SBIR: Designing New Economical and Scalable High-Performance Aluminum alloys for Overhead Electric Transmission Conductors

DE-SC0015323
NanoAl LLC/General Cable Corp.
4/10/2017-12/31/2019

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U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 12, 2019

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Overview

Project Title: Designing new economical and scalable high-performance aluminum alloys for overhead electric transmission conductors

Timeline:

Project Start Date: 06/01/2017

Budget Period End Date: 12/31/2019

Project End Date: 12/31/2019

Barriers and Challenges:

- Energy loss due to resistance of conductors in transmission and distribution systems is ~$20B per year in the U.S.
- Commercial aluminum overhead conductors have a trade-off between strength and electrical conductivity
- Most available technologies are not economical and scalable
- For market mass adoption, a new solution must be low-cost, compatible to current manufacturing, and easy to implement

AMO MYPP Connection:

- Advanced Materials Manufacturing

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$976,787	$0	$976,787	0%
Approved Budget (BP-1&2)	$976,787	$0	$976,787	0%
Costs as of 3/31/19	$644,949	$0	$644,949	0%

Project Team and Roles:

NanoAl LLC

- Dr. Nhon Vo (PI)
- Francisco Flores (alloy development)

General Cable Corp.

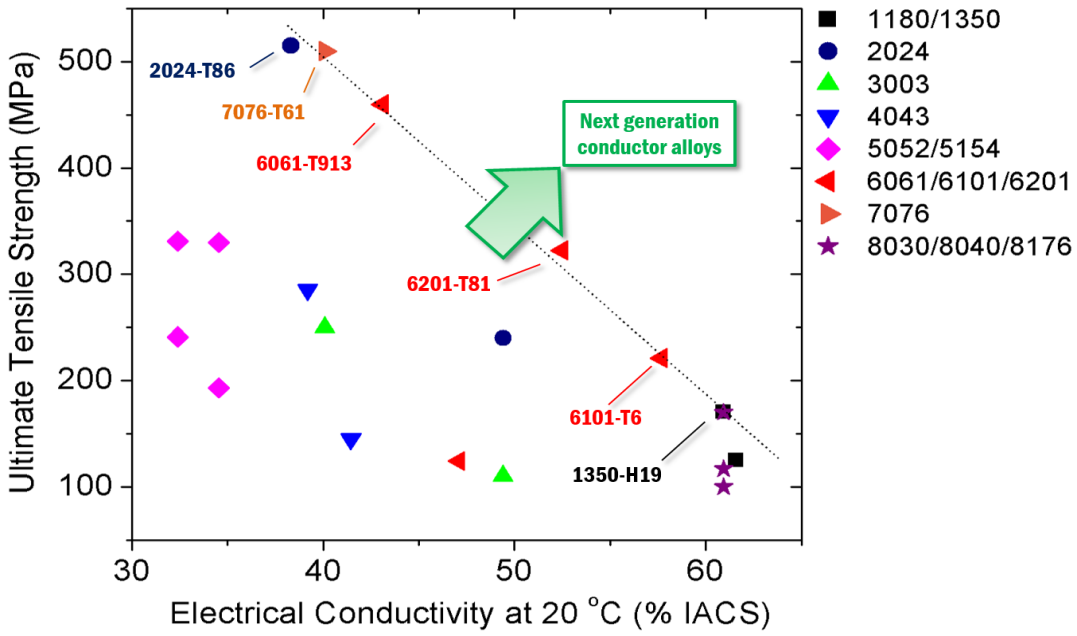
- Dr. Shenjia Zhang (conductor development)
- Janusz Sekunda (conductor manufacturing)

Project Objectives

- Energy loss due to resistance of conductors in transmission/distribution systems amounts ~$20B per year for U.S. economy.
- There is a significant incentive to improve efficiency in electrical energy transmission/distribution. High-performance conductors play a key role.
- **Objective**: Applying nanotechnology to improve both strength/conductivity of commercial aluminum overhead conductors.
- **Target**: Increase 30-50% strength for the same conductivity, or increase 20-30% conductivity for the same strength.
- **Benefits**: (i) increase efficiency in transmission (ii) reduce energy loss, (iii) supply power to more homes and businesses, (iv) reduce tower construction cost, (v) reduce CO_2 emissions and other greenhouse gases at fossil fuel power plants.
- **Difficulties**: Most technologies are expensive and not scalable. Aluminum overhead conductor market is sensitive to cost and significant changes in infrastructure.

