White Paper

Achieving High-end Image Quality on a Handheld Ultrasound

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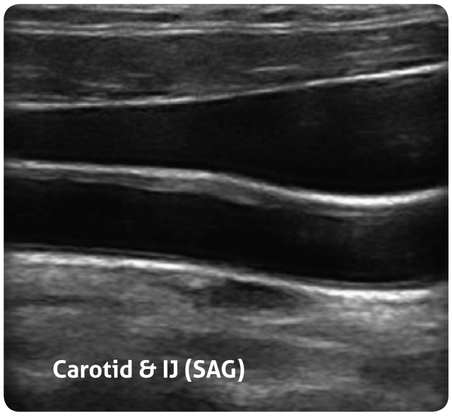
Introduction

With the advent of handheld ultrasound over the past few years, many devices have made their way into the market, offering various levels of features, mobile device support, and image quality. There has been an increase in smaller devices, moving from 10lb mid-range ultrasound laptops to handheld ultrasounds weighing less than a pound. However, generating image quality that is equivalent to or better than the mid-range laptop devices or cart-based ultrasound continues to be a challenge.

Clarius' goal from its inception has been to create a handheld device without the image quality degradation that most handheld ultrasounds suffer from. To do this, Clarius uses a System-on-Chip (SoC) design to greatly reduce the amount of processing electronics required, while keeping the same high-end transmit and receive front-ends that heavy cart systems use. In addition, Clarius scanners are designed with state-of-the-art piezoelectric ultrasonic arrays. While most handheld ultrasound designs focus on reducing power and form-factor of their device, Clarius has found the perfect balance among size, power consumption, and high-performance imaging, making the scanner unique in a market of many different ultrasound manufacturers.

Liver & Kidney

Baby Profile



Carotid & IJ (SAG)

Highly Sensitive Piezoelectric Arrays

Ultrasound transducer materials and technology used in ultrasound systems are key to the sensitivity, resolution, consistency of ultrasound imaging. Piezoelectric technology remains the gold standard for enabling high sensitivity and expanded resolution, which reduces noise and allows for seeing deeper into the body. The nature of piezoelectric material is to be solid state, and thus maintain its acoustic properties without degradation under proper care.

Volume Production Capabilities

Clarius processes its own raw piezoelectric (PZT) material, performing operations such as dicing, grinding, gold sputtering, and re-slicing with extreme precision. New volume manufacturing techniques allow processes to be fully automated, including new techniques for binding PZT to electronic circuits, thus enabling low-cost manufacturing of technology comparable to high-end ultrasound equipment. Because the PZT is coupled directly to electronic circuits, the removal of the traditional ultrasound probe cable is crucial in reducing the overhead of soldering hundreds of small wires on each end. It also increases imaging performance by mitigating electromagnetic interference (EMI) that traditional probes can be susceptible to when improperly shielded and grounded.

Fig. 1

Piezoelectric crystals on assembly line

Tightly Pitched Elements

Typical mid-range laptop and cart-based systems divide raw PZT into 128 elements. Clarius scanners are built with over 9000 individual posts that are connected to 192 individual elements, with each post vibrating individually to provide precise elevation focusing. By using more elements, system complexity increases considerably due to the requirement of more channels and multiplexers. However, there is also great increase in image quality, with improvements in focusing, achievable frequencies, and steering capabilities for technologies such as automated needle enhancement.

Clarius' choices in piezoelectric materials and production processes guarantee that the transmission and reception of ultrasonic waves will be consistent throughout the scanners' extended lifetime.

