A Step by Step of Ultrasonic Microscope Design

By:
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WEBINAR SERIES
(seri-8, 02 September 2020)

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Bidang Keilmuan

- Ultrasonic and Non Destructive Measurement
  Strength of Clay, Concrete, Biodiesel, Oil, Salinity
- Transesterification (Converting Jelantah to Biodiesel)
  Transesterification machine, using ultrasonic as a vibration generator
- Aquaculture Engineering Application
  Water quality, shrimp seed counter, DO sensor, salinity sensor, feeding management system, etc.

https://aigunawan.blogspot.com/

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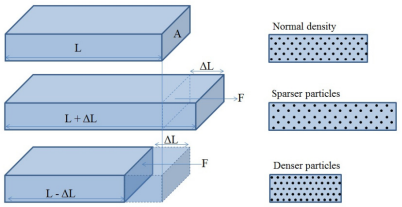
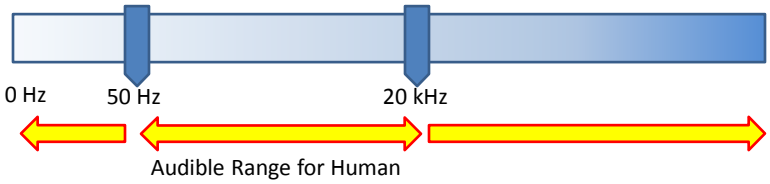
What is Ultrasonic ??

- Gelombang mekanik
- Getaran dari partikel





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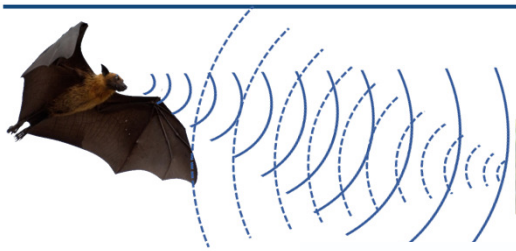
Ultrasonic today



- In the nature → Bat, Dolphin
- Robot obstacle avoidance
- Ultrasonography
- Car parking guidance
- Machine Cleaner
- Level Detector
- Crack material

[1]. https://www.honda-el.co.jp/en/medical/HS-2600.html

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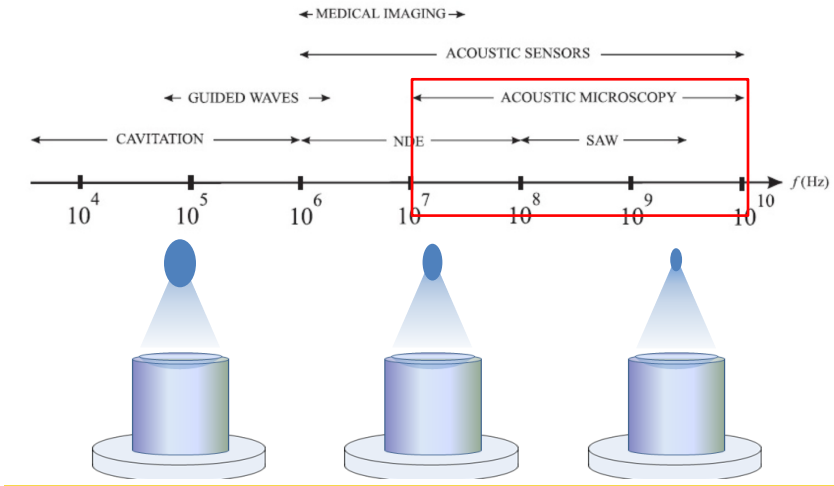
Ultrasonic Spectrum



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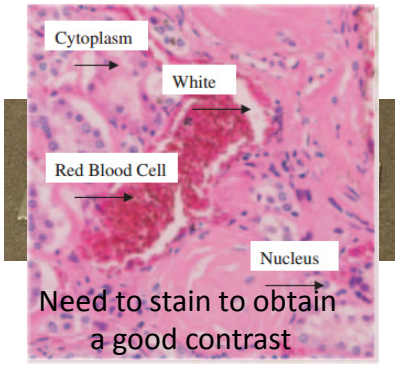
Perbedaan Optical dan Acoustical Observation



Kidney specimen 800 x 800 pixel
(H&E stained)

After staining, the contrast of specimen is much better than unstained one.

- High resolution.
- It is not easy to obtain a good contrast.
- Staining process.
- It needs several hours to days to complete the staining.
- Severe staining could damage the biological function of the specimen.

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Perbedaan Optical dan Acoustical Observation

- Rapid observation can be realized by skipping the staining process.
- The contrast represents visco-elastic property.
- In vitro and in vivo (living specimen) observation.
- Contaminant free (some cases)
- High frequency is required for high resolution.

