Project Title:	AC Loss Studies in Coated Conductors
Organization(s):	**Los Alamos National Laboratory**
Presenters:	Steve Ashworth
FY 2004 Funding:	$300 K

Project Purpose and Objectives FY2004: This project had the objective to study aspects of the ac losses of BSCCO tapes and YBCO coated conductors. Specifically, we aimed to;

1) Measure ac losses in state of the art BSCCO 2223 tapes in the 20-40K temperature regime.
2) Assemble predictive equations for the losses in this temperature range to aid in machine design.
3) Determine conductor temperature rises for BSCCO 2223 tapes in the 20 - 40K temperature regime exposed to large fluctuations in applied field when carrying dc currents (ie 1T increase in 1second).
4) Measurement of losses on coated conductor samples with ac transport currents and ac magnetic fields. The aim being data generation for prospective design studies.
5) Measurement of losses with fields at various angles to the conductor, with the aim of determining the effect of ab plane and c- axis 'peaks' in IC.
6) Measurement of the effect of conductor interaction (stacks, arrays) on ac losses.
7) Low loss coated conductor studies
8) Study cryo-stabilization of coated conductors under ac conditions

FY2004 Performance and FY2005 Plans: A high quality (Ic>100A/cm width)1 cm wide coated conductor sample has losses of order 1W/m at 60Hz in a 30mT perpendicular ac field. This needs to be reduced by 2 – 3 orders of magnitude for widespread use in power applications.

We consider this to be the most pressing problem in ac losses in HTS.

This year's effort has been concentrated on measuring, understanding and working to reduce the ac losses in coated conductor as required by some of our stated objectives from last year. Effort on BSCCO-2223 has been reduced in favor of work on this problem, the rationale being that techniques for the reduction of coated conductor losses need to be implemented, or at least shown possible, if the development of coated conductor for power applications is not to be called into question. All other problems were considered to be subsidiary to this.

We consider that progress has been made on this problem, if initially in a negative sense by demonstrating that the simple route of cutting filaments or striations into the conductor will not work without also imposing transposition of the resulting filaments. We have also though made some progress in developing novel conductor architectures which may result in lower losses.

In 2005 we plan to continue the quest for a low ac loss coated conductor. We will

- Further developing novel architectures, with significantly more integration with the LANL coater conductor effort.
- Introducing a modeling capability into the US to further our understanding of the magnetic field behavior in the conductors.
- Work with US industrial partners to provide data on their conductor samples.
- Make the results of our own innovation available to those partners.

A specific, measurable and highly challenging objective will be to develop a conductor design;

1) with ac losses in perpendicular ac magnetic field an order of magnitude lower than the 'bare' 1cm wide conductor
2) with reduction in dc critical current of less than 10% from the 'bare' conductor

3) in principle manufacturable by a continuous process.

FY2004 Results: In measurements we;

- Reduced the complexity of making calorimetric measurements of losses due to combined fields and currents, doing away with the need for hand assembled thermocouples and thermal insulation.

  This reduced the time required to change samples from about 1 day to less than an hour. This was achieved by replacing the styrofoam and silicone sealant previously used to thermally insulate the sample with an alcohol (IPA) bath. This is frozen in place in the cryostat and acts as the required thermal insulation. After use the alcohol is simply allowed to evaporate and the sample is recovered. This also allows us to make measurements on complex surfaces (cables or coils) which were previously difficult to measure.

- Introduced a system for measurement of magnetic losses which 'captures' all the signal in cases where the field is applied perpendicular to the conductor. Most workers in the field do not do this.

  This entailed utilizing a map of the magnetic field around a conductor sample to build magnetic pick up coils encompassing all the 'lossy' field. Analysis if the derived data then required an understanding of how ac magnetic fields act to require voltages from power supplies.

- Showed that cutting 'striations' into coated conductors does not in fact reduce the ac losses as many workers are assuming, this is an artifact of measuring on small samples.

  Understanding this is essential to focus effort where needed in reducing losses in coated conductors.

- Introduced a system for continuous measurement of losses on long (meter) length samples, for comparison with dc position sensitive critical current measurements.

In working to reduce losses we;

- Measured striated / patterned samples from collaborators or produced at LANL, measuring losses due to simultaneous fields and currents. This is not routinely done at any other laboratory in the US and only two other labs worldwide have this capability.
- Investigated a number of novel adaptations (ie other than 'striations') of the coated conductor to reduce losses. Some of these did indeed reduce the losses, but not by anywhere near enough and with other penalties (eg making the conductor difficult/impossible to wind).
- Made measurements on the interaction of 'windings' of coated conductor.
- Conceived and made first measurements on a novel conductor design based on striations which does have the potential for lower loss – without twisting or transposition.

Research Integration: In the past year we have made extensive measurements on patterned coated conductor samples from IGC-Superpower as part of an ongoing CRADA. We have also begun working with USAF and Long Electromagnetics on low loss conductors for Air Force applications and have a DARPA funded project (including American Superconductor) on low loss conductors.