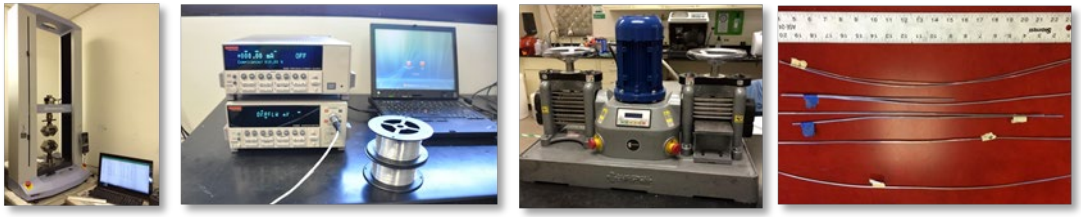
Technical Innovation

- Commercial aluminum alloys (AA1350 and AA6201/6101) are currently used for overhead conductors with trade-off between strength and electrical conductivity.
- Applying NanoAl's technology to design a new class of low-cost and scalable AA6000 aluminum conductors, that have high combinations of strength/conductivity.
  - Microalloying + modified heat-treatments
  - Low cost solution: no exotic or expensive elements are used + compatible with traditional manufacturing processes.
- **Critical Innovations**:
  - Scalable manufacturing
  - Low cost solution
  - Easy adoption/switching

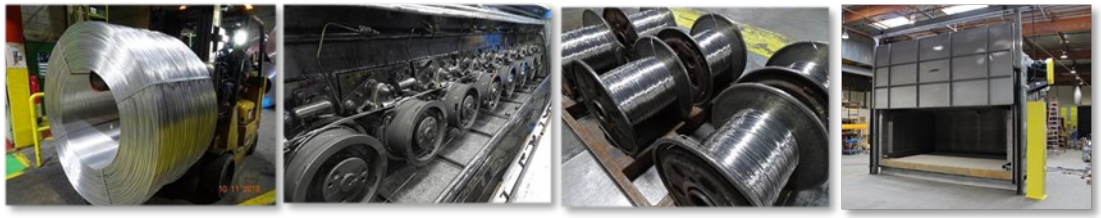


Technical Approach

Lab-scale development:



Production-scale development:



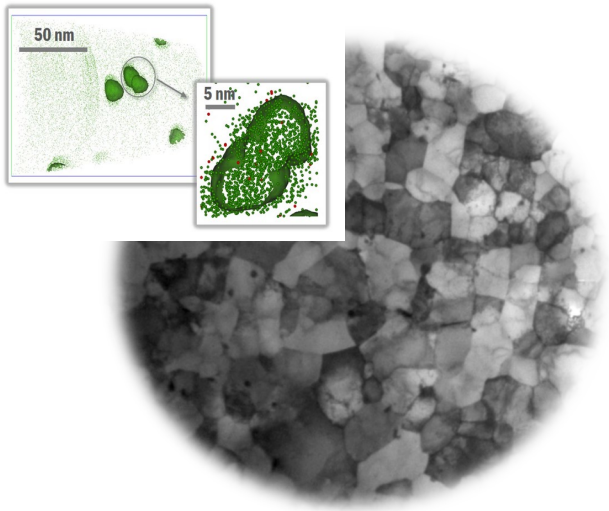
NanoAl LLC:
Vo: Alloy design, modelling, computer simulation
Flores: Alloy lab-scale fabrication & testing, wire prototype and testing, microstructure characterization
General Cable Corp.:
Zhang: wire & cable prototype and testing at pilot-scale
Sekunda: rod, wire & cable production and testing

Standard alloy chemistries
(3000, 5000, 6000, 8000-series)