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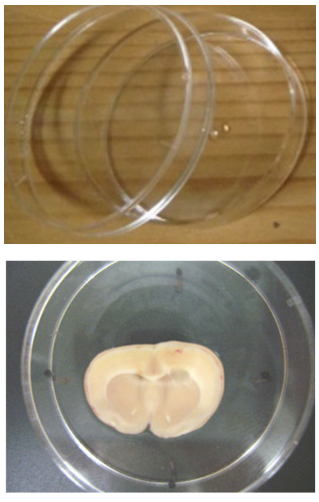
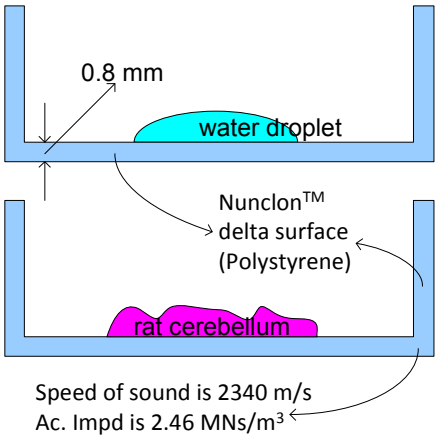
Persiapan Sampel





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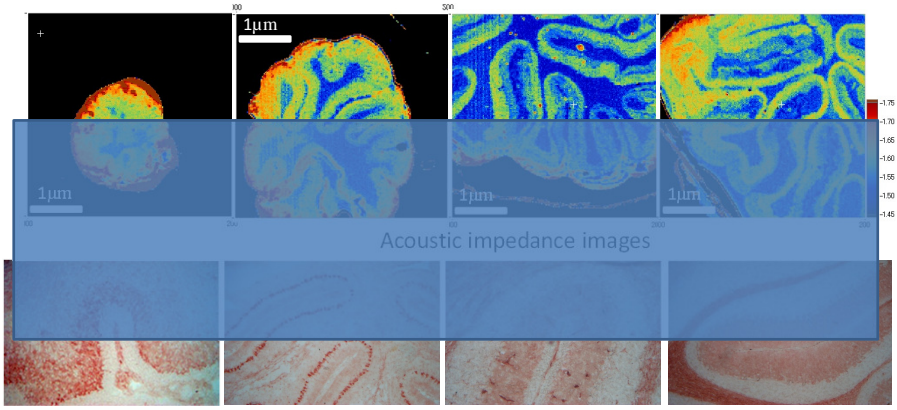
Acoustical and Optical Result



Stained against calbindin D-28k

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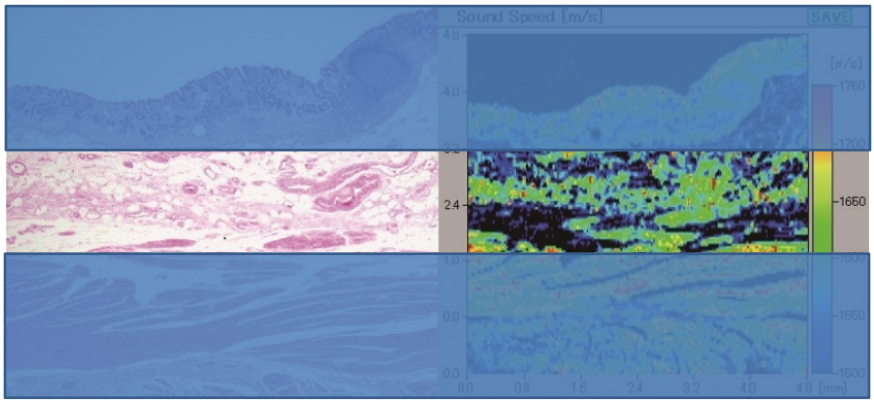
Normal gastric structure



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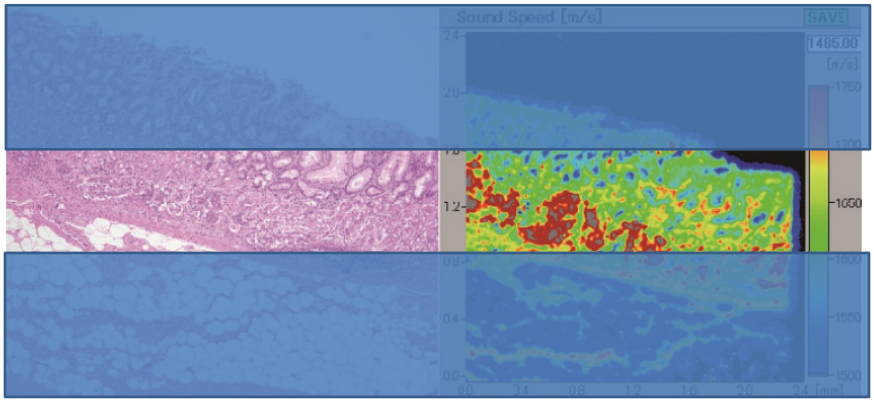
Normal gastric mucosa and submucosa



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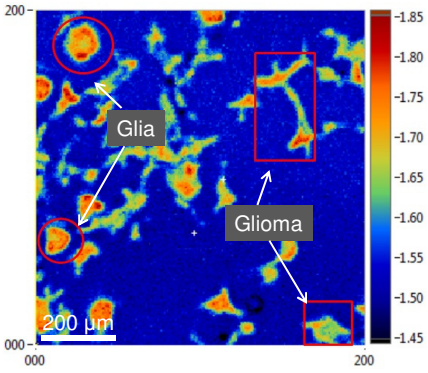
Glia and Glioma Observation

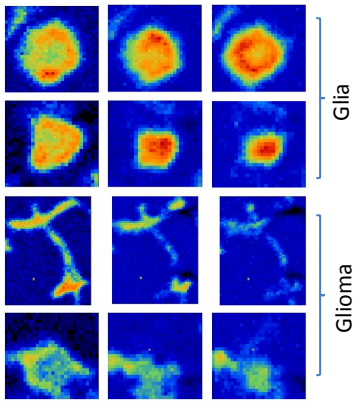


cytochalasin-B (anti cancer drug)

Taken from

Observation is taken at:

Before 45 mnts 90 mnts



Glioma is a malignant tumour of the glial tissue of the nervous system.

