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ultrasonic industry association
UIA
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Vibrations

Powering Sound Ideas

Virtual Collaborations 5 September: IP Tips & Tricks

Intellectual property tips and tricks for moving from ideas to commercial products

Presented by Kevin Houser, Ethicon J&J

Unlock the secrets to transforming your innovative ideas into thriving commercial products at our must-attend Virtual Collaborations. This guide through the intricate world of intellectual property protection, provides the strategies and tools needed to safeguard your groundbreaking discoveries. Discover the patent process, learn proven techniques to bolster your ideas' chances of securing legal safeguards, and explore a unified pathway to commercial success. Packed with invaluable insights and real-world case studies, this event is a must for any ultrasonic innovator seeking to navigate the complexities of transforming their vision into a profitable reality.

Don't miss this opportunity to gain a competitive edge and propel your ultrasonic innovations towards commercial viability.

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UIA53 28 - 30 April 2025 in Halifax, Nova Scotia

Professor Jeremy Brown, School of Engineering at Dalhousie University, Halifax, and co-founder of Daxsonics and Sound Blade Medical will deliver the plenary talk during the *Concept to IP session.*

The UIA is looking forward to an engaging event chaired by Andrew Mathieson, UIA53 Symposium Chair.

UIA53 features a balanced program of medical and industrial presentations from experts in ultrasound from throughout Canada, EU, UK, and the US. UIA offers the crossroads of manufacturing, research and academia that provides for in-depth discussion about the current and future applications of ultrasound.

A key theme of UIA53 will be Concept to IP during which transitioning intellectual property from an idea to a commercial product will be explored.

Halifax offers an exciting intersection of the implementation of ultrasonics in both academic and commercial settings.

We are now accepting abstracts for UIA53 - click here!

UIA52 Sessions ReCap

Monday, 8 April 2024

The Monday Medical session started

with **Dr. Martin Hofmann's** presentation on additively- manufactured ultrasonic osteotomy inserts.

The most used osteotomy tools are oscillating saws. Performance limitations include unintended injuries to non-targeted tissue, thermally induced osteonecrosis, and bone splintering. Ultrasonic bone removal devices are primarily used for performing osteotomies, osteoplasties, drilling and finishing. While ultrasonic instruments facilitate precise cuts and safer operation, they also have limitations related to high manufacturing costs, slow cutting speeds, and elevated temperatures during cutting. The shared research work was centered around the development of additively manufactured ultrasonic blades that cut fast and do not overheat. Additive manufacturing offers design opportunities that are not achievable through traditional machining techniques; for example, the addition of cooling channels located inside the blade. Proof of concept prototypes of seven candidate designs were built to verify manufacturing capabilities and blade performance. Preliminary results showed a tight resonant frequency range and good linear correlation between velocity amplitude and drive signal. Simulated use included up to 10mm deep cuts performed with half millimeter thick blades under 8N and 30N constant loads, and up to 15N variable loads. Tissue selectivity was evaluated by cutting through raw eggshells without damage to shell membrane. Preliminary results support the potential for precise, controlled cutting that could lead to reduced bone loss and minimization of bleeding and thermal injury. Challenges to overcome include blade edge and angle defects, partially obstructed irrigant outlets, deformed and/or fractured inserts, foam formation on the bone model. The ongoing research efforts also include the development of a robot-assisted test platform intended for evaluating bone dissection efficiencies in a variety of simulated surgical procedures.

Next, **Dr Heikke Nieminen** presented on the development path and the first clinical experience of the Ultrasound-enhanced fine-needle aspiration biopsy device, USeFNAB.

Fine-needle aspiration biopsy, FNAB, is a method used for collecting a tissue sample from a suspected area. This is accomplished with a needle, under the low, limited pressure developed by a syringe. Typically, 10-30% of FNABs fail to provide diagnostically adequate tissue yields. The shortcomings of FNAB and the alternate Core needle biopsy, CNB, include inadequate sample, delayed and less precise diagnosis, potentially leading to less-than-optimal patient treatment and false benign diagnosis. The key operating principles of the USeFNAB device together with the highlights of its development path, from Versions 1 to 3, were shared with the audience. Version 3 featuring an improved wave guide transmission was used in the clinical studies. Preliminary results of the ex and in vivo clinical validation tests show that the USeFNAB device improves tissue yield in the biopsy of human head and neck tumors, with an equal or better probability to retrieve diagnostic samples and an equivalent safety profile; all compared against the current FNAB and CNB methods.

