Student and faculty research leads to golden chemical discovery

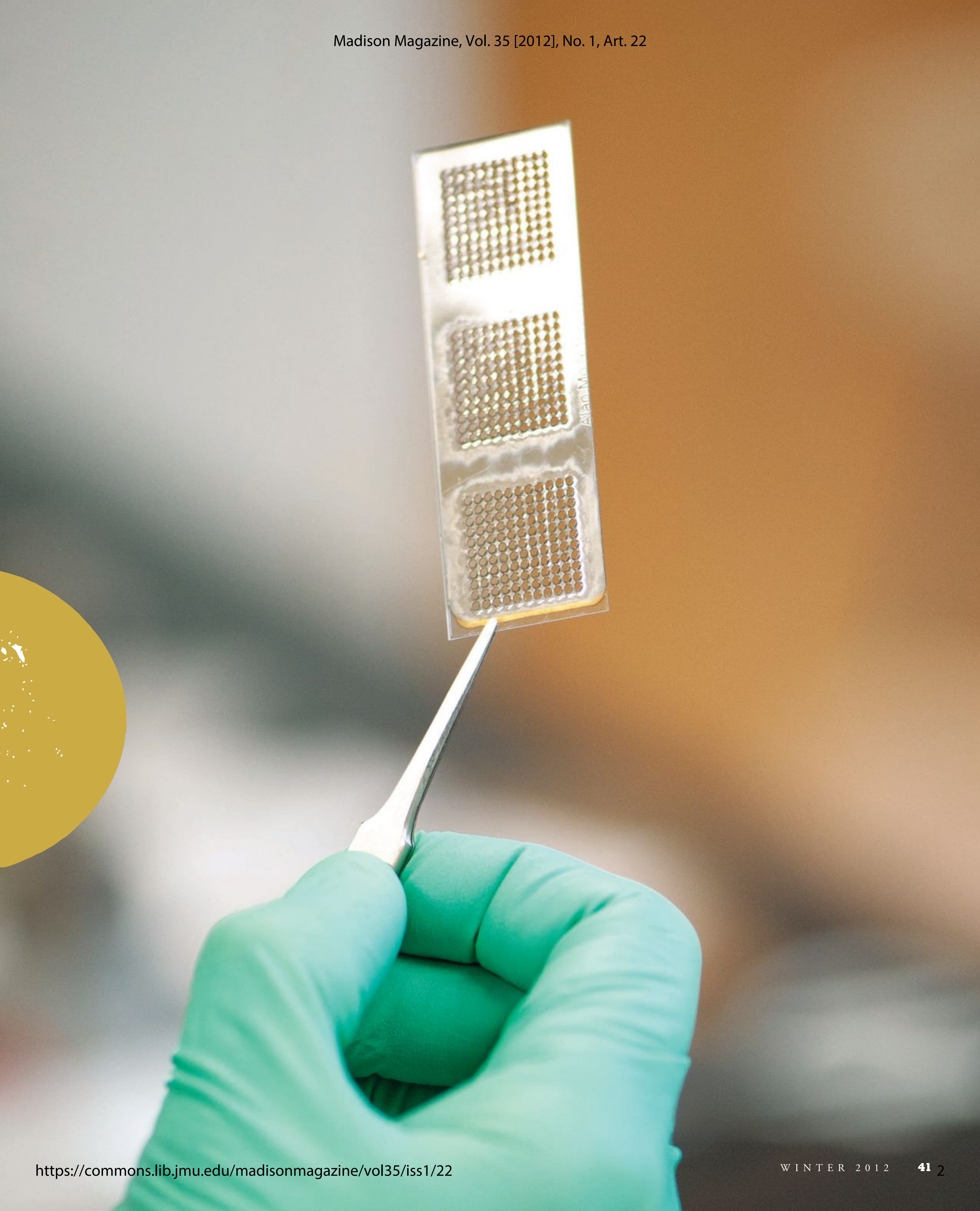
Striking GOLD

BY ERIC GORTON ('86, '09M)

Getting gold film to adhere to plastics is a tricky task. Finding a sure-fire, low-cost way to accomplish it would be a real breakthrough for a number of industries from biomedicine to computer chip manufacturers.

A pair of JMU researchers and a High Point University student thought they stumbled upon the perfect method during summer 2009 while working on a biomedical device to replicate DNA. The solution: Use a solvent to dissolve a polymer and create a silicon oxide layer that the gold would stick to. It worked like a charm. But their excitement was short-lived when a JMU student the following fall could not replicate the experiment.

