Ultrasonics
What is ultrasonics?

Ultrasonics refers to the study of sound with frequencies larger than those which can be heard by humans.

Audible Range of Frequencies: 30 Hz to 20 kHz
Sound - Fun Facts

- Speed of sound in air: 343 m/s
- Speed of sound in water: 1500 m/s

- Attenuation increases with frequency

  Example: At 20 kHz, “half-life” of wave intensity is 5 m in air, 50 km in water.
  At 1 MHz, it drops to 20 m in water, a few centimeters in air.
Types of Applications

- **High Power Ultrasonics**
  - Destructive
  - High Amplitude (5 - 50 um peak)
  - Relatively Low Frequencies (20 kHz - 100 kHz)

- **Low Power Ultrasonics**
  - Non-Destructive
  - Low Amplitude
Cavitation
Cavitation and Implosion

1. Cavitation bubble growth in negative pressure
2. Maximum Bubble Size
3. Bubbles collapse in compression
4. Cycle repeats
   New bubble growth
Application Examples

• Cleaning
• Cutting
• Plastic Welding
• Metal Welding
Cleaning

- One of the first uses of ultrasound
  - Introduced in early 1950s

- Works best on sound reflecting materials
  - Examples: metal, glass, cloth
Cleaning - Common Uses

- Hospital Glassware
- Surgical Instruments
- Photographic Lenses
- Filters
- Fibers
- Circuit Boards
- Semiconductors
- Ball Bearings
- Carburetors
- Engine Parts
- Heat Exchanges
Speeding Dissolution
Displacement of Insoluble Material
Ultrasonics Beats the Alternatives
Ultrasonic Cutting - Common Uses

• Surgical Scalpels
  - Allows surgeons to cut without using pressure

• Industry
  - Useful for difficult-to-cut products

• Fabrics
  - Heat from vibration enables simultaneous cutting and sealing
Plastic Welding

- Vibrations are perpendicular to contact surface
- Generates heat at the interface between the components
Metal Welding

- Components are vibrated parallel to the interface
- Diffusion-bonding mechanism
Low Power Applications - Examples

- Medical Imaging
- Flaw Detection + Analysis
- Precision Measurement
Spread-Spectrum Ultrasonics
Pulse Ultrasonics

- Transmit individual pulse
- Time until reception of pulse can gauge depth
- Echoes indicate other imperfections
Generation of Ultrasonics

- Piezoelectric Transducers
- Electromagnetic Acoustic Transducers
- Lasers
Piezoelectric Transducers

[Diagram showing ultrasonically active liquid and various components such as stainless steel nose piece, ground connection, electrode, electrical insulator, aluminium coupling mass, piezoelectric driving elements, steel back mass, and compression bolt.]
Electromagnetic Acoustic Transducers
References


http://www.rudolphtech.com/products/product_meta300.html

http://library.thinkquest.org/2662/TQ1996/ultrasonic.html

http://www.caeblackstone.com/contents.html

http://www.cride.iastate.edu/ncce/UT_CC/Intro_Adv.html

http://www.powerultrasonics.com/cgi-bin/ultrasonic.pl?page=index

http://radiology.bidmc.harvard.edu/Modalities/Ultra/ultrasound.html