Lisa Shriane from the University of Birmingham presented her groundbreaking work on the in vitro ultrasonic treatment of endothelial cells. Her research focused on angiogenesis, the production of new blood vessels, which is crucial to human health. Shriane conducted a meta-analysis of previous studies using Low-Intensity Pulsed Ultrasound (LIPUS) in the MHz frequency range and continuous ultrasound in the kHz frequency range. Her experiments utilized 45 kHz ultrasound exposure for five minutes, revealing a dose-dependent increase in

UIA52 Sessions ReCap, *continued*

cellular activity after 24, 48, and 72 hours. Notably, active cytoskeletons were observed after 72 hours, indicating significant effects on cell numbers. To ensure accuracy, she employed a tank to minimize reflection and eliminate standing waves. The tests showed promising results, suggesting that the stimulation effect of ultrasound on endothelial cells is time-dependent, with potential implications for future therapeutic applications.

Lisa Shraine

During the question and answer session, Heikke Nieminen asked about the potential mechanisms for growth, and whether they were related to temperature or mechanical effects (such as bubble formation). Lisa Shriane suggested that the mechanism seemed mechanical but mentioned the need to refine the setup to eliminate the possibility of thermal effects. The idea of degassing the cell medium to further clarify the mechanism was also discussed.

Ashraf Agweder from the University of Dundee presented virtually on methodology used for accurately identifying needle tip location under Doppler ultrasound imaging. Ultrasound guided regional anesthesia facilitates real time, needle, and nerve visualization during nerve blockage procedures. The accurate needle positioning is affected by the echogenic similarities of the needle tip and the neighboring tissue. This impacts optimal needle placement. The use of color Doppler shows potential for improved needle visualization with the note that limitations still exist as the color noise around the tip may still obscure visibility and consequently impact the exact assessment of tip location. The test needle was ultrasonically driven by a piezo transducer. Optimal needle detection angle, preferred drive voltage and advanced image processing techniques were investigated. The controlled needle motion at different angle orientations and drive voltage levels was captured and compared against the static needle baseline. Baseline imaging was performed in B mode while the ultrasonically actuated needle location was captured in color Doppler. The findings indicated that 60deg or smaller insertion angles combined with lower color voltage settings, produce optimal results for the needle fit accuracy.

Next, **Alexandr Kiyashko** presented on the design of a miniaturized half-wave ultrasonic transducer intended for soft-tissue dissection. Robotic Assisted Surgery, RAS, devices include robot-assisted joints that enable high instrument maneuverability and precision. Ultrasonic scalpels are the gold standard for minimally invasive general surgery, enabling high precision cutting and coagulation, with minimal blood loss. An ideal device combining the two technologies must

Alexandr Kiyashko

overcome a series of technical challenges including the size of the ultrasonic scalpel and the limited maneuverability of the ultrasonic end effector. The novel transducer developed by Nami Surgical is sufficiently small to fit through a laparoscopic port and can be maneuvered inside the patient body, thus combining the advantages of RAS and minimally invasive ultrasonic surgery devices. Nami Surgical's IP revolves around the introduction of apertures in the transducer design that enable changes to the transducer size without altering the resonant frequency, control of mode shapes and increase of output amplitude. A series of practical examples of transducer design and FEA modeling were presented, including the reduction in resonant frequency, asymmetric mode compensation, nodal plane positioning, control mode separation and coupling modes. Experimental validation testing showed that the burst pressure of a carotid artery cut and sealed with the Nami Surgical transducer was comparable to those of the currently available, commercial devices. The Nami Surgical developed technology offers substantial design flexibility that can be optimized for specific applications.

UIA52 Sessions ReCap, *continued*

Daniel Cotter from Integra LifeSciences closed the morning session with a presentation on the highly structured steps associated with the development of an ultrasonic surgical bone tip. Clinical-simulation and in vivo uses included the removal of the anterior clinoid process. Tip geometry was designed to facilitate use under microscope. The tip abrasive structure consisted of pyramid-shaped elements positioned along helical paths. Benefits over bone drills include lack of high RPM motion and less heating. The horn design includes a stepped section and a Gaussian profile. The difference between the modeled and actual motional amplitudes at 23KHz was approximately 1%. The tip flue is a combination between soft silicone and rigid Radel material. The rigid portion of the flue allows for a more ergonomical grip during use. Instrument life testing included a one-hour ultrasonic activation (approximately 80M cycles at 23KHz). The run time of the first instrument used in a surgical procedure was approximately 30 minutes. Burr and diamond drills were also used during the procedure, side-by-side with the ultrasonic bone tip. The surgeon feedback underlined smooth bone removal, good visibility under the microscope, better hemostasis, ability to stay on path and time savings primarily related to safer operation.

After breaking for lunch, **Dr. Mark Schafer** from Drexel University delivered the keynote presentation, focusing on the design of ultrasound systems for brain research across different spatial scales. His work addresses treatments for conditions such as depression, anxiety, and addiction, utilizing frequencies from 100-900 kHz. Schafer highlighted the spatial scale challenges, starting with experiments on fruit flies, where the flies were glued to holders. The initial ultrasound system was adapted from a dental scaler, with a thin

Dr. Mark Schafer

wire bonded to it. This system was calibrated and its output quantified based on distance. Schafer detailed the experimental setup and the software used to analyze the flies' responses to 15-second ultrasound exposures, repeated 4-8 times with 8-minute intervals. A video demonstrating the flies' measurable responses was shown.

