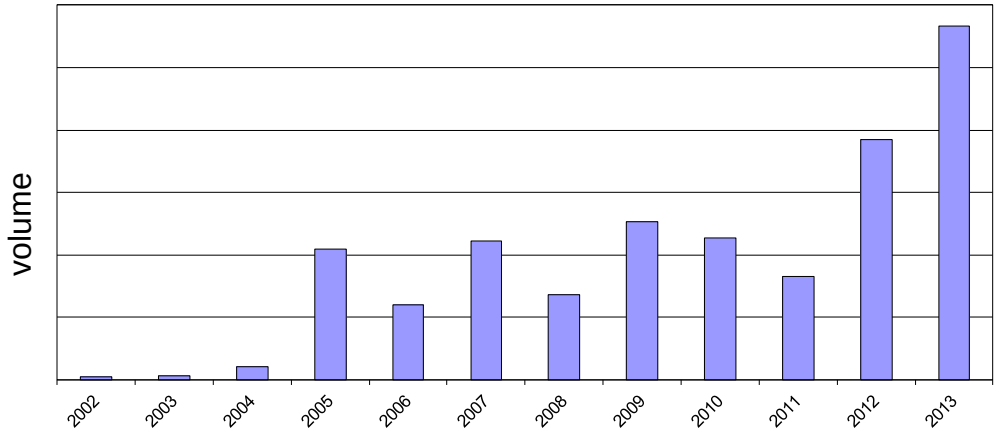
Internal Tin Process Flow



Internal Tin process is proven & reproducible



- Consistent properties during >60 tons of ITER production
- RRP® volume growing as the range of applications has grown



