Forbes/Wolfe Emerging Tech REPORT

Volume 13/ Number 6 / June 2014 www.forbeswolfe.com

The Insider

JOSH WOLFE, EDITOR

This month, we marvel at technological progress in two stagnant markets and relay words of caution regarding a realm that affects each and every one of us.

We lead with Kegan Schouwenburg, the founder and CEO of SOLS Systems (Full disclosure: my venture firm Lux Capital is an equity investor). After spending nearly a decade running and building companies in the 3-D printed manufacturing sector, Schouwenburg has set her

Continued on page 2

3-D Printing Gains Foothold In Orthotics

SOLS Systems Co-founder and CEO Kegan Schouwenburg is a leading voice in 3-D printing and mass customization, and obsessed with bringing nascent technology into the consumer sector (Full disclosure: my venture firm Lux Capital is an equity investor). Schouwenburg's background in industrial design and mass manufacturing gives her a unique perspective on scalable systems and products, and fuels her desire to bring beauty and simplicity to new markets. Previously Kegan spent four years running a consumer design and manufacturing firm, learning the ins and outs of physical product, before becoming tired of the high barrier to entry in manufacturing, and leaving to

KEGAN SCHOUWENBURG

Continued on page 2

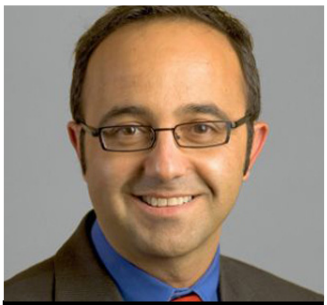
Shedding New Light On Old Germs

MARTIN J. BLASER, M.D.

Martin J. Blaser, M.D., is the George and Muriel Singer Professor of Medicine, professor of microbiology, and director of the human microbiome program at the NYU School of Medicine. He served as chair of the Department of Medicine at NYU from 2000-2012. A physician and microbiologist, Dr. Blaser is interested in understanding the

Continued on page 4

Stethoscope Detects Epileptic Seizures



DR. JOSEF PARVIZI

Dr. Josef Parvizi is an associate professor of neurology at the Stanford University Medical Center. His expertise is in functional mapping of the human brain using the three methods of electrocorticography, electrical brain stimulation, and functional neuroimaging (fMRI) methods. The general theme of his group's research is

Continued on page 6

3-D Printing Gains Foothold In Orthotics

Continued from page 1

join Shapeways (Full disclosure: my venture firm Lux Capital is also an equity investor in Shapeways). There, she built, and ran, the Factory of the Future. Schouwenburg holds a bachelor's in industrial design from Pratt Institute (2007).

When did you first discover 3-D printing?

My background is in industrial science. I've always loved physical products. I moved to New York to study at Pratt Institute where I learned about 3-D printing. I wasn't satisfied with what I could make with my hands so I started outsourcing my projects. One of the factories that I had outsourced them to told me about 3-D printing. At the time, it was not looked favorably in the program, but I fell in love with the technology.

I graduated college and started a company with a classmate where we designed products and 3-D printed them. Both MOMA and Urban Outfitters picked up our designs on the spot at our show. After four years at this company, I discovered how Shapeways was using 3-D printing to open market opportunities for everybody. Why move your manufacturing to China when 3-D printers offer a manufacturing solution? I joined the team at Shapeways and I served as team lead of distribution. I helped bring distribution to the U.S. and built out its factory in New York.

You mention that you began working with 3-D printing because you weren't satisfied with what you made with your hands. Can't traditional manufacturing still work hand-in-hand with computer modeling?

Yes. In fact, 3-D printing is just one means of execution. It's one form of digital manufacturing, where tools are allowing us to shorten the time between having ideas and shipping a product. It will allow us to produce things directly from digital files and to remove the touch points that result in human error.

How did you stumble on orthotics as a killer application for digital manufacturing?

I was working at Shapeways and I was basically seeing all these designs come through and I was amazed at the variety of things that people were designing. There are certain products where customization adds value, particularly products that fit the body. There are so many amazing applications and technologies out there that just don't work yet: I see them all the time. 3-D printing a scoliosis brace is amazing, but it's not yet cost-effective. I think it's great that people are innovating in the sector, but I wanted to create a business that works right now with other technology so we can use that to push it forward. I think that change will come. I looked at all of these products, racked my brain and thought, "What product embodies all of these?"