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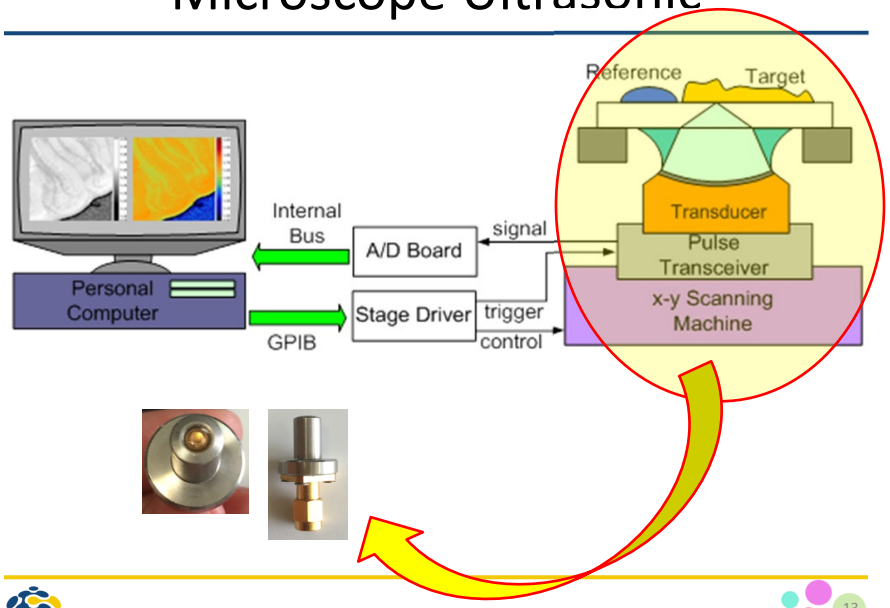
Microscope Ultrasonic



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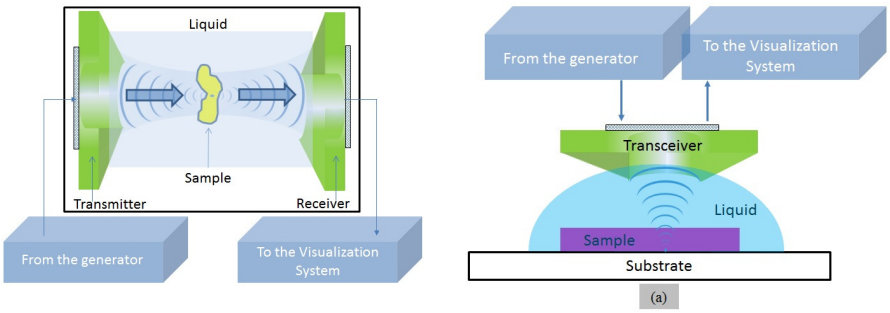
Transmission Mode



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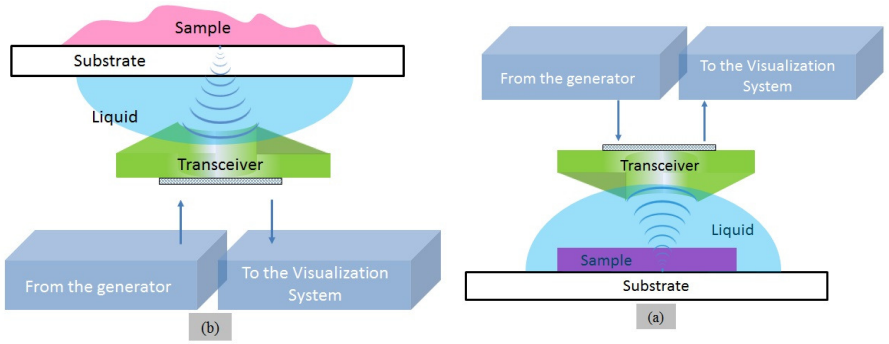
Transmission Mode



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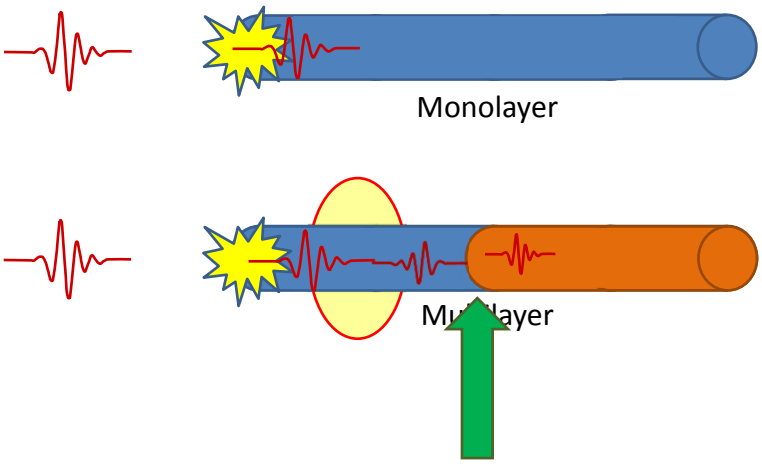
Multilayered Medium



