A tougher conductive ceramic at lower cost

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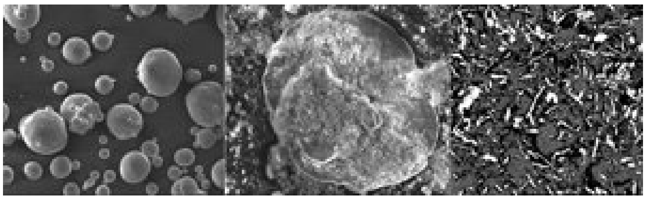

Scanning electron micrographs showing (left to right) the raw Ti particles, the flattened Ti particles after milling, and the final sintered Al_2O_3-TiN conductive composite. Credit: W. Zhai et al

By systematically refining standard processing techniques, A*STAR researchers have developed a low-cost method for manufacturing an electrically conductive aluminum oxide ceramic composite—a hard-wearing material used in many industrial applications.

Aluminum oxide (Al_2O_3) is one of the most commonly used raw materials. It can withstand temperatures of over 2,000 degrees Celsius, and its crystalline form, known as corundum, is one of the world's hardest naturally occurring materials, second only to diamond. It is also very cheap, and can be produced in vast quantities, so it is little wonder that it has found its way into a multitude of industrial applications, from fillers in paints, sunscreen and cosmetics, to abrasives, gas purification, catalysis, advanced filtration, ceramics and composite materials.

Aluminum oxide is an excellent electrical insulator. In some applications, however, such as catalysis and advanced filtration, the ability to electrify the material could provide significant benefits. For instance, in water filtration, aluminum oxide has great promise as a long-lasting filtration membrane that outperforms conventional polymer membranes—but only if the membrane can be electrified to prevent fouling.

Mixing aluminum oxide with conductive titanium nitride (TiN) is known to give a conductive ceramic composite, but has previously involved expensive or complex processing techniques. Wei Zhai and colleagues from the Singapore Institute of Manufacturing Technology have now adapted standard industrial processing methods to achieve a much more cost-effective result.

"We developed a novel processing method to fabricate electrically conductive Al_2O_3–TiN composites by combining ball-milling and reactive sintering, which are both typical methods for powder processing," explains Wei.

The secret to their success was ball-milling together powders of Al_2O_3 and Ti, not TiN, and then heating (sintering) the formed shape under nitrogen to give the final conductive composite.

"Ti powder is much more ductile than TiN, which allows the powder particles to be stretched in the milling process," says Wei. Her team found that the shape of Ti particles, and not their starting size, was the principal factor determining the amount of TiN needed to achieve conductivity. "This reduces the amount of Ti needed to achieve electrical conductivity, which we predicted theoretically."

The team was able to produce a conductive composite with as little as 15 per cent TiN, and by using the smallest Ti particles, was able to prevent appreciable degradation of the material's desired mechanical properties.

More information: Wei Zhai et al. Ti Reactive Sintering of Electrically Conductive Al_2O_3–TiN Composite: Influence of Ti Particle Size and Morphology on Electrical and Mechanical Properties, *Materials* (2017). DOI: 10.3390/ma10121348

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