Everybody has to eat, everybody wears shoes, everybody wants to be more comfortable and we can empower people. We can enable people to walk outside and feel incredible about themselves, as we customize not the outside, but the inside of their shoes.

Before you founded SOLS, what did the orthotics landscape look like?

On the medical side, the industry is stagnant, old and forgotten. There are no regulations on how we do things or standardization in the product's category. It's very much region dependent, lab dependent, and doctor dependent. What happens is you have all those aspects of dependencies and then you end up with people like my dad who will sit down at the dinner table and say, "These are my orthotics from 20 years ago and to this day no one has been able to make me a pair of orthotics like this." This is shocking but true. We hear stories like this every day. Medical orthotics are mostly sold through podiatrists, orthotists, physical therapists and personal trainers—all of these sort of dabble in the categories, but podiatrists have a lock down.

On the consumer side once again you've got unhappy customers, but they're unhappy for a totally different reason. They've barely spent any money and they have a product that promises to be great and they get immediate relief, but that product rapidly deteriorates and smells bad, is ugly and is ill-fitting. People feel so betrayed by the products that they've bought and they feel let down. They can't keep up with their friends, they can't wear the shoes they want

"We're using very simple, mobile-based technology that allows people to capture their feet in a 3-D scan to empower the doctor at the point of prescription."

The Insider

Continued from page 1

sights on bringing a drastically new approach to the $170 billion footwear market. Kegan and her team are harnessing the latest 3-D printing and scanning technology to offer beautiful, highly customizable orthotics at an affordable price.

Next we sit with NYU Professor Dr. Martin Blaser, author of *Missing Microbes* and one of the world's leading experts on the human microbiome. Dr. Blaser shares some startling numbers regarding what many consider to be our largest organ and warns us that decades of antibiotic abuse may be causing unforeseen damage to our hundreds of trillions of bacterial allies.

Finally, we speak with Stanford Medical School neurologist Dr. Josef Parvizi. Inspired by a contemporary string quartet, Dr. Parvizi teamed up with a leading music researcher to develop a method to convert brain signals into musical notes. We learn how this novel technique will revolutionize the way that we detect and treat seizure activity.

As always, here's to thinking big about thinking small…and to the emerging inventors and investors who seek to profit from the unexpected and the unseen.

Continued from page 2

"3-D printing is one form of digital manufacturing, where tools are allowing us to shorten the time between having ideas and shipping a product. It will allow us to produce things directly from digital files and to remove the touch points that result in human error."

to and they feel socially isolated. I always knew there was a problem, but I had no idea how intensely people dislike the current market. I think the fact that we have the opportunity to change that and we can build trust that starts with a product and stems out from that is an amazing opportunity, and one where you truly have the potential to actually help people.

How does your use of technology differ from competitors?

We're using very simple, mobile-based technology that allows people to capture their feet in a 3-D scan to empower the doctor at the point of prescription to effectively see what he's doing to the patient's foot. We're showing him the sole, and what adjusting the degrees of posting, the forefront of the heel and the arch is actually doing to their body. We can do mapping of risk of injury or sensory integration, and predictive pressure mapping, so that two weeks later, when that patient comes to pick up his or her orthotics, they're actually going to fit. These things are seemingly small, but they're major changes to what's happening now.

On the generation end, we're developing and refining an algorithm that allows us to output perfectly fit products that are custom to the patient's foot, custom to the patient's weight, custom to the force patterns across the foot bed and custom to the shoe. That means if you weigh 100 lbs, as opposed to 200 lbs, you're going to need a different product. That's not happening right now. You get the same product. This will be the difference between somebody saying, "I'm not going to wear this" to "I actually want this to be a part of my life."

Will there be any differences between consumer and medical versions of SOLS?

The consumer version will be customized. It will have more of a focus on comfort and performance, whereas the medical version will be more focused on advanced levels of treatment. There will be features that will only have available in the medical product that will not be available in the consumer product.

How has the market response been to SOLS?

The appetite blows my mind. The strongest interest that we're seeing is with the shoe companies. For them the value proposition is quite simple: if they can sell shoes that are more comfortable then they have a lower return rate and everyone's happier. This is a very, very simple thing. Shoes are notoriously uncomfortable. People buy shoes and they're okay with the fact that they're uncomfortable. This is not something we should be doing, especially when we're paying so much money for footwear. The orthotic insoles industry is $4 billion and the shoe industry is $170 billion in the U.S. alone. If we customize even 1% of the shoes that are sold at the manufacturing level, we have a $1 billion company.