Schafer then discussed a system designed for rodent studies, focusing on the central nervous system (CNS). He used an off-the-shelf nondestructive transducer with a custom cone to perform experiments on the uptake of exosomes in rats. The right hippocampus of the rats was exposed to ultrasound without microbubbles, resulting in increased uptake of nanovesicles. Schafer also presented on transcranial focused ultrasound (tFUS), targeting subcortical brain structures such as the hippocampus, amygdala, and thalamus with excitation frequencies of 600-700 kHz. The beam was electronically steered and compensated for bone attenuation. To ensure rigorous testing, a placebo pad was used to attenuate the ultrasound. Schafer concluded by presenting results on using tFUS on the amygdala for treating essential tremors and facilitating coma recovery.

Next, **Ashraf Agweder** from the University of Dundee virtually presented a comparative study on ultrasound imaging texture analysis versus force and pressure measurements. Agweder reviewed the latest technical advancements in ultrasound imaging and detailed an experimental setup involving an 18-gauge needle. He provided an overview of the calculations performed on the texture, as well as the filters and image analysis techniques employed in the study. Agweder's findings highlighted that different gauge needles produced varying feedback, emphasizing the importance of needle selection in ultrasound imaging and its impact on texture analysis.

Dr. Ali Rezai from West Virginia University virtually presented on the clinical applications of ultrasound in neuromodulation, focusing on the use of focused ultrasound (FUS). He provided an overview of current FUS systems and their regulatory status, noting that the system he uses has been FDA approved since 2016 and has treated over 15,000 patients. Dr. Rezai explained the blood-brain barri-

Ultrasound in the News, continued

er (BBB), which only allows molecules under 400 daltons to pass, and how focused ultrasound combined with microbubbles can open the BBB. This technique has potential applications in treating Alzheimer's disease and brain cancers. He presented his work using FUS to modulate the BBB for both delivering antibodies and draining beta-amyloid plaques in Alzheimer's patients, demonstrating a significant reduction in plaques compared to antibodies alone. Additionally, Dr. Rezai discussed his work on using transcranial focused ultrasound (tFUS) to treat addiction, highlighting the promising therapeutic possibilities of these advanced ultrasound techniques.

Dr. Dong Wang from the University of Exeter virtually presented his research on using Digital Image Correlation (DIC) in ultrasonically assisted orthogonal cutting, focusing on osteotomy procedures. He explained that cracks created during osteotomy can lead to instability, emphasizing the importance of minimizing strain. Dr. Wang provided an overview of his experimental setup and detailed the comparison of strain values during the cutting process. His findings revealed a 70% reduction in strain when using ultrasonically assisted cutting, highlighting the significant benefits of this technique in improving the stability and outcomes of osteotomy surgeries.

Dr. David Hughes from Novosound presented his innovative work on metal oxide thin film transducers in his talk on wireless, wearable ultrasound. He highlighted the design's improved sensitivity and discussed a range of potential applications, including use in aircraft seats, dental applications, and various wearable devices. Dr. Hughes elaborated on the wearable technology's potential, suggesting it could be used for cardiac monitoring, blood pressure measurement, dehydration monitoring, muscle activation and rehabilitation, and bladder monitoring. As the final presentation of the day, Dr. Hughes' talk concluded the medical session, after which attendees were invited to a wine and cheese reception for networking.

Dr. David Hughes

Wednesday 10 April 2024

The Wednesday morning session was chaired by Dr. Mahshid Hafezi who is a Postdoctoral Research Associate at Glasgow University.

Dr. Sebastian Schlack

The first talk was presented by **Dr. Sebastian Schlack** from PI ceramics was about "Materials properties of hard piezoelectric ceramics at cryogenic temperatures". Dr. Schlack had the challenge that his audience had all been at a Whiskey tasting followed by dinner and bar hopping the previous night, resulting in pronounced concentration and cognitive challenges. Fortunately, Dr. Schlack exhibited the appropriate sensitivity and communicated his message clearly.

The study was motivated by addressing applications in space where temperatures can drop down significantly and impacts on the properties of the piezoceramic become important. Dr. Schlack showed their setup and some examples of results on hard materials, and some on soft. One of the interesting findings in the study was that the soft material exhibited a significant reduction in piezoelectric activity when cooled down compared to the hard material and Dr. Schlack recommended to consider that effect when choosing material type for actuation at low temperatures.

Dr. Schlack delivered at great talk and afterwards there was a good discussion about hysteresis of the properties during cooling and heating and other ideas for properties that might be measured in the setup such as the coefficient of thermal expansion.

