TATA STEEL

REPLACING COPPER WIRES WITH GRAPHENE-COATED STEEL

DARE TO TRY

Tata Steel Europe has produced graphene-coated steel wires with the aim to replace copper electrical wiring in vehicles, enabling more efficient recycling of automotive steel.

THE CONTEXT

Copper creates challenges in recycling steel from vehicles. Existing recycling processes such as electric arc furnace and basic oxygen steel-making do not separate the copper from steel. Unfortunately, copper contamination of only 0.25% limits steel recyclability as it causes severe distortions in the steel microstructure. The presence of the copper contaminants can cause cracking during hot rolling of steel, and this could lead to potentially dangerous failures in automotive applications. Futhermore, another viewpoint is that vehicle manufacturers would prefer to replace copper wiring as it is expensive and prone to theft.

THE INNOVATION

Emerging technologies such as carbon nanotubes and graphene offer very high electrical conduction properties in very thin films. Hence, the company looked at how to replace copper wires with graphene-coated steel wires.

The team applied multiple layers of graphene (approximately 20 nanometers thick) on tempered steel wires of varying diameter (0.05mm - 0.25mm) using a technique called photo-thermal chemical vapour deposition. The new 0.25mm graphene-coated wires displayed a 10% increase in electrical conduction while the 0.05mm wires achieved a respectable 30% increase.

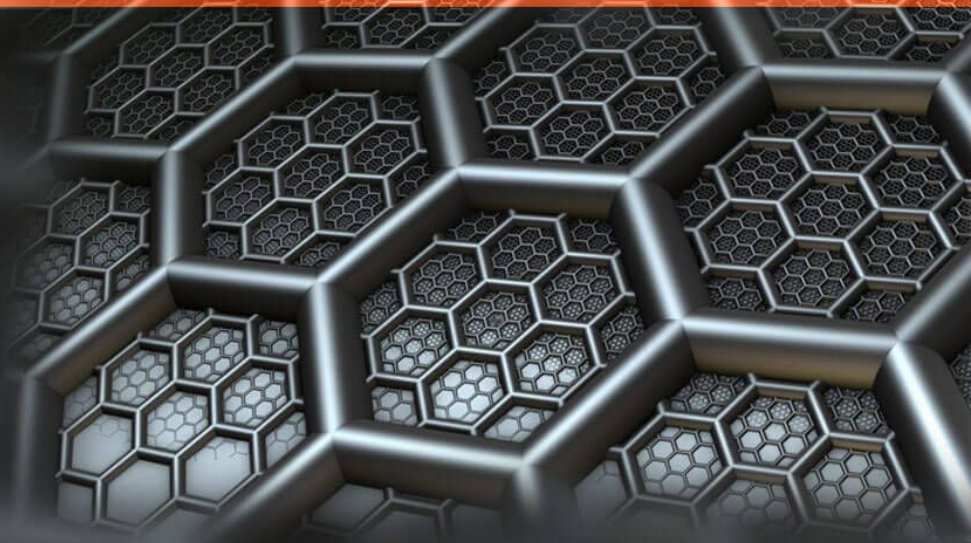
The team realised that the ratio between the graphene coating's thickness and the steel wire's diameter is a significant factor. A thin coating produces only a low conductivity improvement on a large diameter wire while a thick coating can cause adhesion problems with the steel. The most improvement in electrical conductivity was therefore found for the thinner diameter wires.

In order to maximise electrical conductivity, the team bundled the steel wires into multi-core strands. Theoretical estimations showed that by bundling 19 graphene-coated 0.05mm diameter steel wires, the team could achieve a 3.5 times improvement in electrical and thermal conductivities and get a 33% lighter wire than an equivalent 0.25mm single-stranded copper wire.

KEY CHALLENGE

TO PRODUCE AN ELECTRICALLY CONDUCTING GRAPHENE COATING ON A 0.05-MM "THIN-AS-A-HAIR" STEEL WIRE

The team used Raman spectroscopy to verify the graphene coating and its multiple layers. By applying overcoats of around 20 nm thickness on 0.05mm steel wires, the team achieved up to 30% improvement in electrical conductivity. With multi-strand wires, it could potentially improve electrical and thermal conductivity by up to 3.5 times.



POTENTIAL IMPACT

Recycling of steel supports the circular economy while reducing its carbon footprint. If just 10 kg of the copper wiring in a vehicle can be replaced with graphene coated steel, the innovation can potentially generate

£7.2 MN

of new business for Tata Steel Europe based on current steel prices of around £240 per tonne, assuming a 3% market share (in line with the company's current market share for steel production) and a global annual production of 100M vehicles.

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