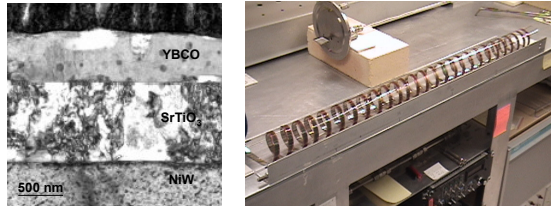


Sandia National Laboratories
Long length scale-up of all solution-deposited coated conductors

Paul G. Clem, Mike Siegal, Cynthia Edney, Don Overmyer
Sandia National Laboratories, Albuquerque, New Mexico, USA



all-solution deposited superconducting wire
SNL $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}/\text{SrTiO}_3/\text{NiW}$ tape

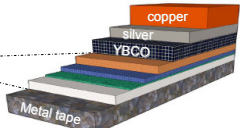
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin company, for the US DOE/NNSA, under contract DE-AC04-84AL80000

Relevance to DOE Programs

Transforming the Grid: Superconducting Cable G. Crabtree, ANL

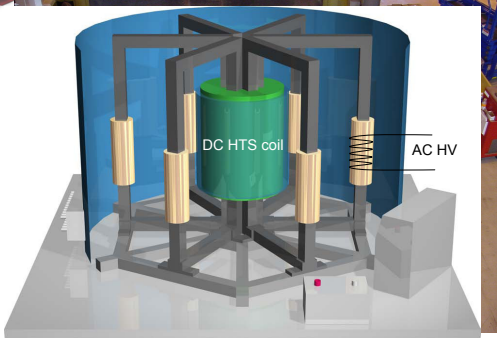
Lower manufacturing cost by factor 10-100

Simplify the architecture
find multifunctional buffer layers
Simplify the sequential deposition processes
Reduce the number of layers



cost (\$/KA-m) **SNL Goals:** Simple structure, All solution deposition, High manufacturing speed (10-90 meters/hr), Low wire cost 200 A/cm width 2G wire

Zenergy Power Fault Current Controller



Requirement: km's of low cost, DC 2G coated conductor
 $I_c \sim 200$ A/cm

FY08 Technical goals

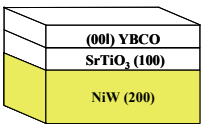
Transfer a high speed (30-90 m/hr) lab scale 2G coating process to commercial fabrication of multimeter lengths
Demonstrate continuous processing of buffer layers and YBCO
Develop a method for $1\mu\text{m}^+$, high speed YBCO processing

Introduce artificial pinning center method to high rate dip coated YBCO

Improve solution planarization for IBAD processing

SNL/Zenergy Power Coated Conductor Scale-Up

All-solution deposited coated conductor

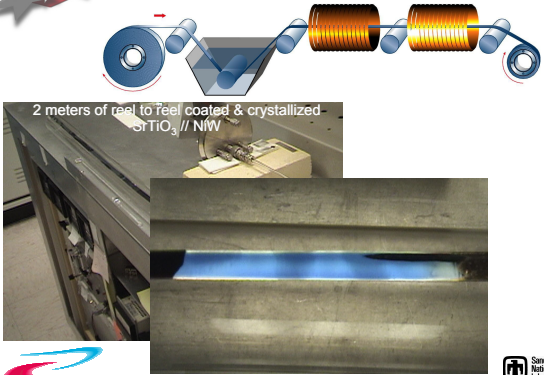


Process details:
Non-vacuum deposition
Dip coated buffer and YBCO
High production speeds (10-90 m/h)
YBCO pyrolysis ≤ 2 min
YBCO crystallization < 10 min
Ni-5%W alloy substrates