Where do you stand in terms of development?

Right now we're in beta testing with 60 doctors. We've been in beta testing for about a month and a half now. The plan is to roll out of beta and start selling this month. In the next month, with our new Web site launching we'll have our new "find a provider" program. Potential customers can put in their zip code and they will be matched to a local provider where they can go get fitted for SOLS. We're rapidly working on expanding our providers. We have a lot on the East Coast right now so now we're starting to expand our West Coast network.

How big is your team right now?

By the end of this month we're going to be up to 22 people, which is pretty incredible. This June has been really eventful. We've got people starting left and right. We're reaching that interesting point where I see great things happening that I'm not involved in anymore. That's a relief for me because it's exactly what's supposed to happen, but it's a weird psychological point that you have to go through. It's my job to keep that foundation aligned and steady and solid so everyone can keep executing.

What are some of the biggest challenges that you've faced and how have you dealt with them?

I think it's hard anytime you enter a market that is so closed and so rooted in its ways. That being said, it's also exciting because our community is starting to trust us and that's vital to our success. This is not about forcing a new product on people. It's about helping them to understand why our product is awesome and allowing them to feel a part of the development. One of the reasons that our beta program has been so critical is there is this vast network of doctors out there that has been doing this for years, know a lot and can teach us a ton of stuff as well. Instead of forcing a new product down everybody's throat, we've made sure to leverage everybody's knowledge to build this together and create something that people are really, really excited about. I think that's one of the ways that we've thought about working on it.

In addition to all of the marketing, branding, sales and hiring challenges of other companies, we are also dealing with an incredibly complex technical challenge. People forget how much really goes into building and supporting a custom, vertically-integrated manufacturing company. But as a result of conquering these challenges, the ceiling of what we can be is beyond anything I had ever imagined.

What lessons or advice do you have for other entrepreneurs or aspiring founders?

Be very, very focused on what you want to achieve and if you want it badly enough you're going to make it happen. Do something that's actually worth doing. I don't need another way to chat with people on the Internet. I saw one amazing company the other day where they were helping people

Continued from page 3

give gifts to sick people. Imagine if we could give products that people actually need instead of something they don't want, and we could actually help people in real ways. I thought that was an amazing idea for a company. Lastly, hire people that are way smarter than you.

Where do you see SOLS in the future?

Obviously I want to have very strong footing in the medical and the consumer sector. We want to do insoles, orthotics and eventually we want to do shoes and modular shoe concepts. I think there are some really cool opportunities as we start to integrate other manufacturing processes. I see SOLS as being wildly different from person to person. Right now, if you and I get a pair of SOLS they're going to be different, but visually speaking they won't look so different. In reality, they should be wildly different. We should be considering everything including shoe type, what sport you play, age, foot pad deterioration and integrating all of that into our algorithm to make a product that truly is customized.

Beyond SOLS, obviously this is our first product, but we want to continue to push our technology to other spaces so eventually that scoliosis brace makes sense along with 3-D printed casts, shin guards, helmets, bicycle seats and more. We see ourselves as supporting customization for the human body to be better versions of ourselves, to empower ourselves, to feel better, more healthy and more beautiful. I think the opportunity in front of us is gigantic. ET

Shedding New Light On Old Germs

Continued from page 1

relationships we have with our persistently colonizing bacteria. His work over the past 30 years has largely focused on Helicobacter pylori and Campylobacter species, which are important as pathogens, and as model systems for understanding interactions of residential bacteria with their human hosts. He is actively studying the relationship of the human microbiome to health and disease. Over the past 30 years, Dr. Blaser has served as the advisor for a large number of students, post-doctoral fellows, and junior faculty, and he has been actively involved in scientific and professional organizations. He served as president of the Infectious Diseases Society of America, chair of the Board of Scientific Counselors of the National Cancer Institute, and chair of the Advisory Board for Clinical Research of the National Institutes of Health. He currently serves on the Scientific Advisory Board of the Doris Duke Charitable Foundation. He was elected to the Institute of Medicine and the American Academy for Arts and Sciences. He holds 24 U.S. patents relating to his research, and has authored more than 500 original articles.

How do you define the microbiome?

The microbiome consists of all the microbes that call us home, as well as all of their interactions with us. This includes bacteria, fungi, protozoa, viruses and all the other organisms that live in and on us.

When did you start getting interested in this space?