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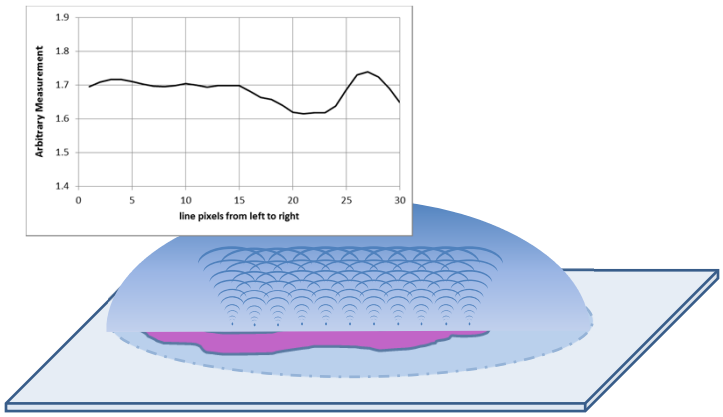
Most Author Did



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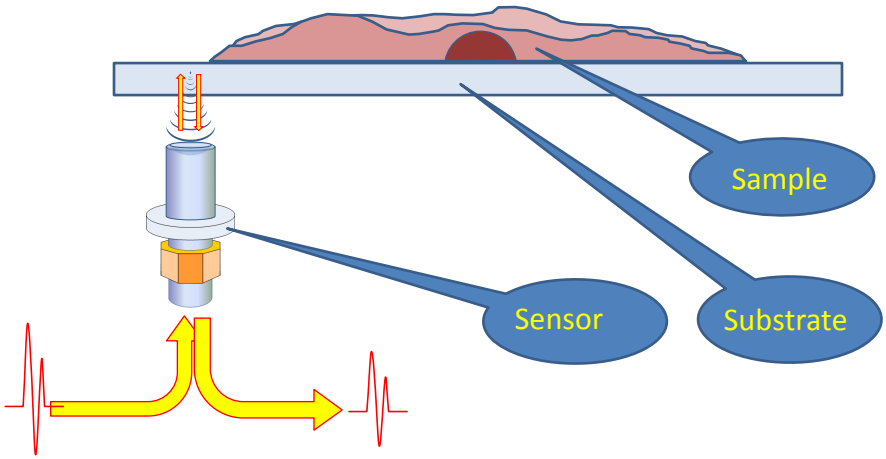
Microscope Ultrasonic



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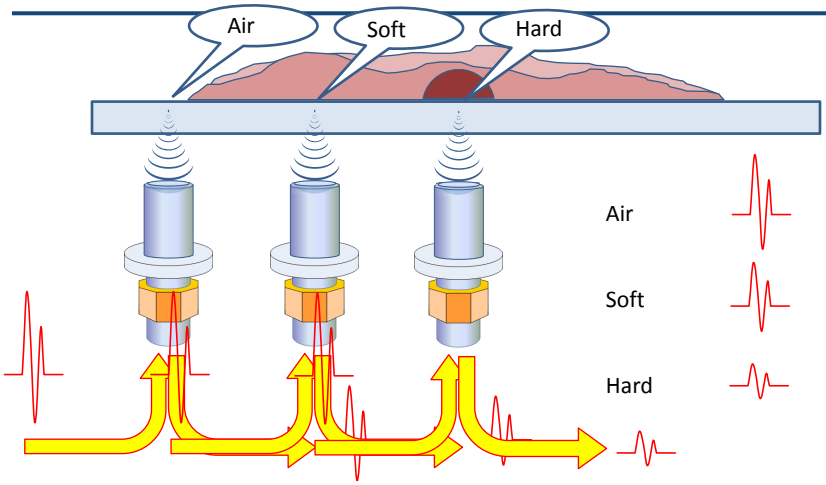
Microscope Ultrasonic



The echo is affected by physical properties (density, hardness, elasticity)

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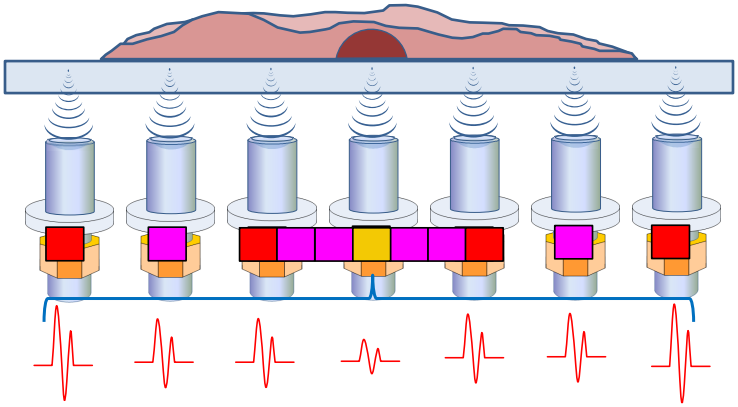
Microscope Ultrasonic



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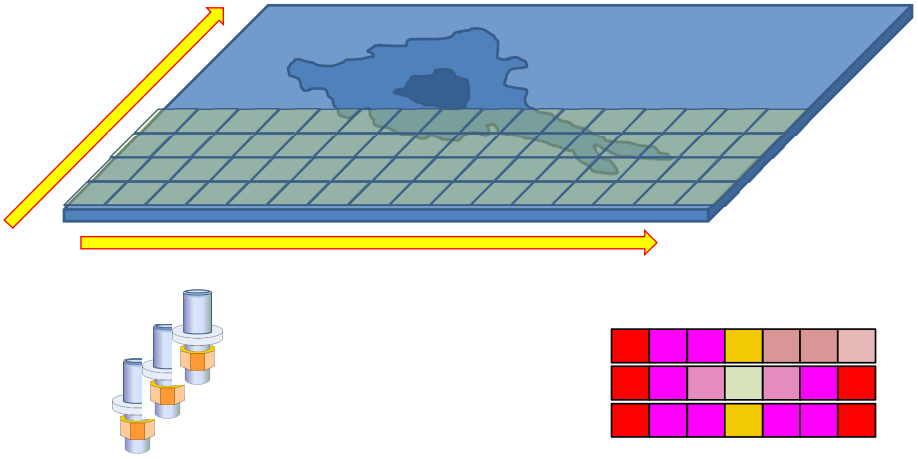
Microscope Ultrasonic