The second talk was **Mr. Yuchen Liu** from the University of Glasgow was about "Understanding the dynamics of Langevin transducers incorporating Nitenol". Nitenol is an alloy of Nickel and Titanium has properties that can be used to compensate for changing resonance behavior when caused be the self-

UIA52 Recap

about "Understanding the dynamics of Langevin transducers incorporating Nitenol". Nitenol is an alloy of Nickel and Titanium has properties that can be used to compensate for changing resonance behavior when caused be the self-heating of Langevin transducers.


Yuchen Liu

Even though Mr. Liu was interrupted early in the talk from his own wake-up alarm he quickly recovered and showed how the tuning of the Nickel Titanium composition was helpful in stabilizing operation of the transducers and ultimately would be useful to simplify the electronic driving system used.

Dr. Dominick DeAngelis from Kulicke and Soffa Industries spoke on "Optimizing the Phase Window of Ultrasonic Transducers". Dominick has had many previous talks at UIA and the experienced audience was looking forward to diving into the details of the impedance and BODE plots that a talk by Dr. DeAngelis always promises. He also had the added benefit of getting extra time to present as the previous presenter finished earlier than planned.

Dr. DeAngelis motivation for the study was to secure robustness in the performance of wire-bonding transducers by giving insight into how to design and estimate and the phase window of a transducer. This is important when driving transducers using phase locking under the changing boundary conditions which occur when the wire-bonding transducer is welding the wires.


Dr. Dominick DeAngelis

Dr. DeAngelis showed how the equivalent circuit could be manipulated and how the addition of extra electronic components and adding or removing piezoelectric rings affects the phase window.

Dr. DeAngelis delivered a great talk and the discussion afterwards circled around currents to the ceramic stack how to apply the study in different situations. Also, great praise is warranted for DeAngelis correct use of the term "ceramic".


Dr. Alex Hamilton

Dr. Alex Hamilton from University of Glasgow spoke about "Stereolithography for additive manufactured flexural ultrasonic transducers". Dr. Hamilton talked about 3D printing membrane transducers for air-coupling applications. Usually, air-coupling transducers are made using a stiff membrane of brass etc. but 3D-resins can be made that exhibit high enough stiffness that they may be used in the application. Dr. Hamilton demonstrated the capability of making transducers operating at up to 350 kHz. The resonator was measured using laser doppler vibrometry working at different temperatures and voltages.

Paul Daly from University of Glasgow discussed "Piezoceramic tube transducers and flow- based sonoprocessing". Mr. Daly showed how sonopocessing could be used in recovering technically critical materials (TCMs) from electronic waste. This can become a useful technology when the increased deployment of batteries generates a need for the raw materials in batteries to be recovered.

Mr. Daly talked about how the limitations of a batch-based system could be addressed by designing a flow-based system. The design proposed, was

Continued on the next page

UIA52 Sessions ReCap, continued

built around a piezoceramic tube through which the waste would flow in an aqueous suspension. Mr. Daly showed how cavitation was activated in the tube and how it enabled separation between copper and graphite in test samples.

The talk was well received, and the discussion afterwards circled around how having samples inside the tube would perturb the cavitation activity.

The afternoon industrial session kicked-off with our industrial keynote speaker

Professor Andy Abbott from the University of Leicester. The title of his presentation was "Ultrasonic delamination of technology critical metals from e-waste using catalytic etchants." The highlight of his talk was on the recycling of lithium batteries used in electric vehicles (EVs), but not from the end-of-life aspect, but rather from reclaiming scrap material from the new production yield loss; this "new" scrap can actually range from 10-20% of the raw material that would otherwise get discarded. He also highlighted the massive future e-waste problem lingering with most current lithium battery technologies, due to not them not designed to be easily recyclable in the current rush-to-market EV environment. In comparison, he noted that a standard "legacy" lead-acid battery has been designed to be 99% recyclable. Using his ultrasonic "cavitation" technology, he showed that the reclaimed scrap material can be reused in a new lithium car battery in just hours after it was discarded as scrap. He also provided a general overview of other e-waste recycling technologies currently in-use for both lithium batteries and other rare semiconductor materials, and why it is so challenging to recycle them now in hindsight.

The next speaker was **Dr. Ben Jacobson** from the University of Glasgow, and the title of his presentation was "Acoustic cavitation enhanced delamination of technology critical metals from printed circuit boards in a deep eutectic solvent." He highlighted the difficulties in recycling electronic printed circuit boards (PCBs), which makes up about 3% of the global e-waste, due to the fact that the lead-free solder is extremely difficult to dissolve. As a result, less than 15% of the PCBs in the UK are recycled, albeit their metal content is high at ~40%, and the rest ends up in landfills. The technology uses focused ultrasound via shockwaves in a liquid solvent, but scaling-up the process will be more challenging.

