Loudspeakers are Rooted in Century Old Technology

“While the industry at large has been able to digitize, shrink and enhance all other device electronics, the last remaining barrier is the speaker, which remains large, heavy, bulky, and very analog.”

Voice Coil Magazine 2015
As electronic devices have grown thinner, smaller, and more mobile, speaker technology has not kept pace.

*Modern devices no longer have the space and power to provide quality audio*
Audio Pixels brings both higher quality sound and a thinner footprint to the electronics market.

Analog speakers require compromise as sound quality shrinks along with speaker size.

Audio Pixels has demonstrated improved sound reproduction in multiple tests.

Secondary speakers or other creative options are currently the only solutions for poor quality audio.

Phase III testing verified significantly better sound quality. (03/2015)
What is an Audio Pixels Speaker?

A revolutionary new way to reproduce sound, with patents in the fields of micro-electro-mechanical structures (MEMS), pressure generation, acoustic wave generation, control, signal processing, and packaging.

<table>
<thead>
<tr>
<th></th>
<th>Conventional Speaker</th>
<th>Audio Pixels Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical Assembly</td>
<td>Required</td>
<td>Semiconductor Chip</td>
</tr>
<tr>
<td>Magnet</td>
<td>Required</td>
<td>Not required</td>
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<tr>
<td>Voice Coil</td>
<td>Required</td>
<td>Not required</td>
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<tr>
<td>Cone</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Number of Components</td>
<td>4-15</td>
<td>1</td>
</tr>
<tr>
<td>Drive Circuitry</td>
<td>External</td>
<td>Integrated</td>
</tr>
<tr>
<td>Digital to Analog Conversion</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td><strong>Enclosure or Chamber</strong></td>
<td>Required</td>
<td><strong>Not Required</strong></td>
</tr>
<tr>
<td>Surface Mount Compatible</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
How does it work?

**Digital Sound Reconstruction (DSR)**

Sound waves are generated from the summation of discrete pulses produced from an array of micro-transducers.

As with analog speakers, different frequencies are produced by varying the timing of the motion.

![micro-transducer array](image)
DSR is different than any other speaker technology

Unlike analog speakers …

- the Audio Pixels micro-transducers do NOT require a large dynamic range. This allows the array to be constructed from identical elements all finely tuned to a particular frequency.

- the chips can be used either as a standalone micro-speaker or cascaded in any multiples of the same chip to replicate the desired function of the speaker.

- there is no need for a DAC, amplifier, or enclosure; meaning fewer parts and a much smaller footprint.

Not just smaller, but better: The chips have higher energy efficiency, lower harmonic distortion, faster transient response, and improved flatness; with a two-octave (frequency) gain.
Audio Pixels Sets New Standards In Sound Quality

Audio Pixels has achieved sound pressure levels (SPL) within the low frequency spectrum that were previously believed by experts to be unattainable within a micro form factor; measuring 80dB (decibels) at 250Hz for a standalone chip.

Audio Pixels delivers a 150% wider frequency range than current phone speaker technology.

What you hear today
Truly disruptive for every device that uses loudspeakers

Form factors will change dramatically

Every product with speakers will undergo design changes

What was external -

- can become this

- can become embedded
**Value Analysis**

*Audio Pixels delivers a superior sound experience in every known device category*

<table>
<thead>
<tr>
<th></th>
<th>Handheld</th>
<th>IOT / Wearable</th>
<th>Tablets &amp; Laptops</th>
<th>Display</th>
<th>Smart Phones</th>
<th>Television</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Strength</td>
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<tr>
<td>High quality audio</td>
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<tr>
<td>within device size</td>
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<td>constraints (“thinness”)</td>
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<tr>
<td>Secondary Strengths</td>
<td></td>
<td>Reduced power</td>
<td></td>
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<td>Reduced</td>
<td>Reduced</td>
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<tr>
<td></td>
<td></td>
<td>consumption</td>
<td></td>
<td></td>
<td>power</td>
<td>vibration</td>
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<td></td>
<td></td>
<td>Enabling</td>
<td>consumption</td>
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<td>far</td>
<td>Reduced</td>
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<td>smaller</td>
<td>power</td>
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<td>footprint</td>
<td>consumption</td>
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<td>Reliability and</td>
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<td>ease of assembly</td>
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</table>
Audio Pixels is currently working with some of the industry’s leading suppliers to develop its manufacturing capabilities.
Major assembly advantages of Audio Pixels Technology

The Surface Mount Advantage
Higher through-put and reliability

Manual soldering of speakers peaks at about 10/minute, compared to 100-1500/minute for components on an automated surface mount line. 
*Tremendous advantage for cell phones and other small electronics.*

Elimination of Existing Components
Weight and cost savings

Speaker brackets, amplifiers, housings, and other bill of material line items can be eliminated.
*Significant impact in automotive, removing $100+/vehicle in mounting and other components.*
After a decade of research, Audio Pixels has built a dominant intellectual property portfolio. Our portfolio covers Geometries, Structures, Methods of Actuation, Actuation Control, MEMS Packaging, Algorithms, Signal Processing, and other functions essential to MEMS speakers.