I started working on the bacterium Helicobacter pylori almost 30 years ago. We first viewed it as a pathogen but then realized that it was the dominant member of this microbiome and that it was disappearing. That brought me into studying the microbiome. I postulated that if one organism was disappearing, others might be as well.

At the same time, I remembered something that I had learned at the Centers for Disease Control and Prevention (CDC): farmers feed antibiotics to their farm animals to promote their growth. They do it because it helps them use their feed more efficiently and the animals gain weight. All of a sudden it occurred to me that the antibiotics that we give children might be having the unintended consequence of obesity later on in life. As I discuss in my book *Missing Microbes*, some of our ancient organisms that are important early in life are disappearing and that carries a lot of consequence.

Talk about some of the numbers involved in the microbiome to give people an idea of how massive this is.

The current estimates are that 70% to 90% of all the cells in the human body are microbes. That means that a minority of your cells are actually "you." The rest are the microbes that you carry. To put it another way, we humans have about 20,000 unique human genes, but we have on average approximately two million unique microbial genes. This means we consist of 99% microbial genes. We used to think that these microbes were just passengers and we were just giving them a free ride. But it has become more and more clear that we interact with them and they're interacting with us. So, in a sense, they're part of our extended genome.

In your book you talk about the harmful effects of overusing antibiotics. Why is antibiotics overuse so prevalent in society?

We suffer from a form of nearsightedness. The discovery of antibiotics was incredibly significant beginning in the 1930s and 1940s. We had terrible disease that could be cured with antibiotics. For certain conditions, they are the difference between life and death. Because antibiotics were so miraculous and because they seemed so free of long-term costs, everybody gave them a clean bill of health and said, "All benefit, no cost." We know that everything has cost. It was foolish of us to think that things as powerful as antibiotics would not have cost, and the connection with the microbiome begins to illustrate what some of those costs are.

How prevalent is antibiotics use in the United States?

In 2010, the CDC conducted a survey of antibiotic use in the United States that showed that we issue five prescriptions for every six people each year. Every child in the U.S. has gotten 10 courses of antibiotics, whereas the average child in Sweden has had four. The Swedes are at least as healthy as we are, which implies that more than half of all American antibiotic use is unnecessary. In China, where antibiotics are available over the counter, people are using them two to four times as much as we are.

I wrote *Missing Microbes* as a wake-up call to sound an alarm. We're despoiling our internal environment as a result of antibiotics.

Can we tailor antibiotics to be less deadly to our microbiome?

I believe the answer is yes. Up until now we have focused on developing broad antibiotics because we don't know what specifically is hurting patients. As a doctor, when I see somebody with pneumonia who's very sick, I want to treat him or her for all the likely suspects.

We will soon have the diagnostic ability to

Shedding New Light On Old Germs

Continued from page 4

quickly distinguish between viral and bacterial infections. If it's a virus they don't need antibiotics. If it's a bacterium, then we will be able to use a narrow spectrum antibiotic that focuses on specific bacteria like a laser and won't cause collateral damage.

Has anyone tried to map the microbiome?

It's mapped all the time in different ways. I've compared our knowledge of the microbiome to a map of Africa in 1800. We knew the outlines and then over the next century we began filling in the details through exploration. That's what we're doing now. It's an ancient ecosystem that goes back ever since animals were formed on this earth and it's very, very complex. By studying it more we begin to understand the roles.

Have we noticed any differences in microbiome composition based on geography, race, culture, etc.?

There was a very good study that my wife was involved in that was published in *Nature* about two years ago comparing the microbiome of people in the U.S., Africa, and Amerindians in South America, showing certain parallels differences between them. To me, the most striking fact was that the diversity in the gut microbiome of the people in Africa and especially the Amerindians was much greater than ours.

This implies that we have lost diversity; that some of our microbes have already disappeared. That's what I prognosticated 15 years ago. Her more recent work, which has been presented at meetings, suggests that the degree of loss of our microbiome already may be 35% to 40%. That is really worrisome.

Do you feel that our culture's fixation on hygiene and cleanliness has hurt our internal ecosystem?

There's an idea out there called the "Hygiene Hypothesis" that has been around for about 30 years. It says just what you've said: "Excessive hygiene is bad for us and if we really want to be healthy, we should cover ourselves in dirt and eat dirt." My hypothesis is different. I believe that microbes in dirt are irrelevant, but the ancient microbes that we have evolved with for millions of years are important. The question is "How do we find the right balance?" I'm not calling for the return of tuberculosis or HIV. We need to figure out which of the ancient organisms that used to live in us are the most important and bring them back.