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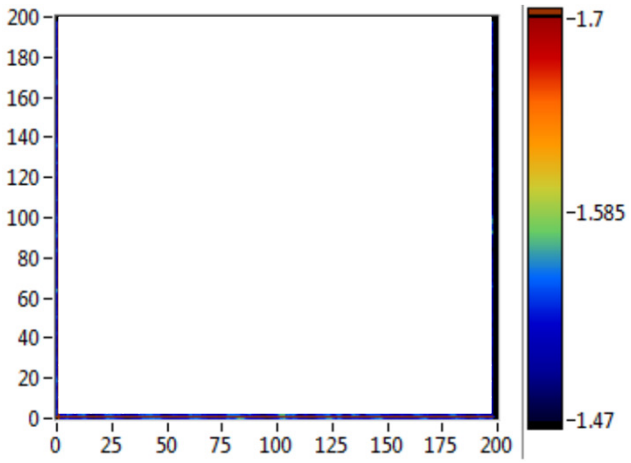
Microscope Ultrasonic



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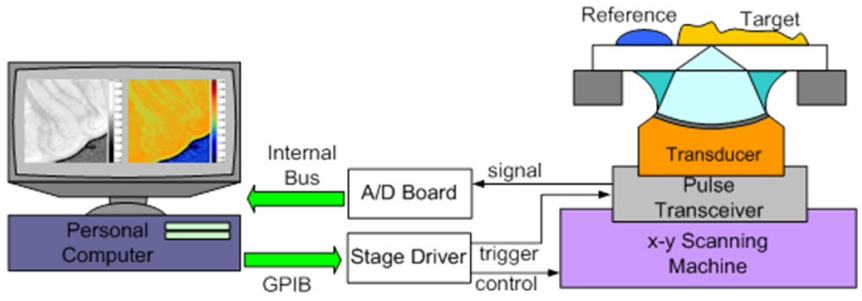
Schematic Diagram



Stage Driver → Sigma KOKI (SHOT-202)
Scanning machine → Sigma KOKI x-y scanning
GPIB → General Purpose Interface Bus
A/D Board → Acqiris DP210 2GS/s 500 MHz

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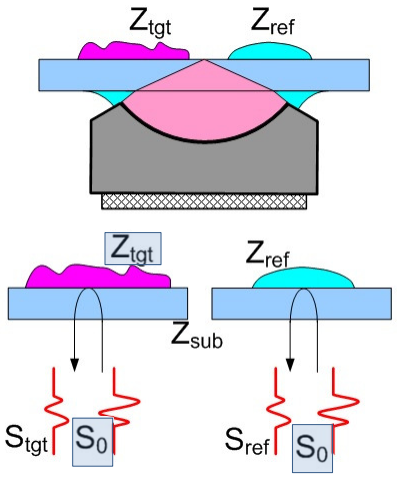
Vertical Incidence Analysis

$$S_{tgt} = \frac{Z_{tgt} - Z_{sub}}{Z_{tgt} + Z_{sub}} S_0$$

$$S_{ref} = \frac{Z_{ref} - Z_{sub}}{Z_{ref} + Z_{sub}} S_0$$

$$Z_{tgt} = \frac{1 - \frac{S_{tgt}}{S_{ref}} \cdot \frac{Z_{sub} - Z_{ref}}{Z_{sub} + Z_{ref}}}{1 + \frac{S_{tgt}}{S_{ref}} \cdot \frac{Z_{sub} - Z_{ref}}{Z_{sub} + Z_{ref}}} \cdot Z_{sub}$$



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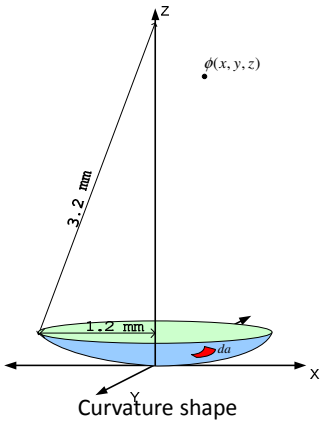
Sound Field Analysis

Improvement:

- Upgrading spatial resolution by replacing 16° transducer with 22° transducer
- All aspects including oblique incidence, pressure wave and shear wave are also considered
- Calculate sound field by utilizing Fourier analysis in *k*-space



