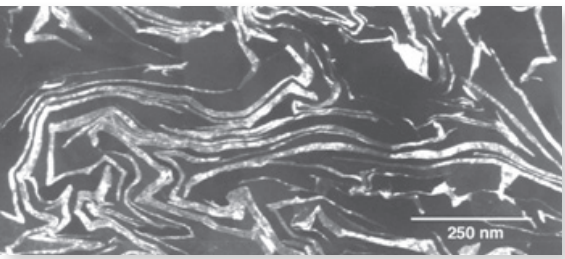
Next-generation Power Cables

Aluminum/transition metal composite may improve cable strength and conductivity, while reducing manufacturing costs

BY STEVE KARSJEN

Iver Anderson inserts a piece of wire into a swaging unit to reduce its diameter, which deforms the microstructure and forms ribbon-like metal fiber reinforcements.

THE STATE OF IOWA IS WINDY. In fact, Iowa is the second largest generator of wind power in the country behind Texas. Iowa is also blessed by its geographical location close to population centers like Chicago that have an insatiable appetite for electricity. The question is how to get the electricity from Iowa's wind turbines to power centers over today's power lines. Currently, that's not easy because there isn't enough electrical-grid capacity, which means there aren't enough south-to-north power lines to carry the electricity.



This micrograph shows how transition metal particles can be strung out into thin ribbons throughout the host material. These ribbons add strength to the composite material.

And there are other problems. The cables you see strung from those massive poles dotting the landscape are old. Many of them have been hanging there for 20-25 years. And there are strict limits on how much current the existing lines made of aluminum and steel can carry. That's because too much power load on the lines actually causes them to heat up, causing the aluminum conductors to expand and weaken; then sag — a hazard in its own right. Finally, there's the expense involved in stringing more power lines in order to expand the electrical grid.

Expanding the grid is a problem that must be addressed nationally, especially since the Obama administration is calling for 20 percent of the nation's electrical power to be derived from wind power by 2030. But other parts of the grid issue, such as how to build stronger cables out of cheaper materials while maintaining high electrical conductivity, are being addressed at the Ames Laboratory.

"We have an opportunity to produce the next generation of high-power transmission cable," says Iver Anderson, Ames Lab senior metallurgist.

Anderson has joined forces with Ames Lab associate scientists Alan Russell and Scott Chumbley to take a new look at some old research that could lead the way in cable design. Some time back, Russell developed a high-strength aluminum matrix conductor made from pure aluminum reinforced with pure titanium. He found that during deformation to shape the bar into wire, the titanium particles strung out into thin ribbons throughout the microstructure and reinforced the aluminum.

The result was a strong material with high conductivity. Although this could have solved the problem of sagging cables, it brought about a new problem: titanium powder is quite expensive, so making transmission lines out of an aluminum/titanium composite would be cost prohibitive.

So the two scientists discussed alternatives, and Anderson suggested using different aluminum/transition metal powder blends to try to create the same reinforced microstructure. Over the past 10 months, the two scientists have experimented with a variety of powder processing and deformation processes.

"Results so far are looking promising," says Anderson. "We've had limited success and we're looking forward to the next several months to answer our questions."

Beyond high strength and high conductivity, the aluminum/transition metal composite must have an additional and critical benefit, which is its cost. The metal should be "dirt cheap" compared to titanium, says Anderson, which is a tremendous benefit when you think of placing thousands of miles of additional power line across the Midwest to expand the electrical grid.

"Developing a stronger cable material might allow us to locate these towers 50 percent farther apart," says Anderson. "Just imagine the savings that could be generated in materials and land costs."

This electrical cable consists of seven stainless steel wires in the center, wrapped by 26 aluminum wires. The steel provides strength; the aluminum is a good electrical conductor.

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Research funded by:
Ames Laboratory royalty income seed funding program