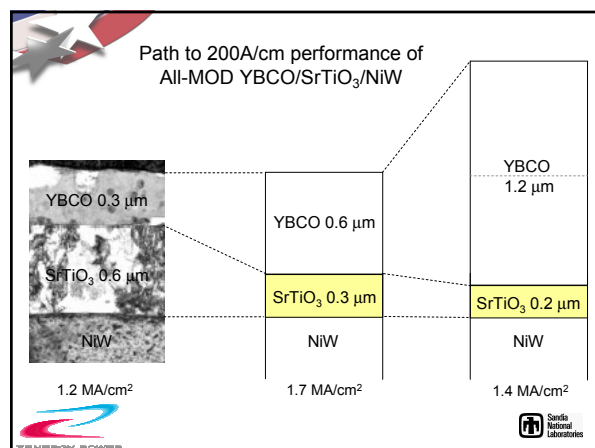
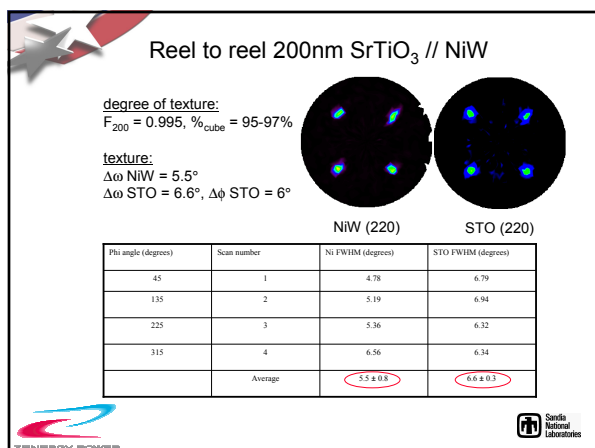
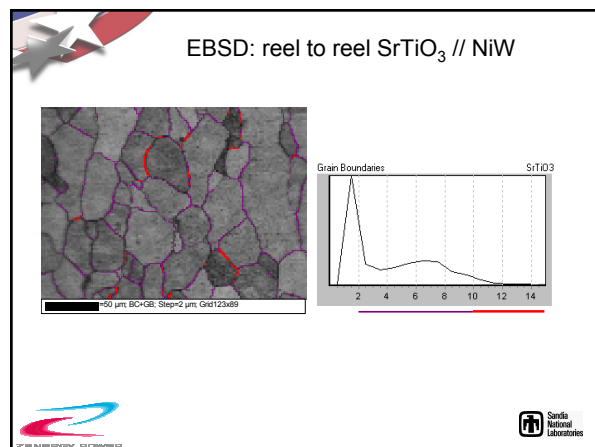
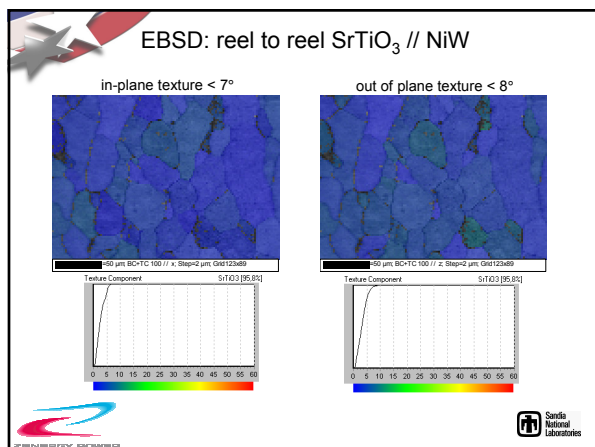
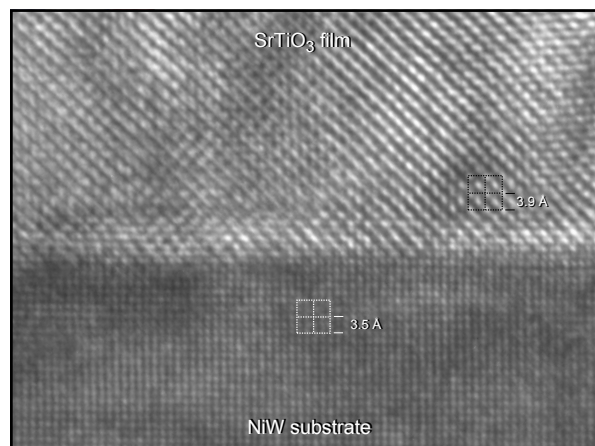
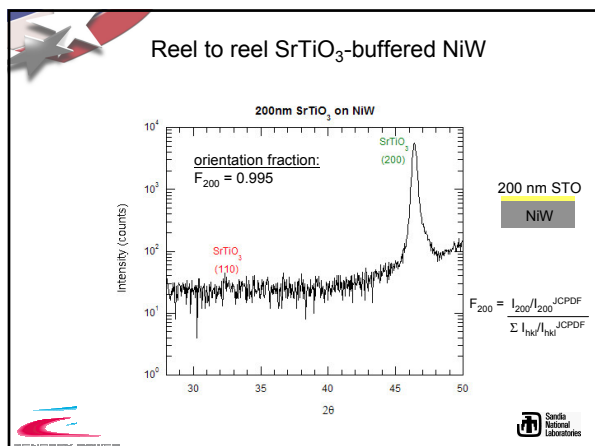
1 kilometer YBCO/STO/NiW reel to reel coater