Microalloyed with common elements

Custom heat treatment

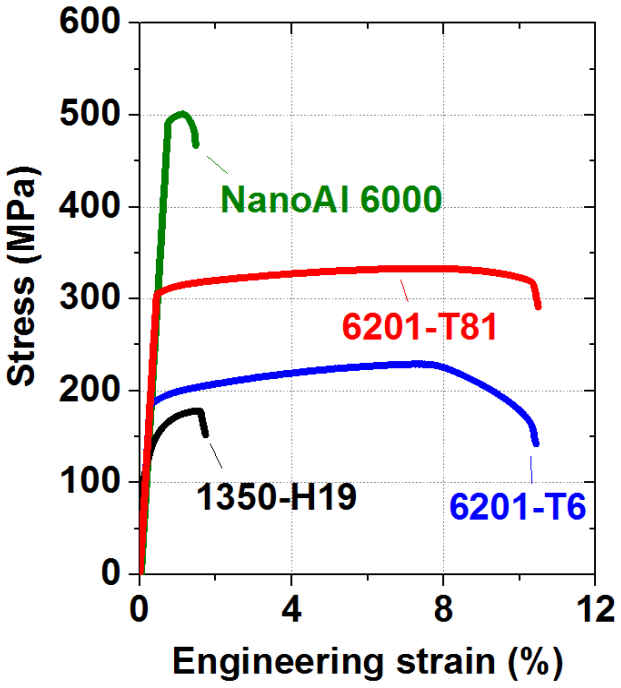
Unique micro/nanostructure
strengthening + stabilization

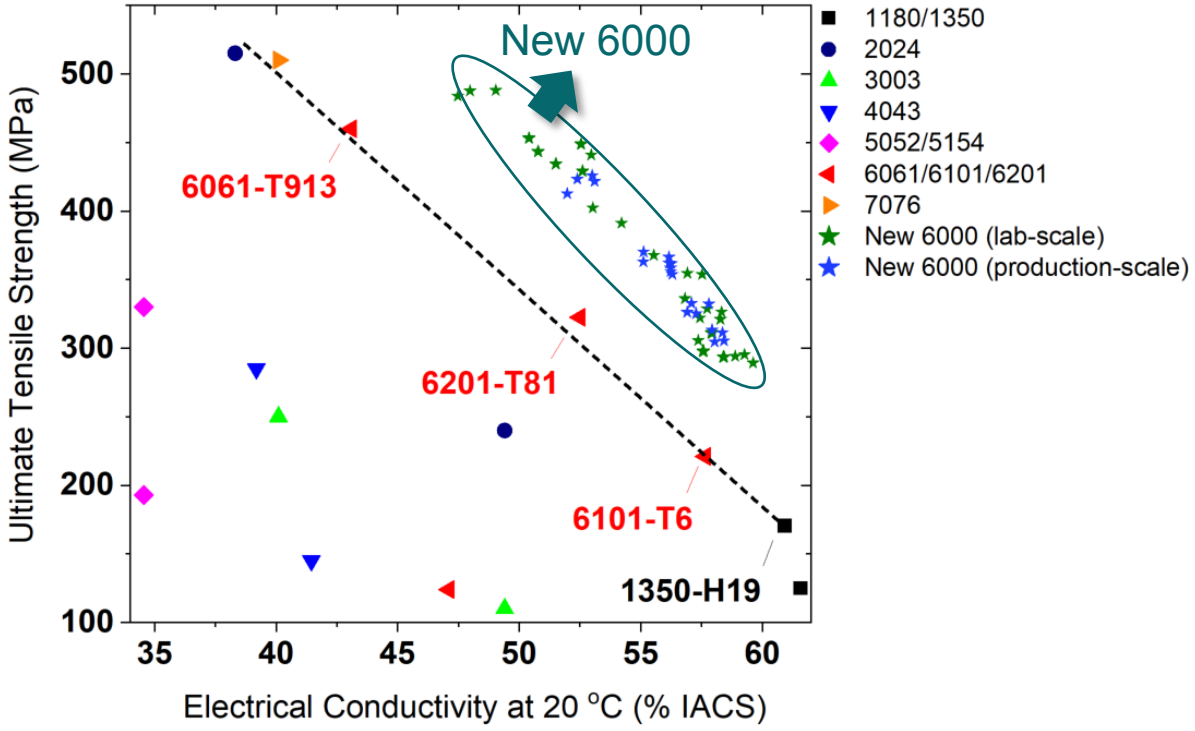


Results and Accomplishments

Newly developed 6000 aluminum alloys:

