



# Vibrations

*Powering Sound Ideas*

## Pivot to Virtual Collaboration

The Ultrasonic Industry Association, like almost all other associations, had to reposition its annual gathering designed to share ideas, latest advances and provide networking opportunities.

The UIA board recognizes that one of the most helpful components of the annual symposium is the

“unconference” portion - the opportunity for individuals deeply involved in the ultrasonic applications and research to discuss the applicability of information to their needs.

In response to this need - which is still as vital as ever - the UIA Board is

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establishing a **Virtual Collaboration**, designed to provide ultrasound information and the opportunity for small groups to discuss ways that this information can be successfully implemented.

The first **Virtual Collaboration** will be held on Thursday, 24 September 2020 at 10

### Special Points of Interest

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**Virtual Collaborations**  
September 24  
10 am EDT  
3 pm BST  
[www.ultrasonics.org/VC](http://www.ultrasonics.org/VC)  
**Piezo Stack Preload in Transducers**



Jay Sheehan will lead the first Virtual Connection with his presentation on Piezo Stack Preload in Transducers.

The program will begin with a presentation on preload basics, mechanical elements and analysis, pressure FEA, effects on piezo properties and applying

preload in practice.

The group will then be divided into small groups for discussion on the application and implementation of preload in both industrial and medical settings.

### Registration is Free

In recognition of the support UIA received from member

companies, this first Virtual Connections is free.

A Virtual Connections will be held every other month to encourage sharing of ideas among members that has been a hallmark of the UIA Symposium.

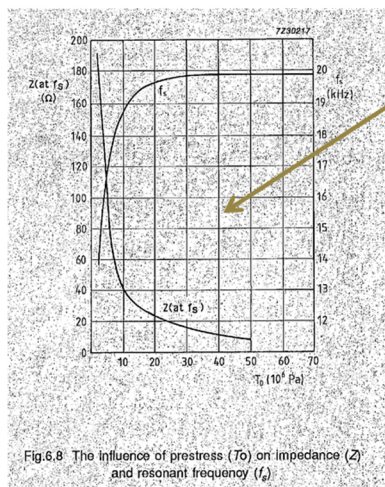
To register go to:  
[Ultrasonics.org/VC](http://Ultrasonics.org/VC)

## More about Virtual Collaborations

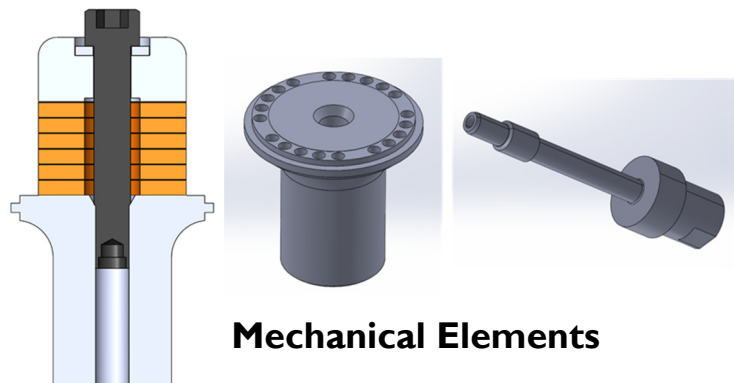
One of my favorite aspects of Ultrasonic Industry Association symposiums is the collaboration that occurs during breaks in the actual symposium presentations. Ultrasonic technology is highly non-linear and often confounding, and bouncing thoughts with peers is practically impossible on a day to day basis due to the significant intellectual investment necessary to understand the issues. With the current pandemic, it is not feasible for many to meet in person and have these collaborations. That is why I am looking forward to the UIA's virtual collaboration on applying pre-load to Langevin-type piezoelectric transducers. Over the years I have experienced several instances of pre-load issues that at the time were confusing, but with hindsight are completely understandable. These collaborative discussions provide the insight needed to overcome common issues that are otherwise difficult to comprehend.

Jeff Vaitekunas Ph.D.

Assistant Professor, Penn State Behrend



Stable preload region between 5000-6000 psi



## Ultrasound Applications in the News

### Focused ultrasound opening brain to previously impossible treatments

University of Virginia researchers are pioneering the use of focused ultrasound to defy the brain's protective barrier so that doctors could, at last, deliver many treatments directly into the brain to battle neurological diseases. The approach, the researchers hope, could revolutionize treatment for conditions from Alzheimer's to epilepsy to brain tumors -- and even help repair the devastating damage caused by stroke.

Richard J. Price, PhD, of UVA's School of Medicine and School of Engineering, is using focused soundwaves to overcome the natural "blood-brain barrier," which protects the brain from harmful pathogens. His approach aims to breach the barrier only where needed, and only when needed, and then deliver treatments in exquisitely precise fashion.