Internal Tin is a flexible process

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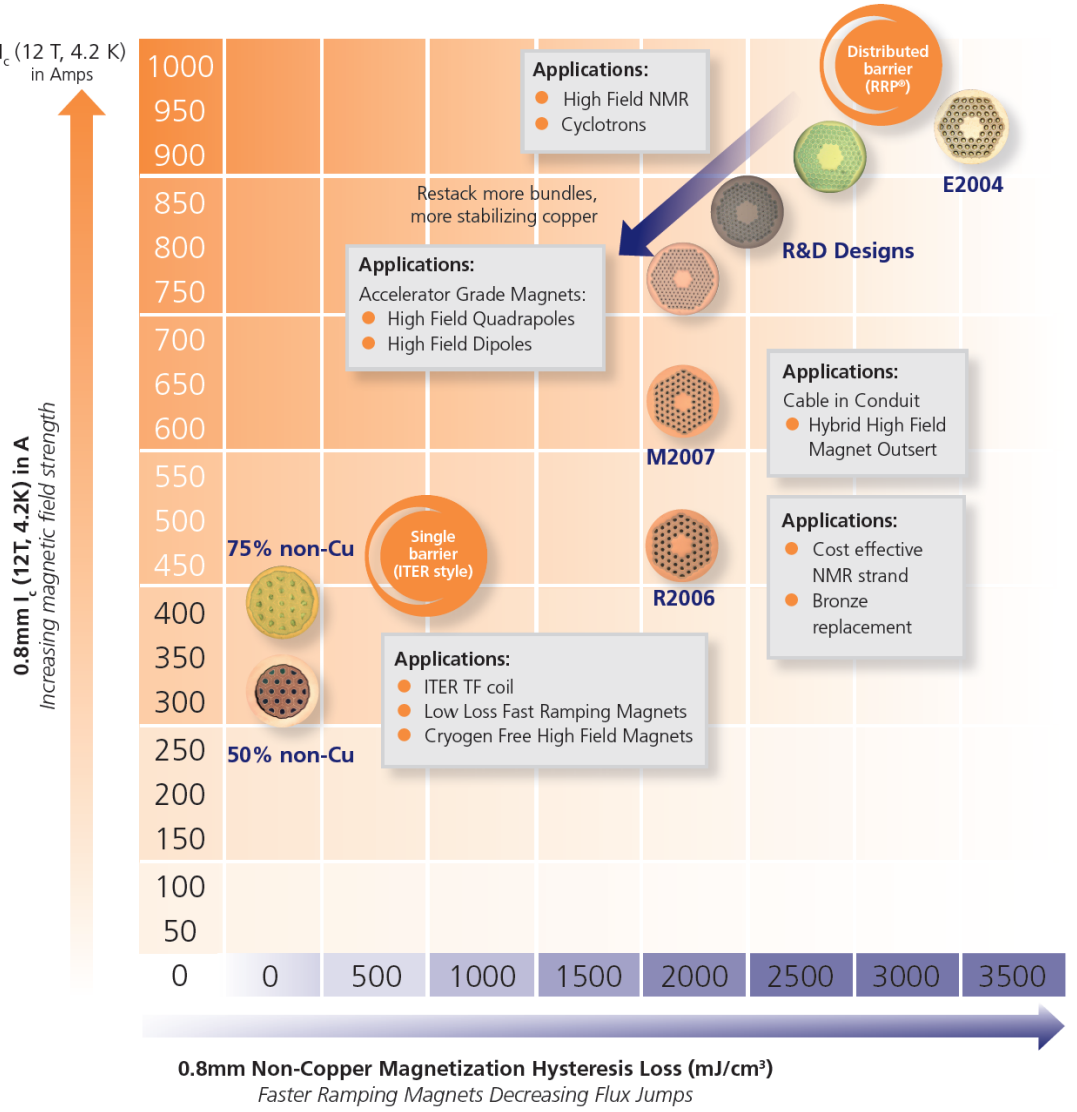
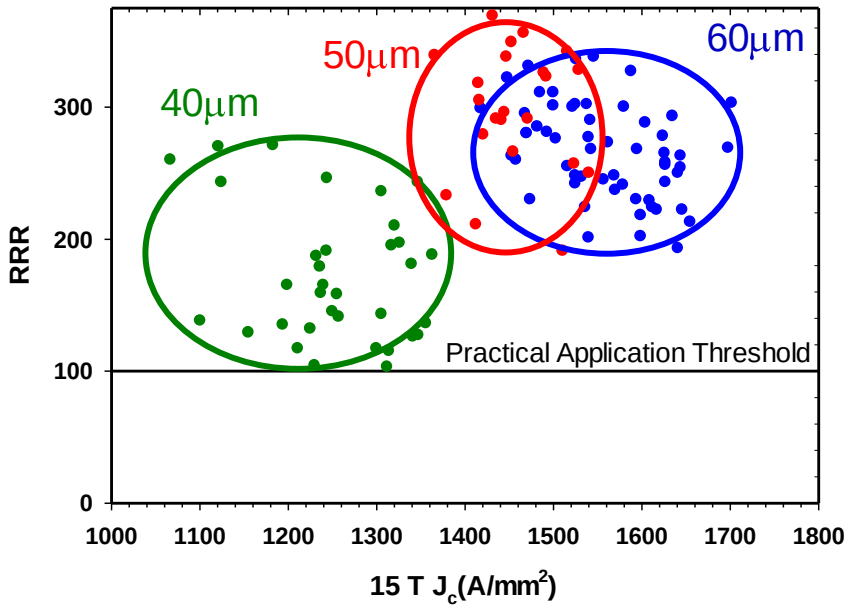
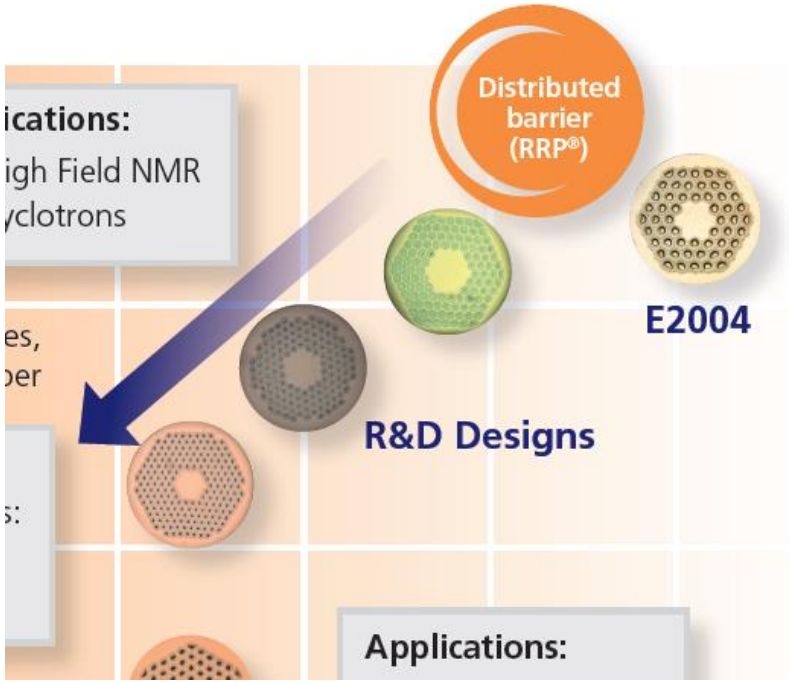
- Distributed barrier RRP® designs for highest field applications
  - highest possible critical current
  - D_{eff} can be adjusted for specific applications
- Single barrier designs for stable low field applications
  - No flux jumping
  - Minimum hysteresis losses