The photo of the UIA52 participants, taken on Wednesday, along with the other photos of our speakers, were taken by Mark Hodnett, UIA board member and unofficial photographer.

UIA52 Recap

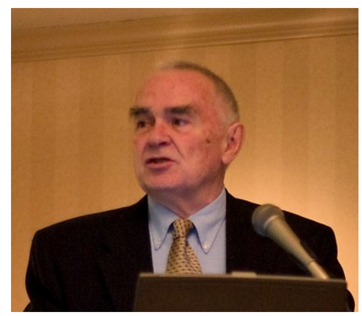
The next speaker was **Hannes Emmerich** from TU Dresden, and the title of his talk was "Selective bubble detection in a multi-phase flow using non-linear acoustics." His research focused on using bubbles with non-linear acoustic techniques to detect flow of a liquid that exists in multiple phases simultaneously, such as gas and liquid, which is extremely challenging for current technologies. His method showed the ability to detect a real-time shift of the gas fraction of a fluid with three phases simultaneously, which could have wide application to many critical detection processes.

TUESDAY WORKSHOPS

The Tuesday workshop sessions were presented by

Liam Dillon, Ceramtec UK on Developing ultrasonic transducers for novel intravascular surgical procedures.

Damian Walmsley presented on behalf of Margaret Lucas on UltraSurge: Surgery enabled by ultrasonics.

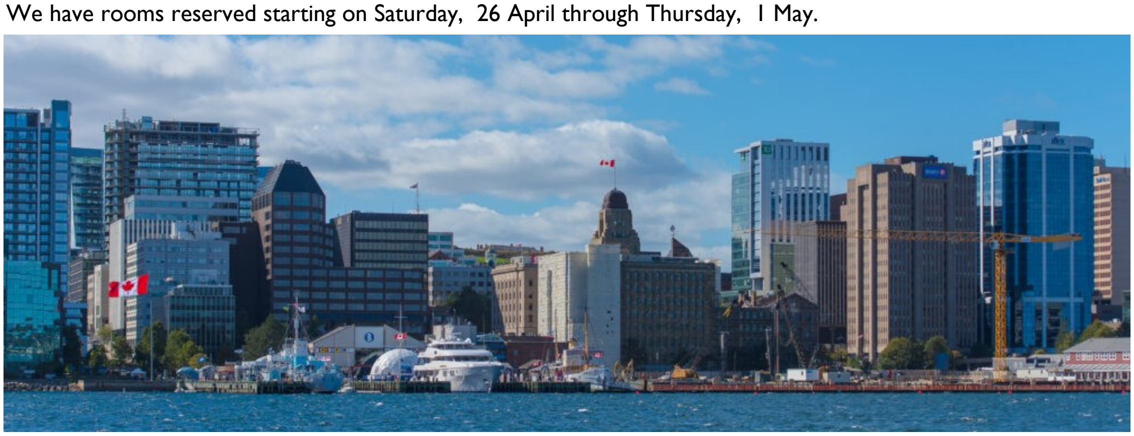


Karl Graff ended our workshop Tuesday with his presentation On the matter of acoustic softening.

UIA53: Halifax, Nova Scotia

The Westin Nova Scotian is the headquarter hotel for UIA53. UIA room rates are just $269 single/double plus 18% taxes.

Make your room reservation by calling 1-866-761-3513.
Please identify yourself as attending the UIA Annual Symposium to get this special rate.
We have rooms reserved starting on Saturday, 26 April through Thursday, 1 May.



To help you plan your stay in Halifax, you will find this link: https://discoverhalifaxns.com/ very helpful.

Ultrasound in the News

"If we can pole piezoelectric-ferroelectric materials at room temperature, it means we can alter the other materials and manufacturing processes we use when creating ultrasound devices to optimize their performance," Jiang says.

Researchers solve long-standing challenge for piezo electric materials

Heat and pressure can deteriorate the properties of piezoelectric materials that make state-of-the-art ultrasound and sonar technologies possible -- and fixing that damage has historically required disassembling devices and exposing the materials to even higher temperatures. Now researchers have developed a technique to restore those properties at room temperature, making it easier to repair these devices -- and paving the way for new ultrasound technologies.

That's because the piezoelectric materials used for sonar and ultrasound applications are mostly ferroelectric. And like all ferroelectric materials, they exhibit a phenomenon called spontaneous polarization. That means they contain pairs of positively and negatively charged ions called dipoles. When a ferroelectric material is poled, that means all of its dipoles have been pulled into alignment with an external electric field. In other words, the dipoles are all oriented in the same direction, which makes their piezoelectric properties more pronounced.

"It's important to re-use these piezoelectric-ferroelectric materials because they are usually expensive -- you don't want to just throw them away," Jiang says. "But often the material is retrieved and the rest of the ultrasound device is discarded.