"The blood-brain barrier is one of the greatest, if not the greatest, challenge to drug delivery for the central nervous system," Price explained. "Evolution gave us this barrier because the central nervous system needs to be protected. The problem is now we want to deliver something to those cells and evolution has had millions and millions of years to optimize a solution to stop it. ... So I'm attempting to circumvent biology with physics."

### Focused Ultrasound's Great Potential

Focused ultrasound focuses sound waves inside the brain much like a magnifying glass can focus light, letting doctors manipulate tissue without cutting into the skull. Magnetic resonance imaging (MRI), meanwhile, lets them watch what's happening inside the brain in real time. While Price, a biomedical engineer, is developing his techniques in the lab, doctors are already using the technology to treat conditions such as Parkinson's tremor.

Use of focused ultrasound to defy the brain's protective barrier

Price marvels at the approach's specificity. "With MRI, we can look at the target, whether it's a brain tumor or maybe it's a part of the brain we want to do gene therapy on, and we can select it -- we can actually make a treatment plan and say, We only want to open the [blood-brain] barrier there. The other 95% of the brain, we don't even touch," said Price, the research director at UVA's Focused Ultrasound Center. "Then, when we apply the focused ultrasound, it opens the barrier there for a few hours. It lets us get the gene therapy across, and then it closes naturally."

### Delivering Gene Therapy

Gene therapy introduced via focused ultrasound would essentially reprogram faulty cells.

For brain tumors, Price is exploring the potential of using focused ultrasound to deliver gene therapy via "deep-penetrating nanoparticles." The nanoparticles, designed by Price's collaborators at Johns Hopkins University, "are specifically engineered to penetrate the tissue extremely well," he said. The problem has been transporting them where they're needed, often deep inside the brain, and Price says focused ultrasound holds the answer.

His solution is to use the focused soundwaves to open spaces between cells in the tissue. "It doesn't help us if you can't get to the neuron that's 50 microns away," he said. "So that becomes an engineering transport problem."

In addition to delivering the therapy, focused ultrasound can "precondition" targeted tissue to enhance the effectiveness of the gene delivery up to five-fold, Price has found. The preconditioning represents a "simple and effective strategy" to boost the benefits of the nanoparticles, he and his colleagues report in a scientific paper.

### Improving Stroke Outcomes

For stroke, a condition that is often debilitating when it's not deadly, Price aims to help the brain heal

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## Ultrasound Applications in the News, continued

itself. He would do this by using focused ultrasound to put "homing molecules" inside damaged areas to recruit neural stem cells to do repairs. For this, his team has developed an innovative technique called "sonoselective transfection" that avoids opening the blood-brain barriers in brains that are already compromised.

"With stroke, there's a lot of effort to try to salvage as much neural tissue as possible by doing things like gene therapy," he said. "In our lab, we thought, well, maybe we can deliver treatment right to the cells that need it, without breaching the blood-brain barrier. And my students basically figured out how to do that."

That notion of helping the body heal itself, of using focused ultrasound to activate an immune response, could be useful in cancer treatments as well. "We would love to be able to put something into those [tumor] cells that will then allow them to start recruiting immune cells into the tumor," he said. "We have a lot of evidence that we can do some interesting things with focused ultrasound with respect to the internal landscape of those tumors."

Price, of UVA's Department of Biomedical Engineering, emphasizes that his work is still early, but he is excited to be creating new techniques that could change how

many major diseases are treated in the not-too-distant future.

"We've had good results [with the research] so far. But what I, as an engineer, get excited about are all these tools we have made," he said. "You can use these tools for all these different applications. We think there are a lot of really exciting possibilities."

**SOURCE:** University of Virginia Health System. "Focused ultrasound opening brain to previously impossible treatments." *ScienceDaily*. *ScienceDaily*, 6 May 2020. <[www.sciencedaily.com/releases/2020/05/200506133649.htm](http://www.sciencedaily.com/releases/2020/05/200506133649.htm)>.

### Researchers destroy cancer cells with ultrasound treatment

An international research team led by Dr. Tali Ilovitsh of the Biomedical Engineering Department at Tel Aviv University developed a noninvasive technology platform for gene delivery into breast cancer cells. The technique combines ultrasound with tumor-targeted microbubbles. Once the ultrasound is activated, the microbubbles explode like smart and targeted warheads, creating holes in cancer cells' membranes, enabling gene delivery. Conducted over two years, the research was published on June 9 in the journal *Proceedings of the National Academy of Sciences (PNAS)*.

Dr. Ilovitsh developed this breakthrough technology during her postdoctorate research at the lab of Prof. Katherine Ferrara at Stanford University. The technique utilizes low frequency ultrasound (250 kHz) to detonate microscopic tumor-targeted bubbles. In vivo, cell destruction reached 80% of tumor cells.