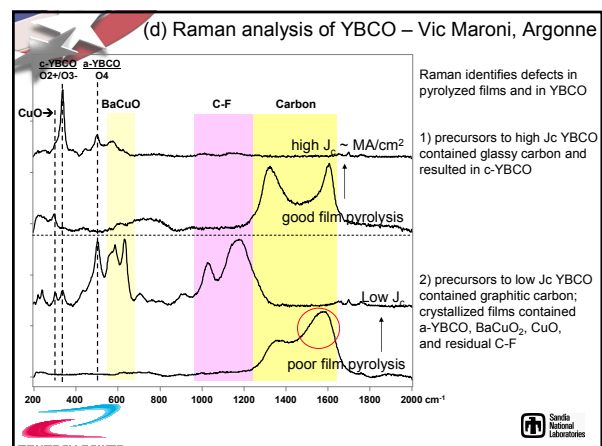
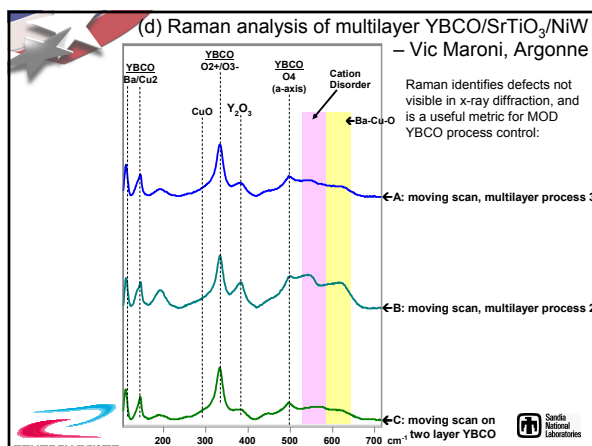
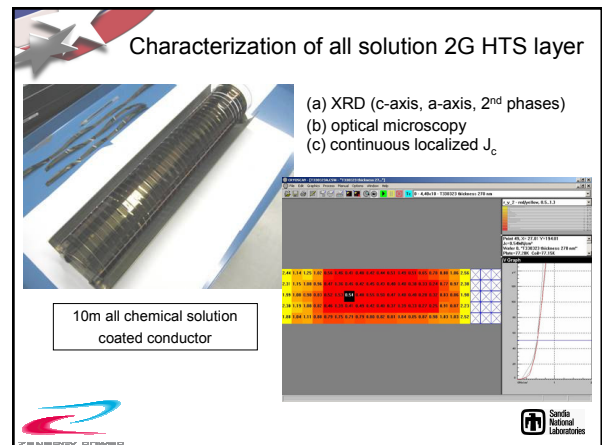
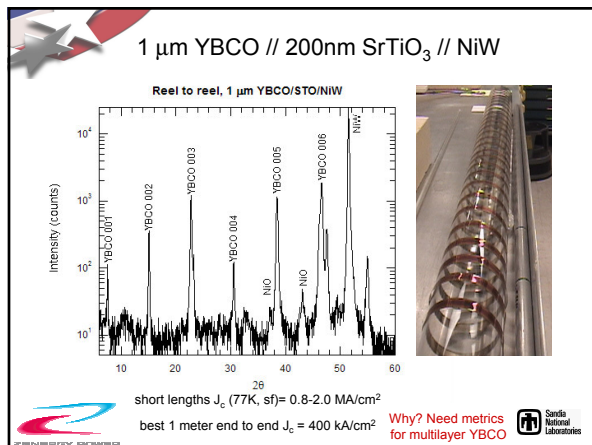
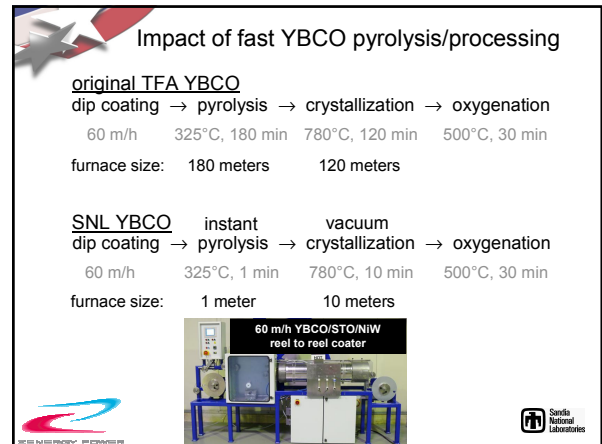
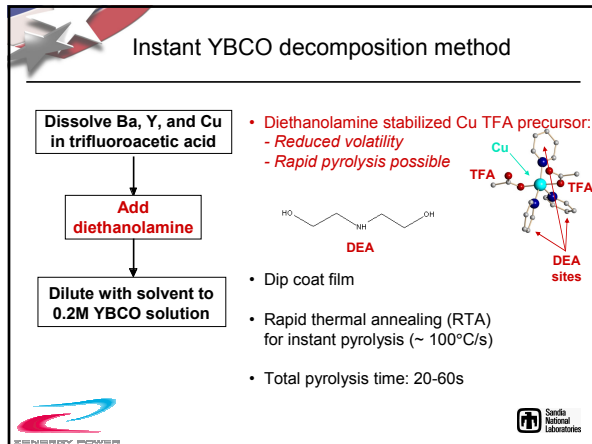
Lab scale-up equipment:
Installed at Sandia summer 2007
Coating at 10-90 m/hr
7/07 First demo of YBCO/STO/NiW
10/07 Transfer of processes to Zenergy
10/07-7/08 Continuous YBCO and STO processing at Zenergy; 30 days of on-site personnel exchange