"If those dipoles aren't in alignment it's difficult to generate targeted ultrasound waves with the amplitude needed for them to be practical," says Xiaoning Jiang, corresponding author of a paper on the work and Dean F. Duncan Distinguished Professor of Mechanical and Aerospace Engineering at North Carolina State University.

"Preserving the poling of piezoelectric-ferroelectric materials poses some significant challenges, because the dipoles can begin losing their alignment when exposed to elevated temperatures or high pressures," Jiang says.

"This is also a manufacturing problem, because it limits which other materials and processes you can use when making ultrasound devices," Jiang says. "And because the elevated temperatures aren't even really that high -- you can see alignment problems as low as 70 degrees Celsius -- even shipping or storing these technologies can sometimes adversely affect the poling and the efficiency of the devices.

"What's more, extended use of some technologies can result in the device itself generating heat that risks depoling the piezoelectric-ferroelectric material."

And once the dipoles in the material have come out of alignment, getting them back into alignment isn't easy. The piezoelectric-ferroelectric material needs to be removed from the device and exposed to high heat -- 300 degrees Celsius

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Ultrasound in the News, continued

or more -- in order to completely depole the material before "repoling" it and pulling the dipoles back into alignment.

"It's important to re-use these piezoelectric-ferroelectric materials because they are usually expensive -- you don't want to just throw them away," Jiang says. "But often the material is retrieved and the rest of the ultrasound device is discarded.

"We have developed a technique that allows us to depole and repole piezoelectric-ferroelectric materials at room temperature. That means we can pull the dipoles back into alignment without removing the material from the device -- and this can be done repeatedly, as needed."

To understand the new technique, you need to understand that there are two ways to pull the dipoles in a piezoelectric-ferroelectric material into alignment. The most widely used technique involves applying a direct current (DC) electric field to the material, which pulls all of the dipoles in the same direction.

"This way works well for creating alignment, but it is virtually impossible to depole the material using only a DC field," Jiang said.

The other technique involves applying an alternating current (AC) electric field to the material, which causes the dipoles to oscillate in response to the waves in the field, until the field is removed, at which point the dipoles lock into place in alignment.

"We found that we can also depole the material using an AC field, even at room temperature. If the material was originally poled using a DC field, we could remove much of the poling with an AC field -- but not all of it," Jiang said. "However, if the material was originally poled with an AC field, we found that could also completely depole the material using an AC field."

The finding has at least two significant ramifications for ultrasound technologies.

"If we can pole piezoelectric-ferroelectric materials at room temperature, it means we can alter the other materials and manufacturing processes we use when creating ultrasound devices to optimize their performance," Jiang says. "We are no longer limited to materials and processes that won't affect the polarization in the piezoelectric-ferroelectric components, because we can pole the material using an AC field after the device has been assembled.

Soundwaves from low-intensity focused ultrasound aimed at a place deep in the brain called the insula can reduce both the perception of pain and other effects of pain, such as heart rate changes.

"What's more, it means that we can easily repole the materials in existing devices, hopefully giving us a long lifetime of peak performance for these technologies."

Materials provided by **North Carolina State University**. Original written by Matt Shipman.

https://www.sciencedaily.com/releases/2024/08/240806131222.htm

WEARABLE ULTRASOUND PATCH ENABLES CONTINUOUS, NON-INVASIVE MONITORING OF CEREBRAL BLOOD FLOW

Engineers have developed a wearable ultrasound patch that can offer continuous, non-invasive monitoring of blood flow in the brain. The soft and stretchy patch can be comfortably worn on the temple to provide three-dimensional data on cerebral blood flow--a first in wearable technology.

A team of researchers led by Sheng Xu, a professor in the Aiiso Yufeng Li Family Department of Chemical and Nano Engineering at

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Ultrasound in the News, continued

the UC San Diego Jacobs School of Engineering, published their new technology on May 22 in Nature.

The wearable ultrasound patch marks a significant leap from the current clinical standard, called transcranial Doppler ultrasound. This method requires a trained technician to hold an ultrasound probe against a patient's head. The process has its downsides, however. It is operator-dependent, so the accuracy of the measurement can vary based on the operator's skill. It is also impractical for long-term use.

Xu's team developed a device that overcomes these hurdles. Their wearable ultrasound patch offers a hands-free, consistent and comfortable solution that can be worn continuously during a patient's hospital stay.

"The continuous monitoring capability of the patch addresses a critical gap in current clinical practices," said study co-first author Sai Zhou, a materials science and engineering Ph.D. candidate in Xu's lab. "Typically, cerebral blood flow is monitored at specific times each day, and those measurements do not necessarily reflect what may happen during the rest of the day. There can be undetected fluctuations between measurements. If a patient is about to experience an onset of stroke in the middle of the night, this device could offer information that is crucial for timely intervention."

