The 'shine' in gold particles has a new use – finding defects

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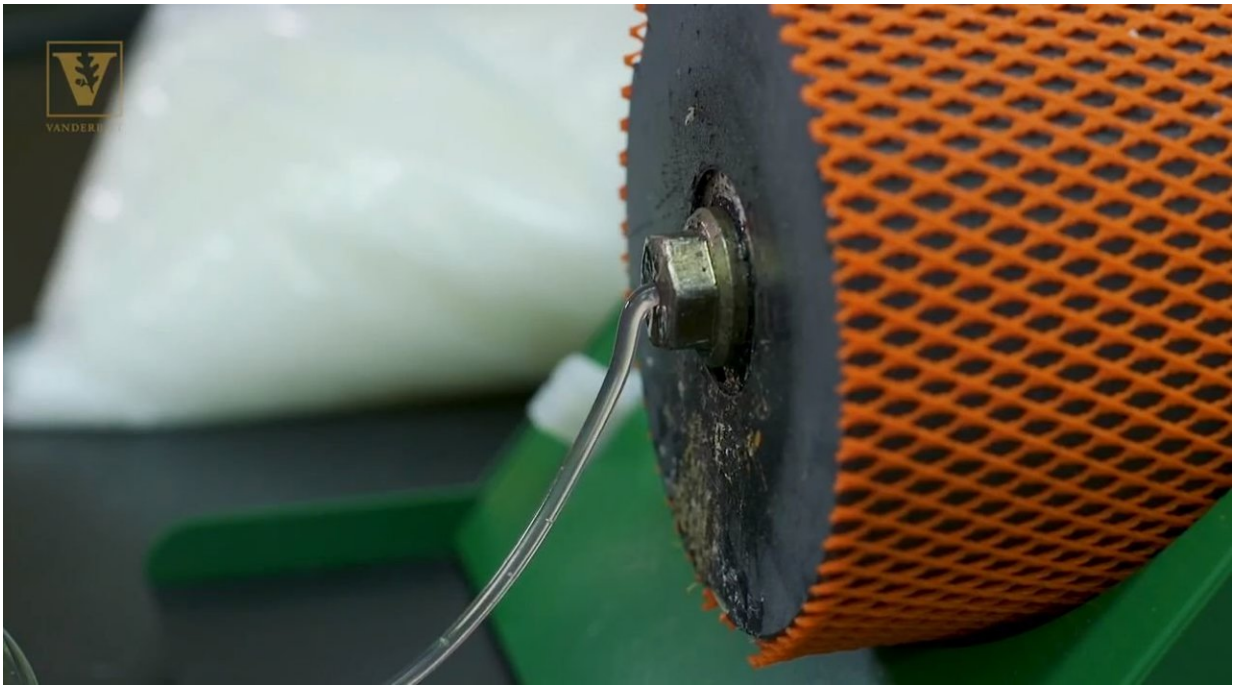

That glint of gold has always captured our eyes, but now the precious metal has a new use – finding defects in 3-D printing.

Vanderbilt researchers have developed a technique for gold to actually 'shine' inside 3-D printed parts to highlight any problems.

"This is one of the first applications using gold for defect detection. We are able to inspect and detect defects that aren't visible to the naked eye, using the optical properties of embedded gold nanoparticles," said Cole Brubaker, civil engineering graduate student, and lead author of the study. "That's a very critical step – being able to say 'We have a defect. It's right here.'"

The research team used super-tiny particles of gold, which actually show up as a deep maroon color. The nanoparticles are approximately 100,000 times thinner than a human hair, but they could solve a major problem in manufacturing.

"3-D printed materials are becoming increasingly common in our day-to-day life, from consumer goods and products to even demonstrations of 3-D-printed automobiles and homes," said Kane Jennings, chair and professor of chemical and biomolecular engineering, and co-author on the paper. "But there can be problems in the processing of 3-D printed materials. Small defects or missing print layers can occur. These defects can compromise and weaken the structural integrity of the 3-D printed products, causing failure."

Researchers decided to try embedding gold inside the printing material to see whether it could help flag those defects.

"It's similar to the gold in your ring, but it has very unique optical properties that don't degrade over time," Brubaker said.

The innovative process involves mixing the gold nanoparticles with a dissolved plastic polymer, dispersing it throughout the medium. When it dries and hardens, the plastic is extruded or pressed into gold nanoparticle-filled polymer filaments, or thin tubing, which can then be used in standard 3-D printers.

After a part is printed, it goes into a special UV-Vis spectrophotometer to inspect for defects.

"We're using the absorbance properties of the embedded gold nanoparticles," Brubaker said. "You just scan light across the surface of the sample and see where the absorbance decreases inside, signaling a defect in that material. A defect can be found with one single nondestructive measurement. It's very quick. It takes just a matter of seconds. We don't have to rely on large sensing systems that have sensors placed all over the part."

The interdisciplinary team included researchers from the departments of civil and environmental engineering, chemical and biomolecular engineering and chemistry, along with help from an undergraduate student studying at Fisk University in Nashville. The research was funded by the U.S. Office of Naval Research. Patents are pending on the technology and the research findings have been published in *ACS Applied Nano Materials*.

"There are tremendous possibilities for what we can do with this technology," Jennings said. "We have demonstrated the 3-D printed parts can be self-reporting. They self-report defects. We're looking now at the possibility to do even more with these smart materials."

"What really gets me excited is the broad range of applications we can use this technology for," said Brubaker. "We've just scratched the surface."

More information: Cole D. Brubaker et al. Nondestructive Evaluation and Detection of Defects in 3D Printed Materials Using the Optical Properties of Gold Nanoparticles, *ACS Applied Nano Materials* (2018). DOI: 10.1021/acsanm.8b00142

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