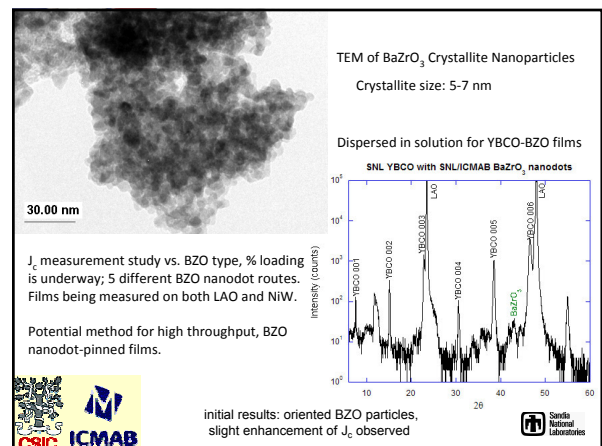
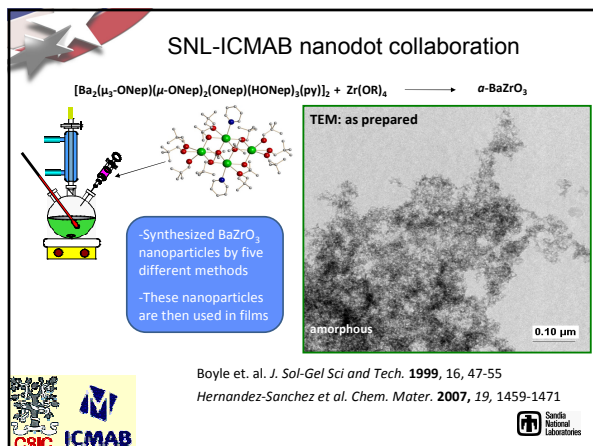
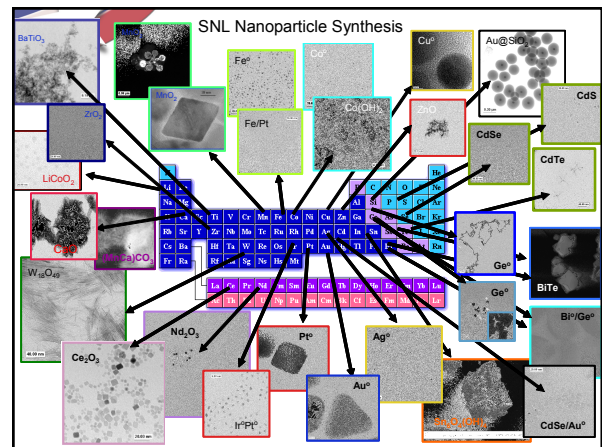
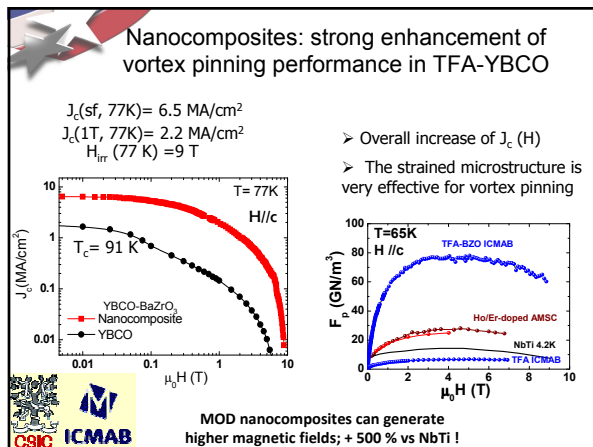
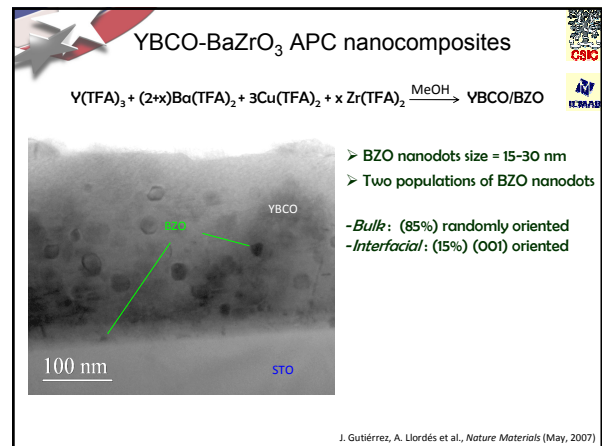
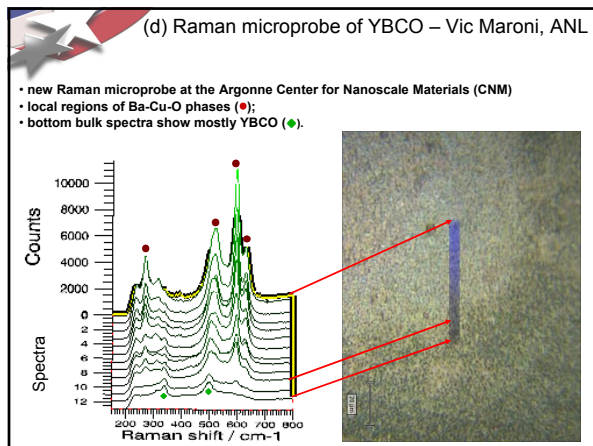
SNL/Zenergy Power Coated Conductor Scale-Up