"The current estimates are that 70% to 90% of all the cells in the human body are microbes. That means that a minority of your cells are actually 'you.' The rest are the microbes that you carry."

Can you talk about what your lab is currently working on?

A lot of our work consists of giving mice antibiotics and measuring different things. We're studying their propensity to become obese, to develop diabetes and to develop asthma. Another thing that we're looking at that very few people are studying is the observation that over the last few decades, people are getting kidney stones more often. The most common kind of kidney stone involves calcium oxalate. Oxalate is a waste product of the human body that we can't metabolize. It turns out there's a bacteria in the gut that does metabolize it, and there is some evidence that oxalobacter is disappearing.

What is the extent of how individualized each person's microbiome is? Will we be able to identify a person based on his or her microbiome?

We almost certainly will be able to identify people by their microbiomes. When people take an antibiotic, the composition of their microbiomes change, but my guess is that we'll still be able to see the ultimate signal. In fact, there was a paper that came out a few years ago that showed that if you looked at computer keyboards in a busy office, you could tell who was using them based on the bacteria that their fingers deposited on the keyboard. Your finger bacteria are different than mine.

You've spoken about the size and complexity of the microbiome. How are we using computers and data to power our search here?

I like to compare the microbiome to the airline business, in the sense that it is almost unfathomable that the airline business could exist before computers. We couldn't do much to study the microbiome until we had high throughput sequencing to tell us what's there and then the computers and the software to put it together. There's just so much work on the informatics. New tools are being created all the time and they're making it easier and it's giving us a deeper and deeper look.

Is the continuing increase in computing power enabling us to study this faster and more efficiently?

Absolutely. There are two things happening. One is the improvement in computer power and the associated software and the other is the dramatic decrease in the cost of sequencing. Sequencing speeds are increasing faster than Moore's Law. We did a study eight years ago to study the microbiome of the skin and to get 2,000 sequences it took one person about three years to do all the work. That was a very big paper. It was the first molecular study of the skin. Now, we can do a single run and we get 20 million sequences after only a few days of computing!

Where do you see the field 5 or 10 years from now?

I think we are going to be harnessing the microbiome to do our work for us to treat disease. I think that we're going to be finding the organisms we've lost and using some of those organisms to treat medical conditions. Let's say someone has an immune deficiency of a certain kind. We'll be able to find a microbe that speaks to those cells and turns them on. In addition to treatment of disease, I think the doctor of the future will be able to perform diagnosis via stool and offer individualized treatments.

What has the response been like to your book?

So far it's been great. Surprisingly, I've had very positive reviews from my colleagues around the world. I'm waiting for the backlash.

Do you think that we can still change the culture of antibiotics usage in this country?

I think it is not too late. A lot of damage has occurred and I wrote *Missing Microbes* as the wake-up call. 50 years ago Rachel Carson wrote *Silent Spring* to tell us about the harm from pesticides and that book made a difference. I'm hoping that *Missing Microbes* can make a difference too. **ET**

Stethoscope Detects Epileptic Seizures

Continued from page 1

the study of functional specializations in the human cerebral cortex and the dynamics of activity across cortical regions. They study human brain networks in experimental and naturalistic settings as well as during rest and sleep. They record simultaneously from multiple nodes of the same functional network and test their causal role in a given behavior or cognitive function. Their goal is to understand the anatomical and physiological basis for human behavior and cognitive experience and how these might be affected in patients with neurological disorders. Dr. Parvizi received his MD from the University of Oslo and Ph.D. in neurosciences from the University of Iowa. He completed his medical internship at Mayo Clinic and Neurology Residency at BIDMC-Harvard before joining the UCLA for fellowship training in Clinical Epilepsy and Neurophysiology. He moved to Stanford University in July 2007 and started the Human Intracranial Cognitive Electrophysiology Program (SHICEP). His research is now supported by NIH, Stanford NeuroVentures Program, and Stanford School of Medicine.

Tell us a bit about your background.

I am trained as a medical doctor. I specialized in treating patients with neurological problems and sub-specialized in treating neurological patients who have uncontrollable seizures that are frequent enough to disable them and prevent them from having a meaningful or regular life. The way we try to treat these patients is try to understand exactly where the seizure is originating and decide whether or not it is safe to surgically operate. I practice as a medical doctor and I see patients with this particular kind of neurological problem at Stanford Medical Center.