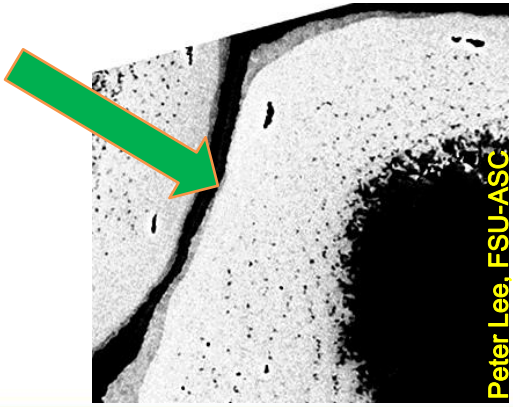


Reducing the effective filament diameter





- RRR reduced by tin reacting through the diffusion barrier



Beyond Nb_3Sn: Bi-2212 wire

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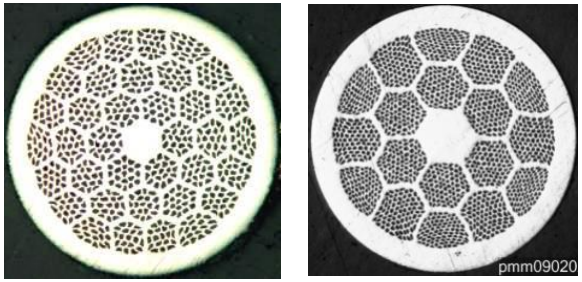
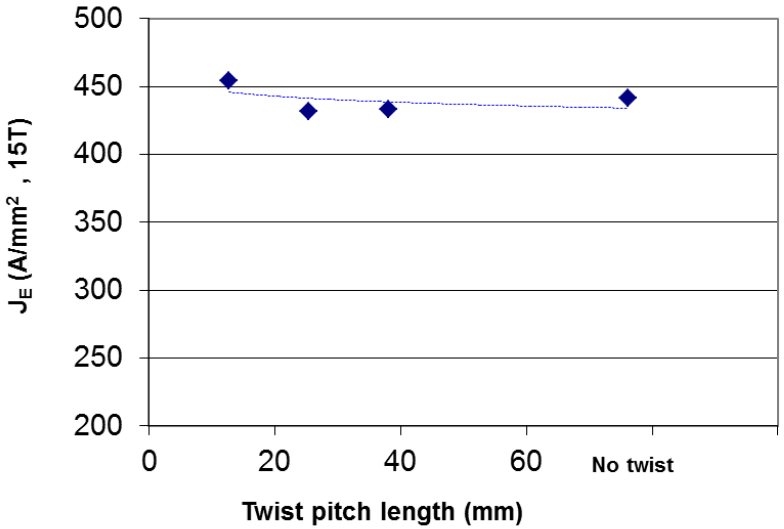
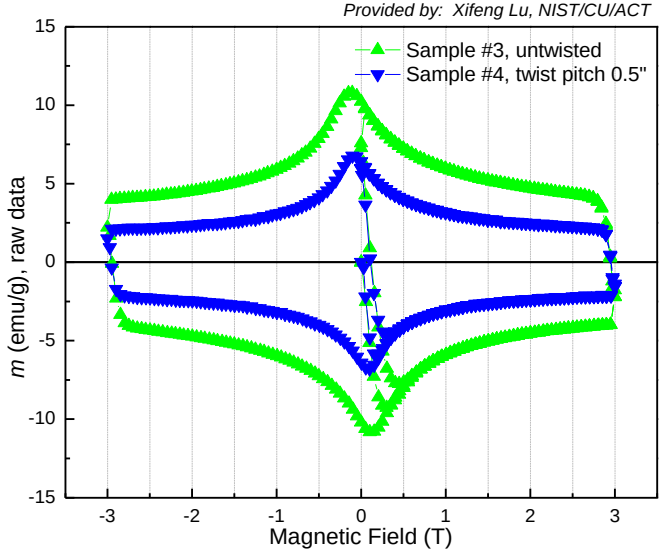
- Unique material for high field magnet application
  - Round wire with isotropic properties
  - High current under high field (> 18 T)
  - Easily twisted and cabled
    - No J_E degradation
    - Significant reduction in hysteresis losses