- **Patent Families**: 18
- **Patent Grants**: 64
- **Patent Pending**: 46

Formidable “head start” equal to 100’s of man years of development.
The complexity of the R&D has given Audio Pixels a dominant position in Digital Loudspeaker Audio Technology.

<table>
<thead>
<tr>
<th>Number of Manufacturers &amp; Developers</th>
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</thead>
<tbody>
<tr>
<td><strong>Analog Speaker</strong></td>
</tr>
<tr>
<td>&gt;3000</td>
</tr>
<tr>
<td><strong>MEMS</strong></td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td><strong>Universite Du Maine</strong></td>
</tr>
<tr>
<td>Analog</td>
</tr>
<tr>
<td><strong>Audio Pixels Ltd.</strong></td>
</tr>
<tr>
<td>Digital</td>
</tr>
</tbody>
</table>

*No Known Competitors!*
Sources of potential competition face enormous barriers.

**Competitors?**

- **Loudspeaker Industry**
  - Patent Barriers
  - Significant technological knowledge gap
  - Incompatible manufacturing knowledge and equipment

- **Semiconductor Industry**
  - Patent Barriers
  - Significant technological knowledge gap

**Extreme barriers to entry:** outside of our strong patent position, a competitor would require multidisciplinary expertise in MEMS design and fabrication, physics, materials, microfluidics, aerodynamics, chip packaging, electronics, and signal processing.

*(Gaining technical or cost competitive differentiation will be major hurdles for any future MEMS audio competitors.)*
Winning Combinations

- Game Changing Product
- Huge Addressable Market(s)
- Proprietary technology
- Unrivaled Performance Advantages
- Uniform Product Macro and Micro Speakers
- No Comparable Competitor

- Digital
- Wider Bandwidth
- Lower Distortion
- Reduced Power Consumption
- No Need for Enclosure or Chambers
- Surface Mount Compatible
- Parametric Capabilities
- Simplified Design in Process
Addressable Market
the last 75 years have shown...pretty much EVERYONE
Primary Market Segmentation

Except for the lowest price point segment of the market, Audio Pixels has the potential to target every device that uses speakers.

- **Embedded**
  - Smartphone
  - Tablet/Phablet
  - Laptop
  - Computer
  - Television
  - Display
  - IOT
  - Wearables
  - Others…

- **Consumer**
  - Docking Station
  - Portable
  - Multimedia
  - Paired
  - Woofers
  - Surround Sound
  - In-wall
  - Outdoor
  - Others…

- **Specific**
  - Automotive
  - Airline
  - Train
  - Others…

- **Customized**
  - Parametric Applications
  - Sensors
  - Ultrasonic
  - Medical
  - Security
  - Others…
Global Demand for micro-speakers is expected to exceed 8 billion units in 2015, growing to over 13 billion by 2020.
Segment Breakdown – Micro Loudspeaker

The market is highly competitive, with a diverse, international cast of manufacturers targeting dozens of product categories.

Source: QYResearch Loudspeaker Research Center; Apr 2015
Home Market – Standalone Speakers and Systems
(not including soundbars)

The home loudspeaker market is currently worth over $4 billion

Home loudspeaker growth is led by demand for subwoofer and multimedia products

Source: Global Industry Analysts
Home Market – Standalone Speakers and Systems

Global soundbar sales will reach 9.9 million units in 2015

Growth is expected in every home market category. The Bluetooth (Portable) speakers market will reach $7 billion by 2019.

Source Infiniti Research Limited – Nov. 2014
Automotive (Aviation) Audio / Infotainment Market

At $3.4 billion, automotive represents an important future market for Audio Pixels. Premium Audio, featuring systems with a dozen or more speakers, has strong OEM penetration in Europe (17%), North America (12%), and Asia (9%).

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012E</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARMAN</td>
<td>2738</td>
<td>3406</td>
<td>3802</td>
</tr>
<tr>
<td>Continental</td>
<td>1829</td>
<td>1863</td>
<td>1913</td>
</tr>
<tr>
<td>PIONEER</td>
<td>2895</td>
<td>3303</td>
<td>3972</td>
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<tr>
<td>ALPINE</td>
<td>2294</td>
<td>2567</td>
<td>2785</td>
</tr>
<tr>
<td>CLARION</td>
<td>2032</td>
<td>2363</td>
<td>2405</td>
</tr>
<tr>
<td>PANASONIC</td>
<td>3238</td>
<td>3331</td>
<td>4080</td>
</tr>
<tr>
<td>FUJITSU-TEN</td>
<td>2482</td>
<td>2358</td>
<td>2302</td>
</tr>
<tr>
<td>JVC-KENWOOD</td>
<td>1232</td>
<td>1358</td>
<td>1426</td>
</tr>
<tr>
<td>Hyundai Mobis</td>
<td>1189</td>
<td>1306</td>
<td>1488</td>
</tr>
<tr>
<td>Delphi</td>
<td>1206</td>
<td>1202</td>
<td>1226</td>
</tr>
<tr>
<td>Visteon</td>
<td>462</td>
<td>508</td>
<td>522</td>
</tr>
<tr>
<td>Denso</td>
<td>1493</td>
<td>1595</td>
<td>1860</td>
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<tr>
<td>Aisin AW</td>
<td>862</td>
<td>974</td>
<td>1149</td>
</tr>
<tr>
<td>Mitsubishi Electric</td>
<td>1822</td>
<td>2008</td>
<td>2309</td>
</tr>
</tbody>
</table>