We realized that this discovery could be used as a platform for cancer treatment and started to inject microbubbles into tumors directly.

"Microbubbles are microscopic bubbles filled with gas, with a diameter as small as one tenth of a blood vessel," Dr. Ilovitsh explains. "At certain frequencies and pressures, sound waves cause the microbubbles to act like balloons: they expand and contract periodically. This process increases the transfer of substances from the blood vessels into the surrounding tissue. We discovered that using lower frequencies than those applied previously, microbubbles can significantly expand, until they explode violently. We realized that this discovery could be used as a platform for cancer treatment and started to inject microbubbles into tumors directly."

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## Ultrasound Applications in the News, continued

Dr. Ilovitsh and the rest of the team used tumor-targeted microbubbles that were attached to tumor cells' membranes at the moment of the explosion, and injected them directly into tumors in a mouse model. "About 80% of tumor cells were destroyed in the explosion, which was positive on its own," says Dr. Ilovitsh. "The targeted treatment, which is safe and cost-effective, was able to destroy most of the tumor. However, it is not enough. In order to prevent the remaining cancer cells to spread, we needed to destroy all of the tumor cells. That is why we injected an immunotherapy gene alongside the microbubbles, which acts as a Trojan horse, and signaled the immune system to attack the cancer cell."

**Source: American Friends of Tel Aviv University. "Researchers destroy cancer cells with ultrasound treatment: Technique combines ultrasound application and tumor-targeted microbubbles that attach to cancer cells and explode." ScienceDaily. ScienceDaily, 26 June 2020. <[www.sciencedaily.com/releases/2020/06/200626141415.htm](http://www.sciencedaily.com/releases/2020/06/200626141415.htm)>.**

### Lego builds anaesthesia skills according to new study

Lego could be used as a practical tool to train doctors in anaesthetic skills according to new research that has shown a simple task using the building bricks can help improve technical skills -- a finding that could improve medical training and patient

safety.

Scientists from the University of Nottingham's School of Psychology and School of Medicine developed a task where people copied shapes using bricks that they could see in a mirror. They found this simple training improved student performance in an ultrasound-guided regional anaesthesia task. The results of the study have been published in British Journal of Anaesthesia

Ultrasound-guided regional anaesthesia is when anaesthetists inject local anaesthetic medicines around specific nerves to provide pain relief after surgery. The anaesthetists commonly use an ultrasound machine to direct their injections into the correct position around the nerve and minimise the risks of the procedure. Training new doctors in these skills currently relies on extensive practice on expensive simulators and learning during clinical care.

Dr Hewson, Honorary Assistant Professor at the University of Nottingham and Consultant Anaesthetist at Nottingham University Hospitals NHS Trust explains: "Ultrasound guided regional anaesthesia is a vital skill practiced by anaesthetists around the world to reduce pain after surgery. These procedures require a high level of accuracy and skill and it is vital we find safe and reliable ways to help train doctors to perform them. We wanted to explore an inexpensive, accessible and self-directed educa-

tional tool to improve the ability of doctors to perform regional anaesthesia using ultrasound direction."

The educational tool required students to view in a mirror two-dimensional images of three-dimensional models constructed from Lego Duplo® bricks. They then had to recreate the models they could see in the mirror. After they had completed building the models, they were able to compare them directly with the originals. If they failed the task, they were asked to return to the mirror and make good any errors. Scientists measured the students ability to perform ultrasound-guided injections on a laboratory model before and after this training and saw that students exposed to the Lego training performed the ultrasound task significantly better than students who did not receive Lego training.

Professor Eamonn Ferguson from the University of Nottingham's School of Psychology helped to design the task and explains why it worked: "This research provides a simple and innovative solution to improving people's spatial rotation and awareness. That is, to perform many modern medical technical skills a doctor has to understand how a two-dimensional image of an organ relates to the three-dimensional world inside the body. This involves finding anatomical landmarks and understanding where you are in 3D space, from a 2D image with no usual cues of judging up-down, top-bottom, left-right. We found previously people with good mental rotation skills were better at

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## Ultrasound Applications in the News, continued

regional anaesthesia, so we wanted to develop a way of developing these skills, in a simple, safe and inexpensive fashion. We did this by developing a simple task that mirrors -- literally- the key features of ultrasound-guided regional anaesthesia -- understanding 3D from 2D. We had people actively engage in building as this helps to coordinate eye-hand movement and 3D representations in the brain. This simple task was extremely effective. Ten to fifteen minutes on this simple Lego building task, can save on expensive time in the simulator. We were delighted with the results." **Source:** Materials provided by Radiological Society of North America