How many people around the world suffer from seizures?

One percent of the population globally speaking suffers from epilepsy. Thirty five percent of epileptics have uncontrolled seizures, or what we call "medicated resistant epilepsy." There are about one million patients in the U.S. alone who have ongoing seizures while they are taking medications.

Do we have any ideas for what causes epilepsy?

We have some ideas for certain kinds of epilepsy, but much still remains a mystery. We need some more research to understand exactly why some patients are more likely to have uncontrollable seizures than others. We treat them medically, but they keep having breakthrough seizures frequent enough to disable them for the rest of their lives. Unless we go surgically and find the focus and cut it out. We usually don't want to go in unless we are confident that we will be able to safely cut the region without causing harm.

> **"We are developing a device that can monitor the brain and notify patients or caregivers when seizures are taking place."**

What are any other symptoms of seizures besides uncontrollable shaking?

There is a popular misunderstanding that seizures are defined by falling, convulsing and shaking, when in fact the majority of seizures have no behavioral manifestations. They are very subtle and can go undetected. Seizures only cause falling and convulsing when they propagate to certain areas of the brain and take over larger segments. Sometimes seizures cause a patient to be confused, lose his or her memory, behave oddly for two minutes, and then after that he or she goes back to normal.

If that's the case, how do you define a seizure?

A seizure is a departure from normalcy due to neurons firing rhythmically in the brain. Imagine you have a city and you try to listen to the city outside your window. You won't hear one specific rhythm unless there is a coordinated mass demonstration, sporting event, rally, etc. The brain operates in a similar manner. When you attempt to listen to the brain, you will only hear a cacophony due to the sheer number of neurons firing separately. Seizures take place when a population of neurons (we still don't know exactly how many) falls into a rhythm.

How does this relate to your work?

Seizures that have behavioral implications can be extremely devastating for somebody's psychological health. I had a patient who got expelled from class due to weird behavior, only for us to find out later that she was having a seizure. We are developing a device that can monitor the brain and notify patients or caregivers when seizures are taking place. There is currently no device available to know what's going on inside the head. As a result, we are working on creating a device that listens to the noise of the brain, detects when neurons are falling into a rhythm and makes it easily noticeable for patients.

What is the current process to evaluate seizures?

The current process is incredibly tedious. Suppose a seizure-prone student starts behaving oddly. He then has to go to the ER, where they will likely perform a CT scan. After nothing shows up, they will show an EEG, which is a rare, time consuming and expensive process. You have to haul an EEG machine that costs hospitals nearly half a million dollars to the patient's bedside. Then they glue electrode after electrode after electrode to the patient's head and it takes a long time. Only after that can they capture the EEG signals.

At this point, you're not even halfway. You have to transfer that EEG signal to a computer that will visualize it with software, etc. Then you have to call a doctor at home to read it and tell you if the patient is having seizures or not. By the time the patient's doctor goes to the computer and sees the seizure, he has to then communicate with the ER doctor, who likely has already finished his shift by then. The current process takes so long that it's awful.

How would your device change the current process for seizure evaluation?

Our device is very intuitive. Our eyes are not trained to capture abnormalities. Our ears, on the other hand, are extremely, evolutionarily predestined to capture varied subtleties. Our device is extremely portable, so you can have it in your pocket, a doctor could have it in the ER or ambulance, and mom can carry it around with her. You put the device on the patient's head and after a few seconds you will be able to hear the sound of the brain.

How does this device accomplish this so simply as compared to the current

Stethoscope Detects Epileptic Seizures

Continued from page 6

process?

As I mentioned before, seizures take place when a large group of neurons fire in synchronicity. We have the ability to hear when neurons fire. While our device is not able to read what your brain is thinking about, it can listen to the global sound of the sphere, so it can hear when parts of the brain are in seizure. Additionally, you can also move it around to see which part of the brain is seizing.

There are patients that come to the Intensive Care Unit right after an operation because they haven't woken up after surgery because the brain has gone into this circular rhythmic way. With our device, a doctor can just put our stethoscope over their head and within a second or two they know if there's a seizure going on.

Your goal is to have this readily available for parents and other caregivers. How easy is it for people to recognize seizures with your device?