Provided by: Xifeng Lu, NIST/CU/ACT



Bi-2212 round wire J_E improvement

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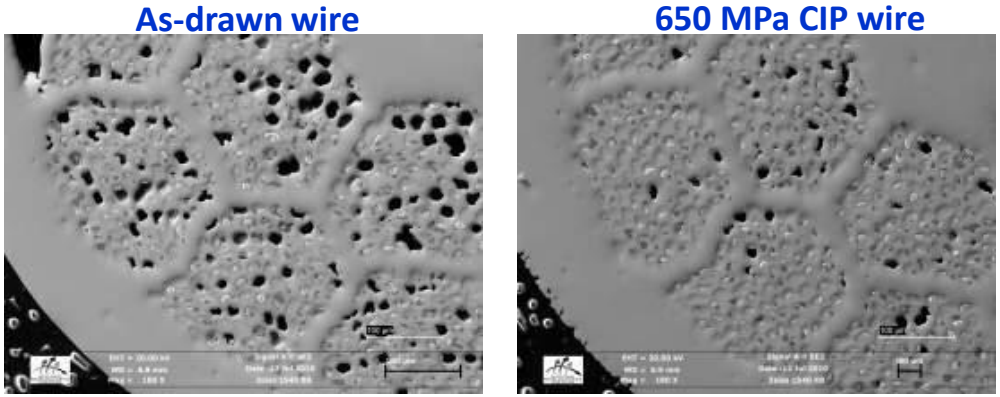
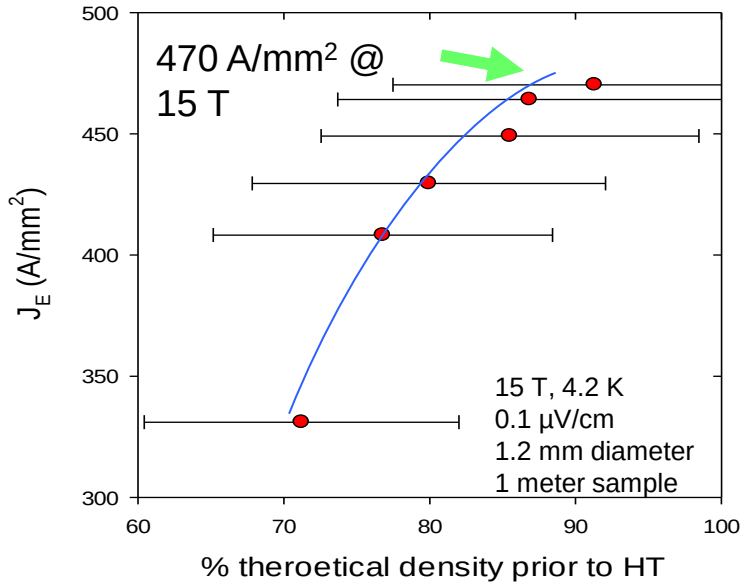
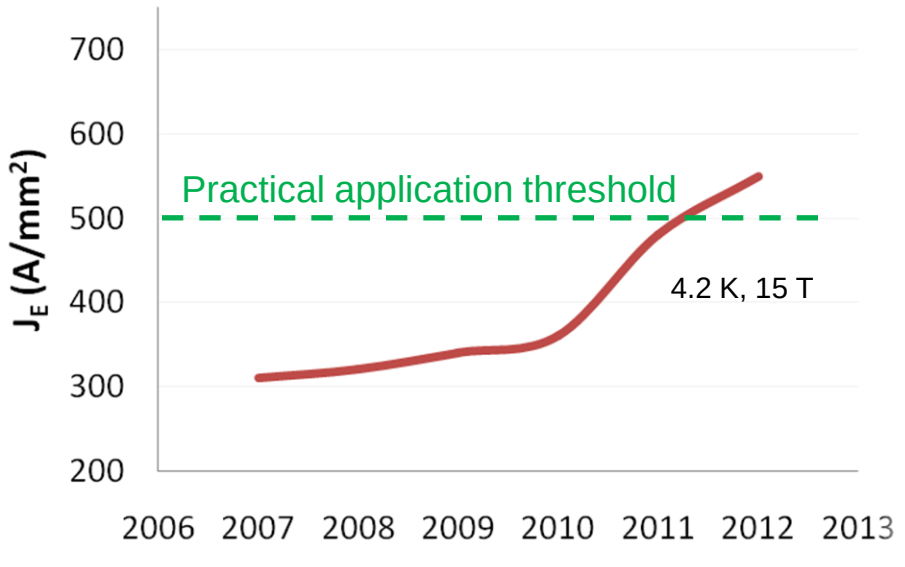
- Critical current density is determined by the filament density



