applied sciences

Editorial

Special Issue on Ultrasonic Transducers and Related Apparatus and Applications

Linas Svilainis

Department of Electronics Engineering, Kaunas University of Technology, LT-51368 Kaunas, Lithuania; linas.svilainis@ktu.lt

Citation: Svilainis, L. Special Issue on Ultrasonic Transducers and Related Apparatus and Applications. *Appl. Sci.* **2022**, *12*, 8284. https://doi.org/10.3390/app12168284

Received: 16 August 2022
Accepted: 17 August 2022
Published: 19 August 2022

This article belongs to the Special Issue "Ultrasonic Transducers and Related Apparatus and Applications".

Use of ultrasound is widely accepted in industry and research. Ultrasound is used for non-destructive testing (NDT), diagnostic imaging in medicine, flow velocity and material mechanical properties measurements. Ultrasonic actuators are popular in micro-scale positioning or mechanical processing. Transduction of the ultrasound still needs improvement: sensitivity, bandwidth and cost of the transducers receive the most efforts in research. The next most important part of any ultrasonic system is the signal technology. Research in signal technologies is aimed at: (i) transmission, reception and acquisition electronics, (ii) search for new signal types, (iii) signal processing techniques and instrumentation.

This Special Issue was aimed to present the most recent developments in ultrasound transduction and signal technologies. A total of six papers are presented in this Special Issue.

Ultrasound application in material processing is offering several advantages over the conventional technologies. In ultrasonic cutting, the vibration applied to a cutting tool reduces the required force, decreases the friction force and the stress on a workpiece, thus providing a uniform cross section of the cut. Hahn et al. [1] presented development and optimization of an ultrasonic horn that can be used for hard materials cutting. It was demonstrated that the cutting force was reduced to 30 % of the conventional requirement and the quality of cutting surface was improved when applied for silicon composite material slicing.

Ultrasonic actuators offer high power-to-volume ratio, do not use magnetic materials and can provide down to nanometers resolution. Jurenas et al. [2] presented a novel ultrasonic motor design, capable of three degrees of freedom (3DoF). Motors with 3DoF can be used as a gyro stabilization platform, positioning other measurement instruments. The presented design was focused on miniaturization and high-power density. It contains a spherical rotor and two unimorph-type actuators. Rotor speed of 30 rpm was achieved at a 70 V driving signal.

Ferroelectrets (FE) are new transduction material, especially attractive for air-coupled ultrasound due to close to air, low acoustic impedance. Material is low cost and easy to process. Flexibility of the film allows it to adhere to complex surfaces. However, only moderate transmission bandwidth can be obtained because of resonant behavior. Quirce et al. [3] have demonstrated an interesting and promising phenomenon: when immersed in water, FE resonance is damped and broadband transducer can be manufactured. Four transducers were manufactured to investigate the attainable performance. The −6 dB frequency bandwidth was expanded from 0.29 MHz in air to up to 2.7 MHz (161%) in water. Furthermore, passband roll off is not very steep (10 dB loss beyond 2.0 MHz). Therefore, it was proposed that spread spectrum signals with programmable spectral content can be used to compensate the spectral losses, offering further bandwidth expansion.

Ultrasound application for Structural Health Monitoring (SHM) is based on permanently installed sensors. Signals received after either active excitation or acoustic emission (AE) caused by structure load are used to locate the position of possible defects. Ultrasonic guided waves (GWs) are of particular attention because these waves can travel long distances with low attenuation. However, defect location using direction of arrival (DoA) is tampered by angle estimation error dependence on the arrival angle. Dibiase et al. [4] proposed a novel approach in sensor cluster design: a specially shaped cluster instead of a conventional triangle formed by three round sensors. The sensor shape optimization and direction estimation procedure was based on Radon transform. The proposed shaping of the piezo-patches ensures that the difference in time of arrival between reference sensor P1 and sensor P2 is a linear with angle, whereas the difference between P1 and P3 is constant across the considered range of DoA. In such case, the uncertainty of DoA estimation is improved. Furthermore, DoA can be estimated without knowing the actual wave mode velocity. SMH can benefit from fact that the speed of GW is proportional to the stress level of the medium. This can be used to monitor the strain level of the structure. Martinho et al [5] proposed the sensitivity to strain enhancement by a post-processing procedure which preserves only the strain-sensitive spectral components. The proposed technique was demonstrated on the aluminum plate, obtaining up to twice higher sensitivity to strain.