Patients who are undergoing and recovering from brain surgery can also benefit from this technology, noted Geonho Park, another co-first author of this study who is a chemical and nano engineering Ph.D. student in Xu's lab.

The patch, roughly the size of a postage stamp, is constructed from a silicone elastomer embedded with several layers of stretchy electronics. One layer consists of an array of small piezoelectric transducers, which produce ultrasound waves when electrically stimulated and receive ultrasound waves reflected from the brain. Another key component is a copper mesh layer -- made of spring-shaped wires -- that enhances signal quality by minimizing interference from the wearer's body and environment. The rest of the layers consist of stretchable electrodes.

During use, the patch is connected through cables to a power source and computer. To achieve 3D monitoring, the researchers integrated ultrafast ultrasound imaging into the system. Unlike standard ultrasound, which captures about 30 images per second, ultrafast imaging captures thousands of images per second. This high frame rate is necessary for collecting robust data from the piezoelectric transducers in the patch, which would otherwise suffer from low signal intensity due to the strong reflection of the skull.

The data are then post-processed using custom algorithms to reconstruct 3D information such as the size, angle and position of the brain's major arteries.

""The cerebral vasculature is a complex structure with multiple branching vessels. You need a device capable of capturing this three-dimensional information to get the whole picture and obtain more accurate measurements," said Xinyi Yang, another co-first author of this study and materials science and engineering Ph.D. student in Xu's lab.

In this study, the patch was tested on 36 healthy volunteers for its ability to measure blood flow velocities -- peak systolic, mean flow and end diastolic velocities -- in the brain's major arteries. Participants engaged in activities affecting blood flow, such as hand-gripping, breath-holding and reading. The patch's measurements closely matched those obtained with a conventional ultrasound probe.

Next, the researchers plan to collaborate with clinicians at UC San Diego School of Medicine to test the patch on patients with neurological conditions that impact cerebral blood flow. Xu has co-founded a startup company called Softsonics to commercialize this technology.

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Ultrasound in the News, continued

This work was supported by the National Institutes of Health (1R21EB025521-01, 1R21EB027303-01A1, 3R21EB027303-02S1, 1R01EB033464-01, 1R01HL171652-01).

https://www.sciencedaily.com/releases/2024/05/240522225226.htm

Ultrasound technology can be used to boost mindfulness, study finds

One of the intriguing abilities of the human mind is daydreaming, where the mind wanders off into spontaneous thoughts, fantasies and scenarios, often without conscious effort, allowing creativity and reflection to flow freely.

In a new study published in Frontiers of Human Neuroscience, University of Arizona researchers used low-intensity ultrasound technology to noninvasively alter a brain region associated with activities such as daydreaming, recalling memories and envisioning the future. They found that the technique can ultimately enhance mindfulness, marking a major advancement in the field of neuroscience.

The researchers used low-intensity ultrasound technology called transcranial-focused ultrasound, or TFUS, to alter the default mode network of the brain, a system of connected brain areas that are especially active during activities like daydreaming.

"We are the first to show that the default mode network can be directly targeted and noninvasively modulated," said lead study author Brian Lord, a postdoctoral researcher in the U of A Department of Psychology.

One area of the default mode network, the posterior cingulate cortex, has been implicated as a major player in how the mind grasps onto experiences, said Lord, who is part of the Science Enhanced Mindfulness Lab, or SEMA Lab, at the university's Center for Consciousness Studies. The default mode network is active when people engage in introspection or let their minds wander, perhaps embedding themselves in a story, recalling past memories or planning future scenarios.

"This is how we form narratives about ourselves," Lord said.

While this narrative making is natural and important to get a coherent sense of oneself, it can also impede people from being present in the moment, Lord said. For instance, when someone is trying to meditate, it could lead to rumination and negative thinking.

To enhance mindfulness and help people engage more with the current moment, Lord's team used TFUS, a tool that can stimulate specific areas of the brain noninvasively with millimeter precision.

Unlike other noninvasive brain stimulation methods, such as transcranial electrical stimulation and transcranial magnetic stimulation, TFUS can penetrate below the cortex, the outermost layer of the brain. Just five minutes of stimulation can induce meaningful effects.

The experiment involved 30 participants who received TFUS to the posterior cingulate cortex of the default mode network of the brain. Researchers used functional magnetic resonance imaging, or fMRI, to observe changes in brain activity. Participants were asked to report their feelings and experiences before and after the TFUS treatment.

The study found that TFUS reduced the brain's connectivity within the default mode network and affected participants' mindfulness and subjective experiences, such as their sense of self and perception of time.

"The best part is you are using a minimal amount of energy to alter brain activity. You are just giving a gentle push to the brain with low-

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Ultrasound in the News, continued

intensity ultrasound," Lord said.