Pictures courtesy of ASC/FSU





J_E value achieved by different CIPing densification

Bi-2212 wire: application ready

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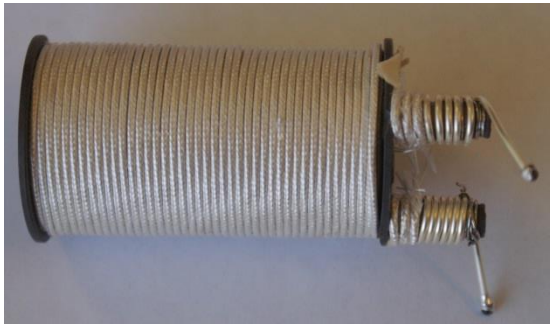
- Unique material for high field magnet application
  - Robust conductor resistant to damage from magnet quenching (Oxford Instruments experience shows >110 quench cycles)
  - Coils can be made using technology developed for Nb_3Sn
  - Ready for volume production using conventional wire drawing techniques and equipment



Bi-2212 round wire development horizon

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Property of importance	Delivered value today	In 2 years	In 5 years
Practical temp. range	4.2-20 K	4.2-20 K	4.2-20 K
Field range	20 -50 T	20 -50 T	20 -50 T
Conductor current density	J_E ~500 A/mm2 at 4.2 K 20 T	J_E ~700 A/mm2 at 4.2 K 20 T	J_E ~700 A/mm2 at 4.2 K 45 T
Conductor form and dimensional range	Round, > 0.5mm	Round, > 0.5mm	Round, > 0.5mm
Conductor length	200-1000 m	400-2000 m	> 3000 m
Conductor strength	110 MPa	150-200 MPa	> 200 MPa
Delivered selling price range $/kA.m, @4.2K&20T	330-550	200-400	100-150

- Performance gains from
  - Further densification
  - Improved powder properties
- Cost reduction simply from
  - Improved performance
  - Volume scale up

Conclusions

- Nb_3Sn via the proven internal tin process can be engineered to meet a wide range of applications
  - Continuous progress in reducing D_{eff} while keeping J_c and RRR high
- Bi-2212 is a unique high field conductor
  - Round wire
  - Practical applications are now possible due to critical current gains realized through densification

THANK YOU