GOLD PHOTOGRAPHS BY MIKE MIRIELLO ('09M)



After closer evaluation of the steps each student used, Brian Augustine, professor of chemistry, and Chris Hughes, professor of physics and astronomy, noticed the students used different solvents in the process. Laura Lee, a High Point University student who participated in JMU's summer Research Experience for Undergraduates program, used chloroform; JMU biology major Alan Mo ('11) used toluene.

"They're both very common organic solvents," says Hughes. "There would be no reason why you would choose one over the other."

Augustine recalls, "Alan asked what to do, and we said 'just get something that dissolves the polymer. Pick toluene. That's as good as anything.'"

The real head scratching began when Mo repeated the experiment using chloroform, and it worked.

"Our reaction was, 'Come on. Do it again,'" Augustine says. "We couldn't believe that. That was ridiculous. The solvent should have no effect whatsoever."

More experiments with a variety of solvents proved that chloroform did indeed make the difference. That resolved the problem of finding a simple, low-cost method for getting gold to stick to plastics, but it created a mystery: What was different about chloroform than the other solvents?

"We had some goofy theories," Augustine says. "When you sort of think about them, you say, 'How can all those atoms move in just the right way? Why would the solvent do that? Why would it stay that way?'"

To find out, Augustine and Hughes had a third student, Vezekile "Veve" Zungu, a summer 2010 visiting student from South Africa, use spectroscopy to investigate what was happening with chloroform.

"Once you understand the why, then you can start making predictions about other things that can happen," Augustine explains. "Now we understand, I think, the basic science or the mechanism behind it, so now we can start making predictions about other metals we think are going to stick or other polymers we think are going to work."

That could be big news for a variety of industries.

"One of the show-stoppers for plastic tech devices is putting electrical contacts onto plastic surfaces," Augustine says. "Intel and all the big players out there are trying to move to plastic electronics or at least some subset of their operation is trying to go to plastic electronics," which are light, durable and less costly to manufacture than silicon-based technologies. "The whole biomedical industry is looking at plastic electronics for implants and stuff like that. Acrylic is an FDA-approved material to go inside the body, so you can put implants into the body with electrodes that are maybe sensing glucose levels."

Hughes says, "JMU has filed a provisional patent application for the process. Soon, scientists and manufacturers may have the option of using plastic electronics to design and build devices we haven't thought of yet."

The professors plan to submit the findings about the chemical reactions to a top-tier journal. The first paper touting the research was published in the March 2011 issue of *The Journal of Vacuum Science and Technology A.* The paper primarily focused on the discovery of a more efficient process to adhere gold to plastic rather than the details of the chemistry that made it possible. In the two months following their first article's publication, it was among the top 20 most downloaded articles from the *JVSTA* website.

"That paper was the work of Laura Lee basically discovering that chloroform has some effect, although she didn't know that; Alan really figuring out that it was chloroform that was doing it; and then Veve doing a little bit of spectroscopy to figure out there's some sort of chemistry happening in there," Augustine explains.

Watch a video from the lab
www.jmu.edu/link/gold

Brian Augustine, professor of chemistry, and Chris Hughes, professor of physics and astronomy, work with JMU biology major Alan Mo ('11) on experiments to find the best solvent to use to get gold to stick to plastic.

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All three students were co-authors of the paper along with Augustine, Hughes and JMU chemistry Professor Tom DeVore. The research was significant enough that a quarterly newsletter for American Vacuum Society members chose it as one of three research papers to feature in June out of hundreds published in the various chemistry journals. The AVS has more than 4,000 members in industry, academia and government laboratories.

"It's a very significant thing from the applied technology side of things," Hughes says. "But then the basic science of why this is happening is also interesting. And those are two different audiences that are met by different journals. And that's the way we ended up segregating things."

Hughes also notes that the JMU research environment has a lot to do with the opportunity to go beyond just finding a method that works. "Industrial labs or national labs, but also most grad schools these days, if they had come to the point where we were — where they were trying to develop a device and ran into that problem — the device is always supreme. You have a client you need to make the device for, or you have to make it for your dissertation. In those environments it is much more likely that a researcher or grad student would say, 'Well, let's just find a work-around and get the job done.' At JMU, we had the freedom to pause and ask: 'What the heck is going on here?' That freedom is part of our research environment."

The JMU research resulted from a collaboration with the University of Virginia, which wanted gold film to work as mirrors inside a polymerase chain reaction device used to amplify DNA, and has received funding from the National Science Foundation. M