Curvature shape transducer

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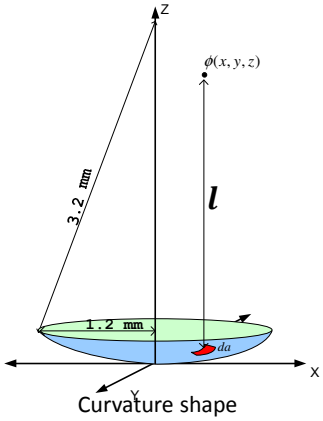
Sound Field Analysis

$$\phi(x,y,z)=\phi_0\frac{e^{-j\cdot(\boldsymbol{k}.\boldsymbol{l})}}{|\boldsymbol{l}|}\,da$$

$$\boldsymbol{k}=k_x+k_y+k_z$$

$$\boldsymbol{k}=\frac{c}{\omega}$$



Curvature shape transducer

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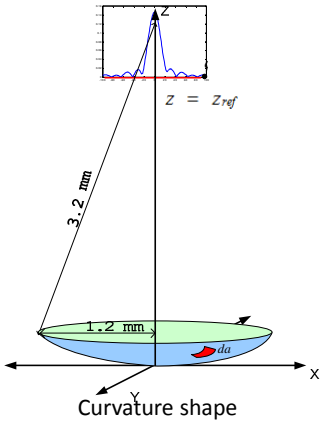
Sound Field Analysis

$$\phi(x,y,z)=\phi_0\frac{e^{-j\cdot(\boldsymbol{k}.\boldsymbol{l})}}{|l|}\,da$$

$$\boldsymbol{k}=k_x+k_y+k_z$$

$$\boldsymbol{k}=\frac{c}{\omega}$$



Curvature shape transducer

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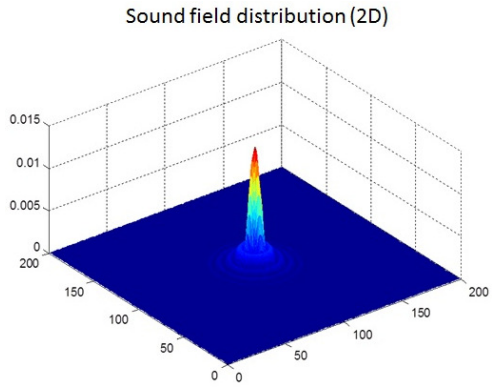
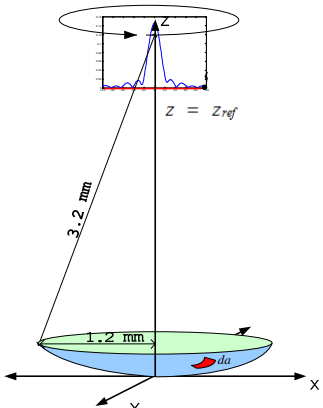
Sound Field Analysis





Curvature shape transducer

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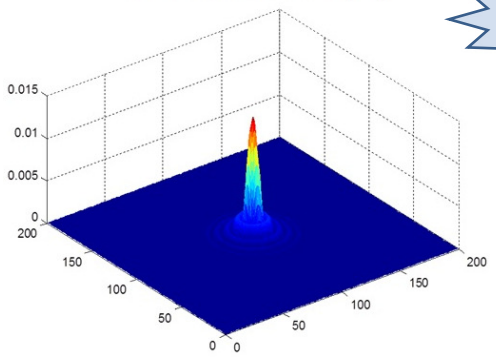
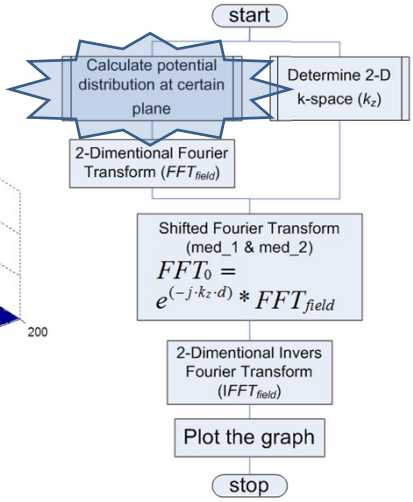
Sound Field Analysis

Sound field distribution (2D)





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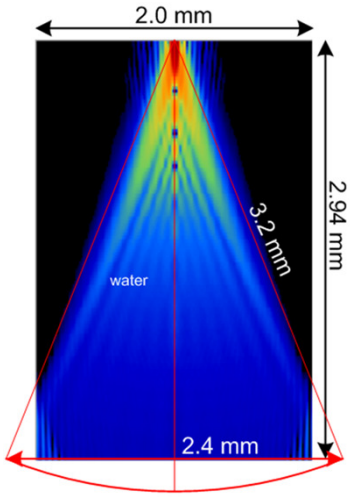
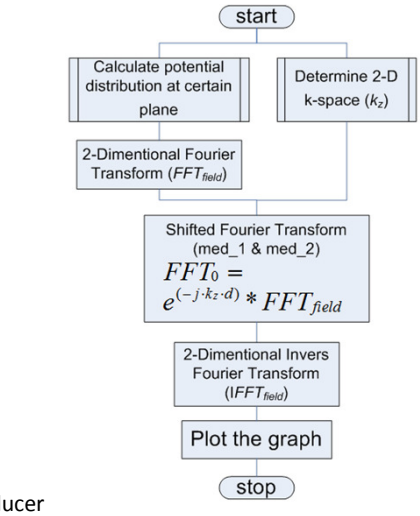
Sound Field Analysis



