Alan Pierce
pierceaj@techtoday.us

Recent Material Science Breakthroughs

Today's technology and products could not exist without past breakthroughs in material science. Two recent major material science breakthroughs will probably soon play a role in the development of new tools, technologies, and products for use here on earth, or in outer space.

Gold is a soft precious metal that has played a significant role in every civilization since the dawn of time. In its pure form, gold is extremely malleable, so for most of history it has been combined with other metals to increase its hardness. These alloys have also kept gold's luster and color intact at a fraction of the cost.

Titanium doesn't have the same long history as gold; it was first discovered in 1791. It is often alloyed with gold, where the gold provides the beautiful color and luster, and titanium provides the alloy's strength and toughness. Both of these metals are biocompatible, so they both have a well developed history of being used inside the human body.

Jeff Fitlow/Rice University

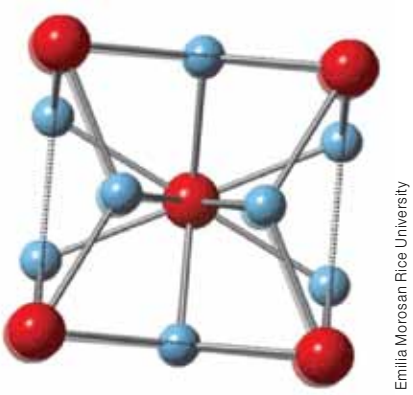
Photo 1—Professor Emilia Morosan, right, working with a member of her team. Her experiment brought forth an unexpected outcome which led to a major material science discovery.

A new chance breakthrough at Rice University has gold increasing the hardness of titanium rather than titanium increasing the hardness of gold. Dr. Morosan and her team (Photo 1) used a very high temperature furnace to createx a gold titanium alloy. Their alloy formula was 25% gold and 75% titanium. When they tried to grind this alloy they found that a diamond impregnated grinding tool could not easily rip into their gold titanium alloy's surface. Creating a super hard alloy was not their goal and they needed to figure out what happened by chance that created a major material science breakthrough.

They discovered that the very high fabrication temperature that they used to make their alloy caused the gold and titanium atoms to take on a new cubic structure (Fig. 1). This crystalline arrangement of atoms gave their alloy an extreme hardness not found if the same gold titanium formula was used to create the alloy at a lower temperature. The gold titanium alloy that they created is now called Beta titanium-3 gold and its superior hardness and biocompatibility should quickly lead to it being used for medical implants.

Using a similar very high temperature approach with the addition of extreme pressure, material scientists at MIT recently changed the properties of a form of carbon called graphene into an extremely light foam that is ten times lighter, ten times stronger, and has 5% the density of steel. Just like the researchers at Rice University, they found that by dramatically increasing the fabrication temperature and also pressure they could change the geometric structure of the graphene. This structural change was not achieved when lower heat and pressure were applied in the fabrication process.

Just like Beta titanium-3 gold, the enhancement of graphene foam was not created by changing the actual ingredients. Their graphene foam



Emilia Morosan Rice University

Fig. 1—The very high temperature used to form the alloy caused its atoms to arrange themselves into a much stronger geometric structure than normally found when gold and titanium are smelted together.

super strength was formed by the pressure and heat it was subjected to during the fabrication process. In both cases the scientists at these universities created the correct conditions to create a super strong crystalline internal structure that increased the materials' properties dramatically.

Photo 2 shows a 3D-printed model of what their graphene foam's microscopic structure looks like. For further insight into this dramatic scientific discovery, check out this YouTube video: https://www.youtube.com/watch?v=VIcZdc42F0g.

At both universities, teams of scientists found that it was possible to make significant changes in the

---

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.

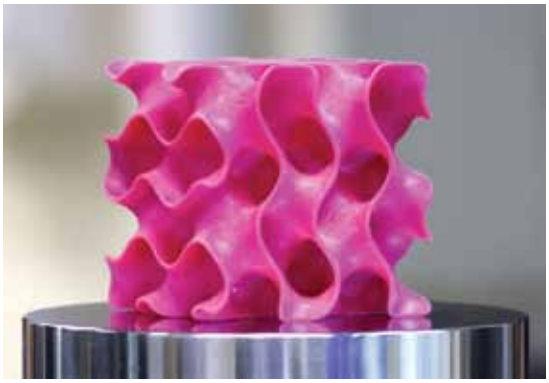
structural geometry of a material by altering the fabrication conditions—temperature alone at Rice; temperature and pressure at MIT. This research, which was performed at Rice and MIT, appears to have sparked a race to find new materials by altering the fabrication conditions from current procedures. These breakthroughs should quickly find their way into current technologies and perhaps become the backbone of future technologies.

Taking It a Step Further

1. Working in teams of 3 or 4, research how gold, titanium, carbon (the stuff that graphene is made of), and graphene are currently being used by our technological society.

2. Which team can find the most significant and most bizarre uses of these materials?

3. With your team, design and build small models that are the same size, but have different internal geometric structures. After building the models out of paper, wood, or on a 3D printer, test to see which model has the strongest geometric shape.



Melanie Gonick/MIT

Photo 2— The actual cells of their graphene foam are microscopic. The team used 3D printer modeling to show how the pressure and heat combined to create a super strong graphene foam.

Program Funding Ideas Needed!

In May, **techdirections** will run a special feature on fundraising, and we would love to share your success stories, and failures, with our readers.

Have you ever used a fund raising campaign to raise money for your classroom? Did your students create something to sell? Did you use a fund raising company? If so, which one? What did you purchase with the money that you raised? Was it successful and would you do it again?

As a thank you, five responses will be randomly selected from those received to receive either one of our posters or three On-Demand Classroom Projects of their choice. The drawing will take place April 5th.

Thanks in advance,
Vanessa Revelli, Managing Editor
vanessa@techdirections.com