In our tests we have shuffled four normal brain sounds and four seizure brain sounds and have given this to subjects in multiple surveys. Our data shows that more than 92% of people can accurately detect seizures using our device. The amazing thing that taking these brain waves and turning them to sounds accomplishes is that it only takes a second or two for them to say "Ah, this is seizure. I can hear it." Anyone has the ability to identify if the brain is behaving normally or not. By the way, we don't envision this only for humans. Many pets in this country have seizures as well. This covers any living organism with epilepsy.

What inspired you to convert brain waves into music?

In 2008, I was very tired after taking care of a patient who was implanted with electrodes in the head. I went to a concert at Stanford by Kronos Quartet. I listened to their performance called "Sun Dreams," where they converted signals from NASA spacecraft into music. I learned that engineering-wise, it's possible to turn any signal into sound.

It was in this performance where they had converted the signals from space into sound, and I realized that you might also be able to convert brain signals into sounds. I found Chris Chafe, director of Stanford's Center for Computer Research in Music and Acoustics, who happened to be on sabbatical so he could waste this time experimenting with the signals that I sent him. He's been a wonderful colleague and we're working on this front to make sure that we can actually turn this signification to something that is more than just instant seizure detection. We are working on developing the ability to listen to the mood of the brains. Currently, we can grossly determine if someone is fatigued or drowsy versus vigilant and aroused.

Now that you have developed the ability to convert these brain signals into noises, what are your next steps?

Our goal is to turn this device into an instant seizure detection device that will help tons of doctors and patients. We would like to get this device into every single ambulance, ER, ICU, doctors' offices, and into the hands of every mom and dad of epilepsy patients. Additionally, patients can wear these devices as regular monitoring devices. The device will be small enough that they could wear a hat over it if they choose to.

When you first started thinking about turning brainwaves into music did you have seizures in mind, or was that kind of an accidental discovery?

I was more interested in learning how the brain sounds. It started out as a curiosity, but later on I became more focused on developing this as a medical device. The problem with most neurofeedback devices is that they attempt to visualize brainwaves, whereas I believe that an audio format is much more easily digestible. We give you the ability to listen to your brain in a dark room with closed eyes.

Some scientists are researching using "noise cancelling" with neuro-stimulation. Is there any chance that scientists could mitigate a seizure by using this device to read brain waves and "cancel them out?"

A company is working on similar work here at Stanford, and my colleague is the chief scientist studying this. We have the technology to do this, but it involves implant devices in patients. This is very different because it involves planting an electrode at the source of seizures in the brain, and it detects the seizure and then stimulates it. For that you need to conduct an invasive surgery to implant this device, which is a very risky proposition. We envision our device to serve as a "stethoscope for the brain," an inexpensive, easy-to-use solution that tells you when something is wrong.

What are next steps for commercialization?

We don't want to prematurely get this out. We want to make sure that our product is FDA approved and for FDA approval we need a clinical trial. We are beginning clinical trials now and will hopefully complete them within three months. We have a prototype that we've been working with, but it's very early and not durable. IDEO is going to help us turn this into a nicer-looking, sturdy device.

You mentioned you want wide distribution for this device. Will the device be portable? If so, how will it be powered?

It will be portable, battery-powered and will be able to transmit information to the cloud where it will be saved. That is one of the aspects that make this device so interesting. If someone has two or three events per month and the doctor wants to know what these events are, they currently either have to wear an EEG for a whole month, or they have to come to the doctor very, very precisely at the time that their event occurs, which is impossible as you can't predict when they happen. The beauty of this device is that if you think something feels wrong, you can put on the device, which will record your brainwaves and send them to the cloud for further analysis.

Should you recognize that a seizure is taking place, what can be done to treat the condition or mitigate symptom?

When you know that a child is confused due to seizures, you can treat it appropriately. When I said "uncontrollable epilepsy," it doesn't necessarily mean uncontrollable seizure. Seizures can be controlled right there with medication. Current treatments abort seizures that are currently taking place, but they unfortunately do not prevent seizures from developing in the future.