The Audio Pixels Solution is uniquely suited to the automotive market due to:

- Size & weight advantages
- Sound quality
- Speaker positioning
- Directionality
- Power consumption
- Noise cancelation
- Wiring
- and other aesthetic and technical form factors.

Source: Extrapolation from accumulated Public Domain Research
Customized “Niche” Applications

Audio Pixels is frequently approached to apply its technology to industry specific applications, thus expanding market opportunities beyond conventional loudspeaker functions.

Sensors

Ultrasound is already in use for touchless gesture recognition input. Audio Pixels’ chips have the added advantage of also offering audible sound in the same “sensor.”

The total gesture recognition and touchless sensing market is expected to reach $22.04 billion by 2020 with a double digit CAGR.

source: marketsandmarkets Apr. 2014
Customized “Niche” Applications

Parametric Speaker

Fundamentally, Audio Pixels produces Sound-from-Ultrasound allowing the speaker to project a narrow beam of sound that can be heard only along the path of the beam (directional speaker).

This effect, which is not possible using conventional loudspeakers, enables countless applications to become a new reality.
Customized “Niche” Applications

Parametric Speaker

**Television** – projecting sound at different volumes, settings and even different languages

**Automotive** – Separation between driver navigation and communication to rear seat entertainment

**Advertisement** – projecting sound directly at the consumer

**Public Safety and Museums** - Transmitting warning and informational messages in airports, train stations, escalators entrances, and any other place where a message should be directed and heard only in a designated target area

**Bank Teller, Automated Teller Machines, Passport control etc…** - any other application where confidential information should not be overheard

**Commercial Advertising** - billboard messaging to get the attention of the listener without distracting staff or other customers
Audio Pixels will target applications where size and high quality sound are both important.

Based on industry estimates, Audio Pixels’ target market will reach 1.6 billion speakers in 2016.

Gartner, QYResearch, IHS and other sources

Development Timeline

Phase III -- integrate, test and optimize all components
Completed March 2015

Phase IV – Mass manufacturing phase, pre-production planning
In progress

Begin shipping sample product to leaders in consumer electronics
In conjunction with Phase IV
Target unit totals are much higher when measured in chips per speaker.

With the exception of micro-speaker applications, which generally have a 1:1 speaker to audio chip ratio, most digital versions of analog speakers will use between 2 and 64 chips.

Audio Pixels’ target speaker market will require more than 3 billion audio chips.
Investment Thesis— The Analogous Story of MEMS Microphones

MEMS Microphones

- Electret Condenser Microphone (ECM) invented at Bell Laboratories in the 1960s.
- Fundamentally unchanged. But ECM’s dominated the market for roughly 50 years.
- MEMS Microphones were introduced sometime in the late 90’s.

Advantages of MEMS over ECM:

- Reduced Noise
- Size
- Surface mount compatible

Significant Cost Disadvantage - Average microphone price per unit at the point of introduction of MEMS microphone –

ECM microphones cost less than $0.10 per unit compared to >$2.00 for a comparable MEMS microphone.
Despite the cost disadvantage, MEMS microphone production accelerated

Over the past decade more than a dozen manufacturers began producing MEMS microphones, driving improvements in performance, size and cost. Nonetheless MEMS microphones remain >10x the price of ECMs.

How has the market responded?

• In 2013 MEMS microphone shipments overtook analog microphones
• MEMS microphone sales are expected to reach 5.4 billion units by 2017

And the trend continues

• Sales of MEMS microphones are expected to grow from $1.0 billion (USD) in 2014 to $1.4B in 2017
• Growth of the MEMS microphone market is exceeding forecasts as more microphones and more applications are added to devices.

Source: HIS technology Apr. 2014
Manufacturers of micro-speakers tend to be public, with greater capital requirements to support large quantity OEM demands.

Manufacturers of Home Speakers typically remain private, due to market dynamics of very high margins, relatively limited quantities, and end-user direct sales.
Success Factor

Given the digital nature, enhanced sound reproduction, improved power consumption, ease of assembly and design-in, and smaller more compatible package …there is little reason any company would continue to use conventional speaker technology.
Key Takeaways

1. Proprietary Game Changing Technology
2. No Direct Competition on the Horizon
3. Final Phase of Productization
4. Immense, Diverse and Stable Market Opportunities