Diagnostic imaging in medicine using ultrasound is offering several benefits: there is no exposure the ionizing radiation, and acoustic waves directly interact with tissue mechanical properties. Not just contrast, but elasticity of the possible abnormalities can be investigated. However, tissue signal attenuation with distance finally makes electronic noise predominant with respect to tissue speckle. The maximum depth of penetration (DoP) is used as an indicator of how deep the imaging system is able to display the anatomical features. DoP depends on the equipment, signal and processing type used. Therefore, DoP has to be evaluated in order to make sure that clinician can identify and characterize possible abnormalities. Currently DoP is evaluated manually. Fiori et al. [6] proposed an automated procedure an adaptive Signal to Noise Ratio threshold method (AdSTM) and compared it to an alternative technique, tangent threshold method (TTM). Results indicate that AdSTM have a higher sensitivity than the TTM. For a scanner with limited gray level dynamic range, the TTM was less reliable. AdSTM require less computing therefore resulted in twice lower processing time.

Submissions for this Special Issue have been closed, therefore just a small fraction of the topic was covered. Nevertheless, it can be concluded that transduction is still limiting the ultrasonic systems performance. That is why new piezoelectric materials, sensitivity, bandwidth and durability of ultrasonic transducers are under constant development. Yet, electronics and signal processing are the counterparts that should not be forgotten, since only mutual optimization can ensure full system performance. Fortunately, new developments in these areas continue to emerge, offering new ultrasound applications.

Funding: This research received no external funding.

Acknowledgments: Guest Editor would like to thank the authors who contributed to this Special Issue 'Ultrasonic Transducers and Related Apparatus and Applications'. Special thanks to the reviewers, who dedicated their time to ensure high scientific standard of publications.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Hahn, M.; Cho, Y.; Jang, G.; Kim, B. Optimal Design and Experimental Verification of Ultrasonic Cutting Horn for Ceramic Composite Material. *Appl. Sci.* **2021**, *11*, 1954. [CrossRef]
2. Jurenas, V.; Kazokaitis, G.; Mazeika, D. Design of Unimorph Type 3DOF Ultrasonic Motor. *Appl. Sci.* **2021**, *11*, 5605.
3. Quirce, J.; Svilainis, L.; Camacho, J.; Gomez Alvarez-Arenas, T. Ferroelectret Ultrasonic Transducers for Pulse-Echo Water Immersion. *Appl. Sci.* **2021**, *11*, 8771. [CrossRef]
4. Dibiase, M.; De Marchi, L. Clusters of Shaped Ultrasonic Transducers for Lamb Waves' DoA Estimation. *Appl. Sci.* **2021**, *11*, 8150. [CrossRef]

5. Martinho, L.M.; Kubrusly, A.C.; Pérez, N.; von der Weid, J.P. Strain Sensitivity Enhancement of Broadband Ultrasonic Signals in Plates Using Spectral Phase Filtering. *Appl. Sci.* **2021**, *11*, 2582. [CrossRef]
6. Fiori, G.; Fuiano, F.; Scorza, A.; Galo, J.; Conforto, S.; Sciuto, S.A. A Preliminary Study on the Adaptive SNR Threshold Method for Depth of Penetration Measurements in Diagnostic Ultrasounds. *Appl. Sci.* **2021**, *11*, 6533. [CrossRef]