- Achieving very high combinations of strength/conductivity
- Achieving the same specific strength of high-strength galvanized steel, while having much higher electrical conductivity (~50% vs ~6% IACS)
- Successfully demonstrated at production-scale
- Standard continuous casting procedure



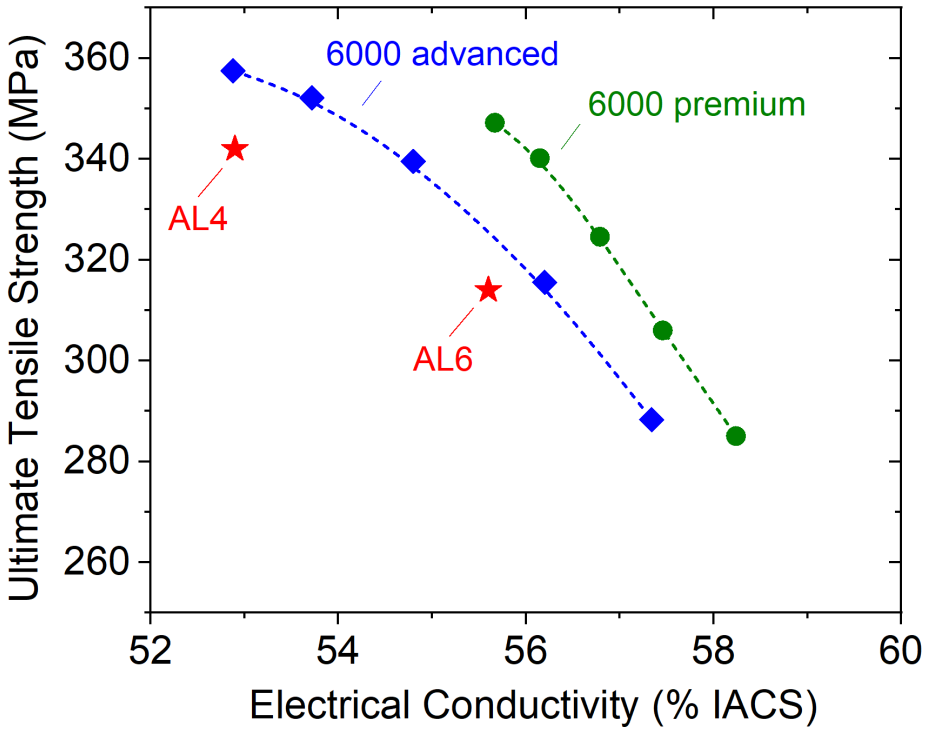


Results and Accomplishments

Product Introduction at Interwire 2019 Conference (Atlanta - May 2019)

Aluminum 6000 Advanced and Premium Benefits:

- No solution heat-treatment
- Follow AA6201/6101 chemistry standard
- Standard continuous casting production
- Exceed European EN 50183 standard (which requires expensive solution heat-treatment)
- 6000 Premium achieves outstanding strength/conductivity levels

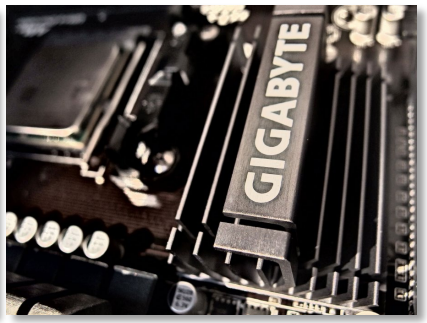


Transition

- Technology readiness level of 7-8 is anticipated by the project end (12/31/2019)
- Two utility patent applications are filed (both US and International)
- Commercial agreement with General Cable Corp is being negotiated for wire & cable products
- Product development partnerships for other applications (heat management, battery packaging, etc) are on-going
- New 6000-series alloys will be produced at Braidy Industries (Ashland, KY) starting 2021

Overhead cables

Battery packaging



Heat management