2 meters of reel to reel coated & crystallized SrTiO_3 // NiW







FY 08 technical activities

- 1) All-solution coated conductor scale-up (SNL, Zenergy CRADA)
- 2) Fast reaction rate, multilayer YBCO scale-up (SNL, Zenergy CRADA)
- 3) Solution routes for pinning and IBAD substrate planarization

Project funding

Budget

DOE OE: Scale up of all-solution buffer/YBCO 300K
Zenergy Power CRADA funds-in 250K

Personnel

C. Edney, D. Overmyer: technicians (*full time*)
P. Clem, M. Siegal: co-PIs (*part time*)



FY08 Priorities and Plans

FY08 CPS Technical Milestone:

Reel to reel pyrolysis and crystallization of 1 MA/cm² YBCO and buffer layers
☒ Completion date: 7/1/2008

FY08 Plans:

Tier 1:

- ☒ Develop continuous reel to reel crystallization process for buffer layers
- ☒ Develop continuous crystallization furnace for YBCO
- ☐ Demonstrate 1 meter length, 150 A/cm, 30 m/h, reel-to-reel 2G process
10 meter lengths; 1.4 MA/cm², 30 m/h reel-to-reel continuous 2G process

Tier 2:

- ☒ Multilayer YBCO for 1-2 micron thickness films
- ☒ Correlate electron microscopy and Raman to understand J_c vs. substrate quality
- ☒ Write conclusion reports for SC Power Systems CRADA, evaluation of path forward
Negotiated 3rd year of CRADA
- ☒ Transfer low-shrinkage a-Y₂O₃ planarization coating method to LANL (≤ 4L → 1 nm RMS)



Research Integration and Tech Transfer

to Zenergy Power CRADA: ultralow cost 2G scale-up
1 km reel-to-reel equipment, substrates, project guidance
–Woody Gibson, Bert Nelson, Michael Backer

to Los Alamos National Laboratory: IBAD sol-gel planarization
multimeter a-Y₂O₃ planarization tech transfer to LANL
–Vlad Matias

with Institut de Ciència de Materials de Barcelona: BaZrO₃ pinning
nanoparticle flux pinning for solution precursors
–Susagna Ricart, Xavier Obradors, Fernando Martinez

with Argonne National Laboratory: Raman defect analysis
correlation of J_c with chemical & structural defects
–Vic Maroni, Dean Miller



FY09 Milestone and Plans

FY09 CPS Technical Milestone:

Reel to reel pyrolysis and crystallization of 150 A/cm high rate YBCO and buffer layers
☐ Completion date: 7/1/2009

FY09 Plans:

Tier 1:

Develop multilayer process for MA/cm², 30m/h YBCO deposition/decomposition
Decrease Δθ of reel-to-reel 2G process buffer layers to < 6°

Tier 2:

Incorporate pinning nanoparticles into high rate YBCO processing, measure pinning forces
Write conclusion reports for Zenergy CRADA, evaluation of path forward

Decrease roughness of a-Y₂O₃ LANL 2L planarization coatings method to ≤ 5 nm RMS)



Summary

YBCO (001)	3.82 Å
SrTiO ₃ (100)	3.91 Å
NiW (200)	3.52 Å

- 1) Sandia research: thicker (1-2 μm) fast reaction rate YBCO, commercial scale-up of all-solution YBCO/SrTiO₃/NiW
- 2) Scaled-up to continuous 10m lengths with Zenergy in 2008

FY08 DOE OE funding \$300K

Other research collaborations:

- a) Argonne: Raman analysis of YBCO/STO/NiW
- b) ICMAB: High throughput nanoparticle integration
- c) LANL: IBAD substrate planarization layers with LANL