**Source: University of Nottingham. "Lego builds anaesthesia skills according to new study." ScienceDaily. ScienceDaily, 21 July 2020.**

**<[www.sciencedaily.com/releases/2020/07/200721114720.htm](http://www.sciencedaily.com/releases/2020/07/200721114720.htm)>.**

### Scientists achieve major breakthrough in preserving integrity of sound waves

The new findings, which appear in the journal *Science Advances*, will pave the way for cheaper, lighter devices that use less battery power, and which can function in harsh or hazardous environments. Andrea Alù, founding director of the CUNY ASRC Photonics Initiative and Professor of Physics at The Graduate Center, CUNY, and postdoctoral research associate

Xiang Ni were authors on the paper, together with Amir Ardabi and Michael Leamy from Georgia Tech.

The field of topology examines properties of an object that are not affected by continuous deformations. In a topological insulator, electrical currents can flow along the object's boundaries, and this flow is resistant to being interrupted by the object's imperfections. Recent progress in the field of metamaterials has extended these features to control the propagation of sound and light following similar principles.

In particular, previous work from the labs of Alù and City College of New York Physics Professor Alexander Khanikaev used geometrical asymmetries to create topological order in 3D-printed acoustic metamaterials. In these objects, sound waves were shown to be confined to travel along the object's edges and around sharp corners, but with a significant drawback: These waves weren't fully constrained -- they could travel either forward or backward with the same properties. This effect inherently limited the overall robustness of this approach to topological order for sound. Certain types of disorder or imperfections would indeed reflect backwards the sound propagating along the boundaries of the object.

This latest experiment overcomes this challenge, showing that time-reversal symmetry breaking, rather than geometrical asymmetries, can be also used to induce topological order. Using this method, sound propagation becomes truly unidirectional, and strongly robust to disorder and imperfections

"The result is a breakthrough for topological physics, as we have been able to show topological order emerging from time variations, which is different, and more advantageous, than the large body of work on topological acoustics based on geometrical asymmetries," Alù said. "Previous approaches inherently required the presence of a backward channel through which sound could be reflected, which inherently limited their topological protection. With time modulations we can suppress backward propagation and provide strong topological protection."

The researchers designed a device made of an array of circular piezoelectric resonators arranged in repeating hexagons, like a honeycomb lattice, and bonded to a thin disk of polylactic acid. They then connected this to external circuits, which provide a time-modulated signal that breaks time-reversal symmetry.

As a bonus, their design allows for programmability. This means they can guide waves along a variety of different reconfigurable paths, with minimal loss. Ultrasound imaging, sonar, and electronic systems that use surface acoustic wave technology could all benefit from this advance, Alù said.

**Source: Advanced Science Research Center, GC/CUNY.**

**"Scientists achieve major breakthrough in preserving integrity of sound waves." ScienceDaily.**

**ScienceDaily, 17 July 2020.**

**<[www.sciencedaily.com/releases/2020/07/200717204521.htm](http://www.sciencedaily.com/releases/2020/07/200717204521.htm)>.**

## From the President

These have been “troubling times” for us all, and I hope everyone stays safe until this cloud on the world passes. It pains me to see all our hard work for the UIA 2020 Warwick symposium go up in the COVID



**Dominick DeAngelis**  
UIA President

smoke, but we at the UIA hope to embark on some virtual collaboration to keep our curious minds mingling again until we can reconvene next year in Warwick. To start things off, our board member and past UIA 2019 Toronto symposium chair, Jay Sheehan will do our first Virtual Connection in the series on “Piezo Stack Preload in Transducers.” Jay will share some of his wealth of experience designing “bolted sandwich” or Langevin transducers for high power ultrasonics, which I am sure you will not find in any book! This first Virtual Connection will be our “trial balloon” to see if there is interest in these events, so please register for the webinar now if you would like to see this series continue. Don’t worry if you were looking forward to our great program in Warwick this year, since like I told you before our symposium chair, and two-term past president, Mark Hodnett never disappoints, so I am sure he will be able to cajole the same crew back to Warwick next year!

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## How can ultrasonics enhance the value of your business?

UIA is the international business forum for users, manufacturers, and researchers of ultrasonics. Our members use acoustic vibrations to improve materials, industrial processes, and medical technology. We call this *powering sound ideas*.

Let's work together to power your sound ideas. Contact a member consultant or company through our online Referral Network, learn about ultrasonics with our online primer, or meet industry leaders at our next symposium.



## Important Dates

**24 September 2020: Virtual Connections: Piezo Stack Pre-Load in Transducers**



**Virtual  
Collaborations**

**September 24  
10 am EDT  
3 pm BST**

[www.ultrasonics.org/VC](http://www.ultrasonics.org/VC)

**Piezo Stack Preload in Transducers**