Sound field distribution in front of transducer



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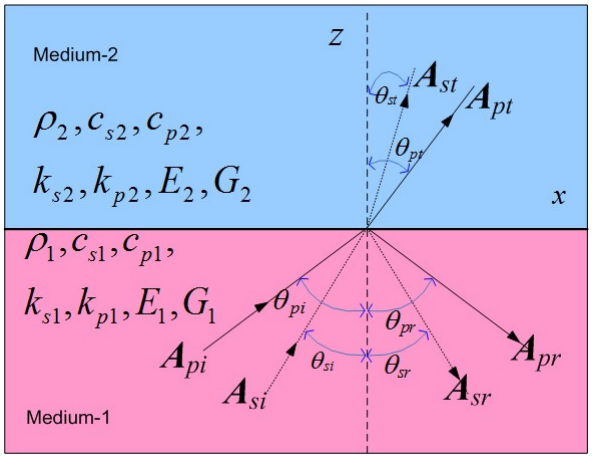
Oblique Incidence Wave



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Oblique Incidence Wave (TF)

$$\begin{bmatrix} \begin{pmatrix} k_{s1} & k_{p1} & k_{s2} & -k_{p2} \\ -k_{s1} & k_{p1} & k_{s2} & k_{p2} \\ \rho_1 & -\rho_1 & \rho_2 & \rho_2 \\ -\rho_1 & -\frac{\mu_1\rho_1}{\lambda_1+2\mu_1} & -\rho_2 & -\frac{\mu_2\rho_2}{\lambda_2+2\mu_2} \end{pmatrix} \begin{pmatrix} \cos\theta_{sr} & \sin\theta_{pr} & \cos\theta_{st} & \sin\theta_{pt} \\ \sin\theta_{sr} & \cos\theta_{pr} & \sin\theta_{st} & \cos\theta_{pt} \\ \sin 2\theta_{sr} & \cos 2\theta_{sr} & \sin 2\theta_{st} & \cos 2\theta_{st} \\ \cos 2\theta_{sr} & \sin 2\theta_{pr} & \cos 2\theta_{st} & \sin 2\theta_{pt} \end{pmatrix} \end{bmatrix} \cdot \begin{pmatrix} A_{sr} \\ A_{pr} \\ A_{st} \\ A_{pt} \end{pmatrix} =$$

$$\begin{bmatrix} \begin{pmatrix} k_{s1} & -k_{p1} \\ k_{s1} & k_{p1} \\ \rho_1 & \rho_1 \\ \rho_1 & -\frac{\mu_1\rho_1}{\lambda_1+2\mu_1} \end{pmatrix} \begin{pmatrix} \cos\theta_{sr} & \sin\theta_{pr} \\ \sin\theta_{sr} & \cos\theta_{pr} \\ \sin 2\theta_{sr} & \cos 2\theta_{sr} \\ \cos 2\theta_{sr} & \sin 2\theta_{pr} \end{pmatrix} \end{bmatrix} \cdot \begin{pmatrix} A_{si} \\ A_{pi} \end{pmatrix}$$

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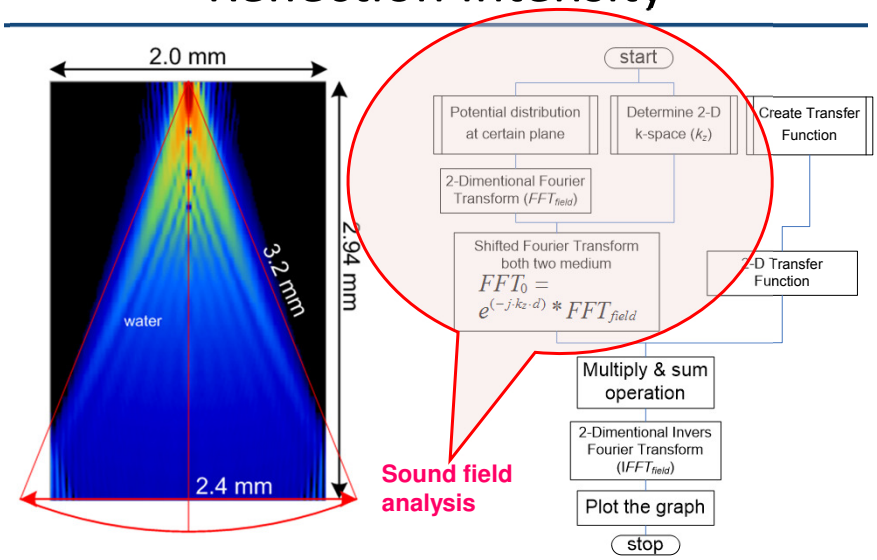
Reflection Intensity



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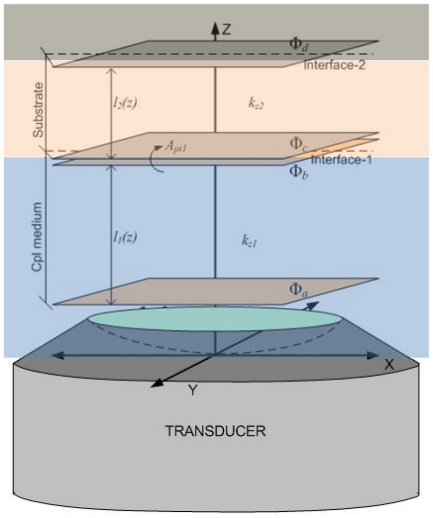
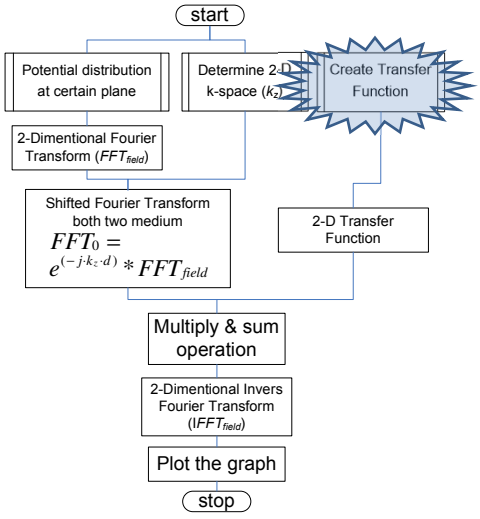
Reflection Intensity