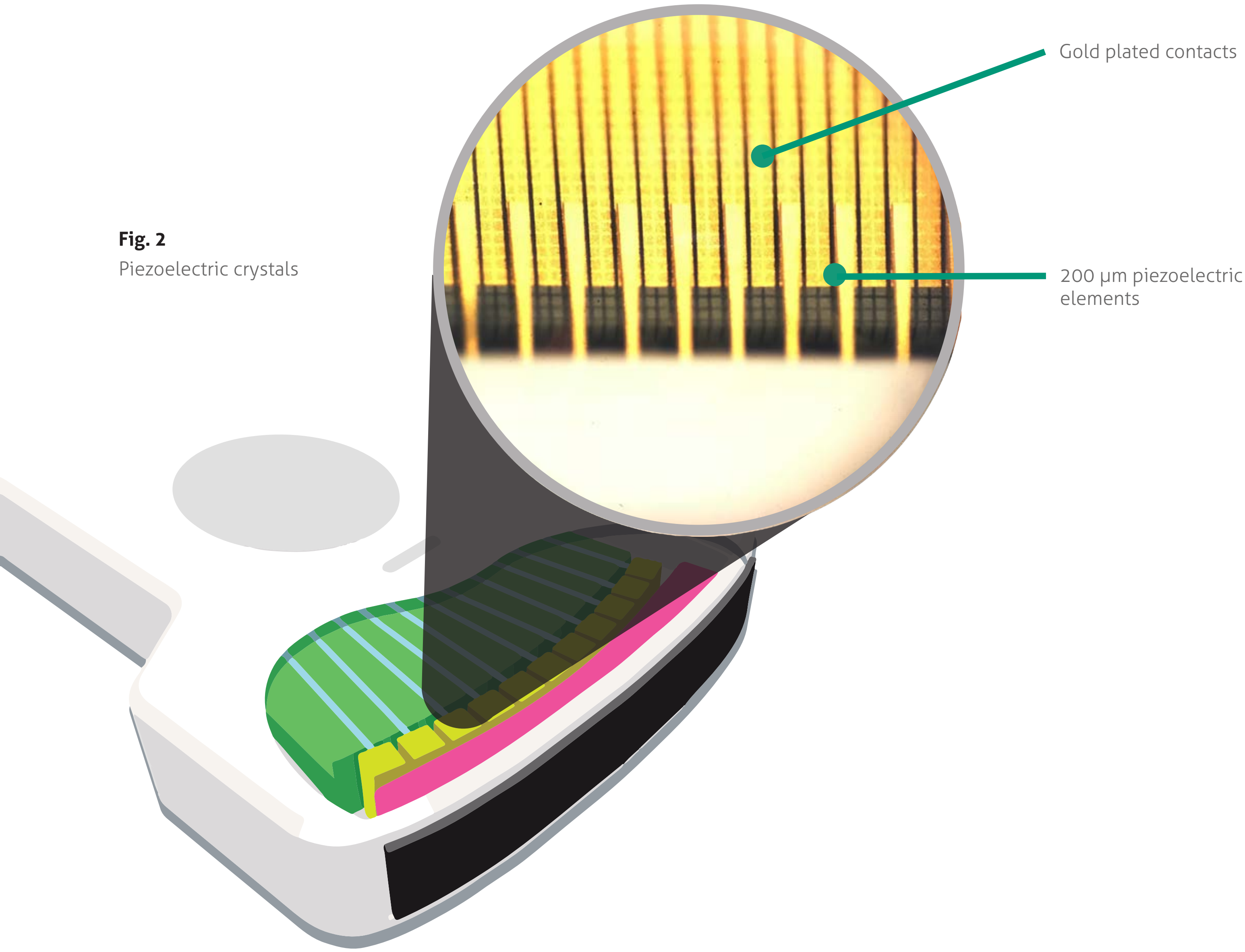


Fig. 2
Piezoelectric crystals

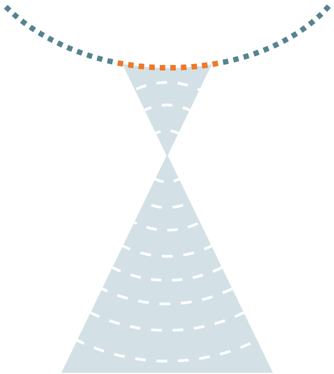


Fig. 3
Parallel beamforming

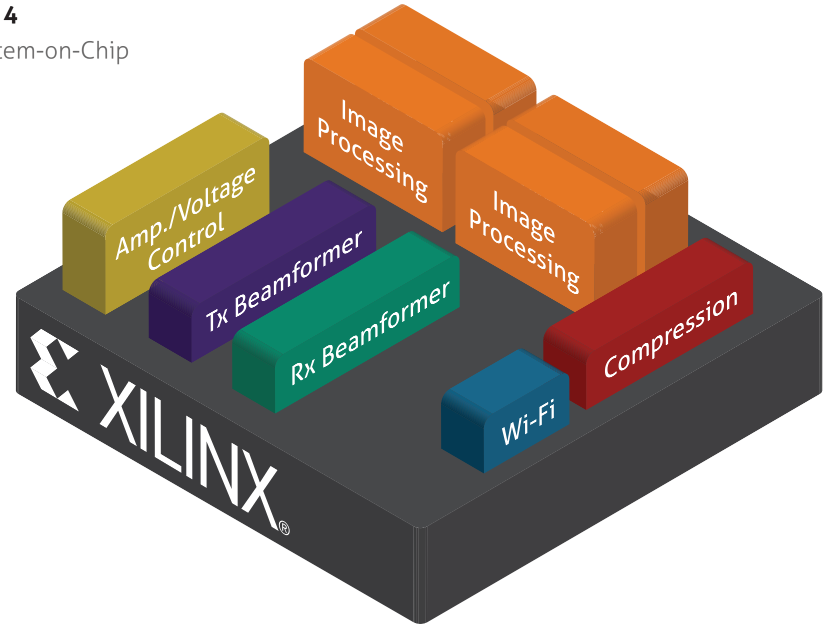
Micron-level Parallel Beamforming

Currently, most laptop ultrasound systems compromise on beamforming performance, as it requires complex electronics and multiple signal paths. These systems offer dozens of physical buttons and controls to make adjustments, and the user is tasked with setting parameters such as focal zone position and count, and managing their own trade-offs between resolution and frame rates. Because of this traditional approach to ultrasound imaging, there is often little incentive to invest into the development of modules which integrate features like parallel beamforming.

System-on-Chip Technology

Clarius' architecture leverages System-on-Chip (SoC) technology, introduced by FPGA world-leader Xilinx in 2015, which enables ultra-miniaturization of complex architectures such as parallel beamforming. This SoC technology, combined with Clarius' proprietary shared beamforming architecture, allows for the integration of up to eight parallel beamformers in a handheld device. This architecture places the Clarius system on par with high-end laptop and cart-based units based on pure processing power.

Fig. 4
System-on-Chip



Highly Optimized Imaging Architecture

Clarius uses a highly configurable back-end that allows engineers to develop new signal and image processing modules with ease. The SoC architecture gives each module the option of running on a high-end dual-core CPU, or enhancing speed and performance within the programmable logic space. This design methodology removes the need to continuously develop new electronics and allows improvements to device performance and feature-set over the lifetime of the scanner. Users receive these improvements as Clarius provides App updates with these new features.

The software architecture has been designed so that a tree of processing modules or nodes can be strung together through simple additions to high-level scripts, as opposed to modifying lower-level C or assembly code. This technique allows rapid testing and tuning of new modules. A single processing module can have dozens of parameters that require hundreds of hours of fine-tuning by scientists and engineers before becoming a part of the product. Clarius' core image processing module took over a year to develop and started with an algorithm definition, eventually being transformed into MATLAB code, and finally optimized into the fabric of the device for real-time performance of over thirty frames per second.

Automated Performance

As most ultrasound systems on the market tend to opt for a more traditional approach to user controls, imaging performance is often highly dependent on the skill of the operator to ensure that the many controls are tuned to the patient and scanning view. Although these devices include many pre-defined presets, it is up to the user to navigate menus and adjust Time-Gain-Compensation (TGC) curves, frequencies, and focal zones.

Clairus uses an automated approach for image quality adjustments, giving the user the single control of depth adjustment to automatically tune the image as needed. Through highly tuned depth-based internal parameter adjustments, automated TGC, and specialized virtual focusing techniques, Clarius reduces the learning curve and enables users to quickly start scanning without adjusting parameters.

For more information about Clarius' automated approaches, see the white paper **Simplifying Ultrasound with Automated Parameters**.