The ability to target and alter brain networks opens the possibility of using TFUS for precision therapeutics, which are medical treatments tailored specifically to an individual's unique characteristics, such as their genetic makeup, lifestyle and environment. TFUS could also potentially be used to treat mood disorders like depression and anxiety, a possibility other research groups are now exploring, Lord said.

"Unlike neuroimaging techniques where you can only make correlations with brain activity, noninvasive stimulation tools like TFUS allow you to probe the brain and develop causal models," Lord said. "That's a really powerful thing for the whole field of neuroscience."

https://www.sciencedaily.com/releases/2024/07/240711215537.htm

Breakthrough approach enables bidirectional BCI functionality

Brain-computer interfaces or BCIs hold immense potential for individuals with a wide range of neurological conditions, but the road to implementation is long and nuanced for both the invasive and noninvasive versions of the technology. Scientists have now successfully integrated a novel focused ultrasound stimulation to realize bidirectional BCI that both encodes and decodes brain waves using machine learning in a study with 25 human subjects. This work opens up a new avenue to significantly enhance not only the signal quality, but also, overall noninvasive BCI performance by stimulating targeted neural circuits.

In their latest research, published in *Nature Communications,* the He group demonstrated that through precision noninvasive neuromodulation using focused ultrasound, the performance of a BCI could be improved for communication.

"This paper reports a breakthrough in noninvasive BCIs by integrating a novel focused ultrasound stimulation to realize bidirectional BCI functionality," explained Bin He, professor of biomedical engineering at Carnegie Mellon University. "Using a communication prosthetic, 25 human subjects spelled out phrases like "Carnegie Mellon" using a BCI speller. Our findings showed that the addition of focused ultrasound neuromodulation significantly boosted the performance of EEG-based BCI. It also elevated theta neural oscillation that enhanced attention and led to enhanced BCI performance."

For context, a BCI speller is a 6x6 visual motion aide containing the entire alpabet that is commonly used by nonspeakers to communicate. In He's study, subjects donned an EEG cap and just by looking at the letters, were able to generate EEG signals to spell the desired words. When a focused ultrasound beam was applied externally to the V5 area (part of the visual cortex) of the brain, the performance of the noninvasive BCI greatly improved among subjects. The neuromodulation-integrated BCI actively altered the engagement of neural circuits to maximize the BCI performance, compared to previous uses, which consisted of pure processing and decoding recorded signals.

"The BRAIN Initiative has supported more than 60 ultrasound projects since its inception. This unique application of noninvasive recording and modulation technologies expands the toolkit, with a potentially scalable impact on assisting people living with communication disabilities," said Dr. Grace Hwang, program director at the Brain Research Through Advancing Innovative Neurotechnologies® initiative (The BRAIN Initiative®) at the National Institutes of Health (NIH).

Following this discovery, the He lab is further investigating the merits and applications of focused ultrasound neuromodulation to the brain, beyond the visual system, to enhance noninvasive BCIs. They also aim to develop more compact-focused ultrasound neuromodulation device for better integration with EEG-based BCIs, and to integrate AI to continue to enhance the overall system performance.

https://www.sciencedaily.com/releases/2024/06/240617173427.htm

From the President

Margaret Lucas

UIA President

The annual UIA Symposium in Dublin in April was a great success with a diverse and exciting program; a write up of the presentations and workshops can be found in this issue of Vibrations. Of note were the two keynote lectures, from Mark Schafer on the interaction of ultrasound and neural tissue and from Andrew Abbott on the recovery of technology critical metals from electronic waste. These typify the breadth of ultrasonic technologies and research covered by the UIA. Taking advantage of the great location in Ireland, delegates were treated to a whiskey tasting along with dinner at The Dublin Liberties. At the Symposium, Mark Schafer and Mark Hodnett both received the award of Fellow for their exemplary contributions to the field of ultrasonics and for their dedicated service to the UIA. Next year the Symposium is in Halifax, Canada – hope to see you all there.

We held another of our Virtual Collaborations on-line events in June, this time delivered by Tony Crandall, entitled: ‘A simple Ultrasonic Air Detector - A guide to ultrasonic design and where to find the information you need’. Virtual Collaborations is a series of presentations and discussions on topics that provide really excellent training and insights into some of the fundamentals of ultrasonics across different applications. They are great way for students and early career practitioners to learn about this field and the technologies, and a great way for established researchers and practitioners to refresh or learn something new.

UIA Board

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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.

28 - 30 April 2025
The Westin Nova Scotian, Halifax, Canada

Important Dates

5 September 2024: Virtual Collaborations - IP Tips & Tricks

1 November 2024: Abstracts due for UIA53

7 April 2024: Deadline to make hotel reservations for UIA53: 1-866-761-3513

28 - 30 April 2025: UIA53, Westin Nova Scotian Hotel, Halifax, Nova Scotia