There is evidence that detecting seizure early on and acting on them shortens the length of hospitalizations. So, if one hospital can shorten 10 nights of stay, you're talking about numbers near $100,000. If one of our devices can be sold for $200, that's totally worth it. **ET**

The Emerging Tech Portfolio

Company[symbol]	Coverage Initiated	Current Price	52-week range	Mkt Cap ($mil)
INTELLECTUAL PROPERTY INCUMBENTS Leading researchers in the physical sciences, with big potential for spin-offs and revolutionary breakthroughs				
GE [GE]	8/07	$26.67	$22.76-$28.09	$267,490.00
Hewlett-Packard [HPQ]	3/02	34.40	20.25-35.20	64,370.00
IBM [IBM]	3/02	181.97	172.19-200.94	184,190.00
LIFE SCIENCES Companies that are working at the cutting edge of medical technology				
Nanosphere [NSPH]	11/07	1.61	1.20-3.80	123.84
ELECTRONICS Companies that have corralled the key intellectual property that will be the foundation for next generation electronics				
Nanosys [private]	3/02	n/a	n/a	n/a
ENERGY Companies that are developing high-efficiency, low-cost alternative energy technologies				
First Solar [FSLR]	8/07	71.10	35.59-74.84	7,120.00
ENABLING TECHNOLOGIES Tools and instrumentation that enable critical science and technology discoveries				
Veeco [VECO]	3/02	34.23	28.23-44.39	1,370.00
FEI Company [FEIC]	1/03	88.80	71.04-111.57	3,750.00
Accelrys [ACCL]	3/02	12.50	7.75-12.58	696.99
INVESTMENT VEHICLES Funds that have investments in promising emerging technology companies				
Harris & Harris Group [TINY]	5/02	3.29	2.83-3.94	102.64
PowerShares WilderHill Clean Energy [PBW]	8/07	6.89	4.93-8.02	207.36

Stock prices as of June 23, 2014

Word on the Street

GE: General Electric rose 0.7% during a month of marathon negotiations concluding with the French government approving its offer to acquire most of Alstom's business for $13.5B. As part of what would be GE's largest-ever industrial acquisition, the multinational agreed to sell its rail signaling business to Alstom for $825M and will be setting up a series of JVs to make nationally strategic technologies such as nuclear turbines. The French government announced that it would buy a 20% stake in Alstom, making it the company's largest shareholder. The acquisition is expected to close next year.

HPQ: Hewlett-Packard finished the month up more than 1%, continuing its meteoric rise over the past 18 months. The computing giant touched on a new 52-week high following an upgrade from **Goldman Sachs** [GS] from Sell to Neutral. HP stock is up more than 21% year-to-date, and almost 175% since November 2012.

IBM: Big Blue declined 2.6% for the second consecutive month as the IT conglomerate continues to try to break out of a sales slump. Reports suggest that the company is in talks to sell its semiconductor plants to Global Foundries, as the company is evaluating an exit from the chip-making business. IBM stock is down more than 3% year-to-date and is currently trading at a 35% discount to the S&P 500 index.

NSPH: Nanosphere was flat for most of June until shares soared almost 17% on June 23, as the molecular diagnostic supply company announced that it had been selected by HealthTrust to provide tests for more than 1,400 acute care facilities. Under the agreement, HealthTrust will offer members access to purchase Nanosphere's Verigene tests to detect infections in the bloodstream, respiratory and GI tracts. Nanosphere stock is up almost 15% this month.

FSLR: First Solar gained more than 17% last month as the U.S. Department of Commerce announced anti-subsidy tariffs ranging from over 18.5% to 35% on Chinese solar equipment companies, greatly benefiting American solar companies. Additionally, First Solar announced that it plans to acquire the German firm Skytron Energy in a move that would more than double the company's operations and management assets. The company was also chosen to build a 150 MW facility near El Centro, California.

VECO: Veeco Instruments shares gained 4% during the month, as the LED and hard disk drive manufacturer saw its Buy rating reaffirmed by analysts at Berenberg Bank.

FEIC: FEI Company shares climbed 11.1% after it more than doubled its dividend to $0.25 per share. Despite a rare earnings miss last month, the company believes that it remains on track to hit $1B in sales.

TINY: Harris & Harris Group declined 2.6% on the month.

PBW: The PowerShares WilderHill Clean Energy portfolio gained 9.2% on the month.

Forbes/Wolfe Emerging Tech Report
is published monthly by Forbes Media LLC and Angstrom Publishing LLC, 60 Fifth Avenue, New York, NY 10011
Editor: Josh Wolfe Contributing Editor: Jeff Weinstein

Forbes Media LLC
Vice President/Editor, Newsletters: Matthew Schifrin
Senior Editors: John Dobosz, Tina Russo
Subscription Director: Diane Schmid

To subscribe call 1-877-733-7876 from within the U.S. or 952-646-5381 from outside the U.S.; or visit Forbes.com Investment Newsletters (www.forbesnewsletters.com) on the Web.

For editorial information, e-mail: nanotech@forbes.com