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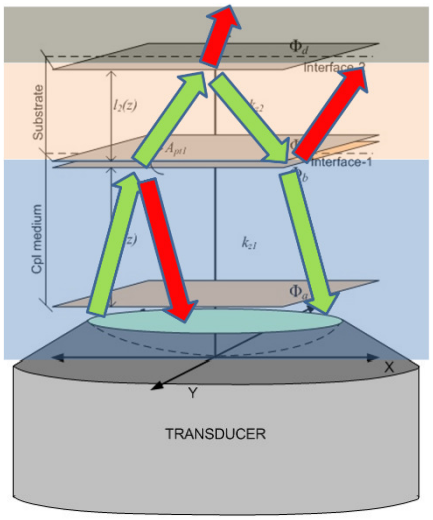
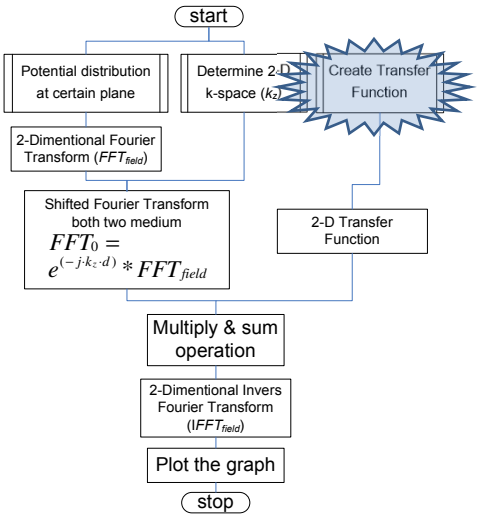
Reflection Intensity





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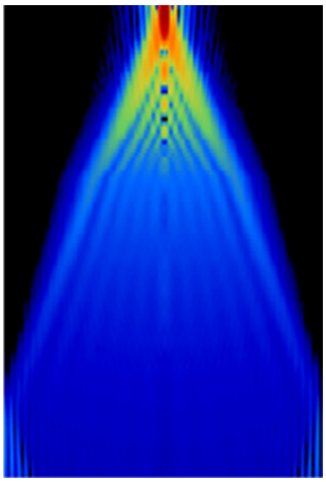
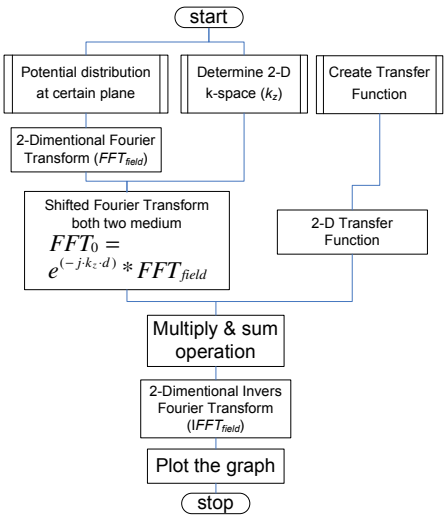
Reflection Intensity





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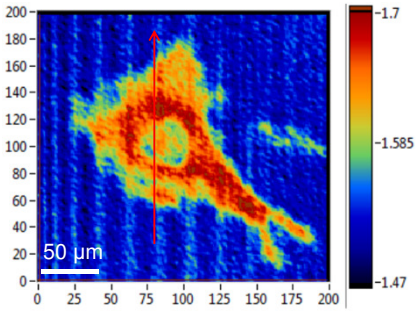
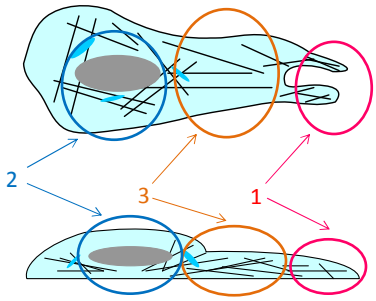
Acoustic Impedance Profile of a Glia in Enlarged Scale



This figure was 250 x 250 µm, covered by 200 x 200 pixels.



Cell Motility, defined by Mitchison and Cramer [103], Raftopoulou and Hall [105].

Classified into 3 areas:

1. Protrusion area → microtubules
2. Cell body → the thickest region containing nucleus (rich of actin filament and microtubules).
3. Intermediate area → lay in between cell body and protrusion area (rich of actin filament and microtubules).

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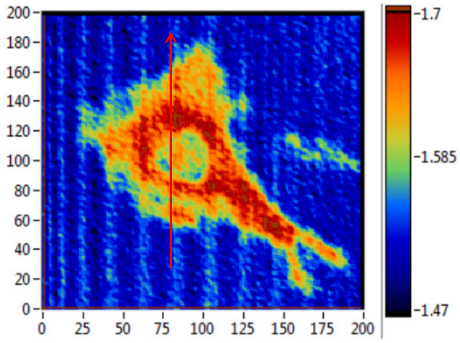
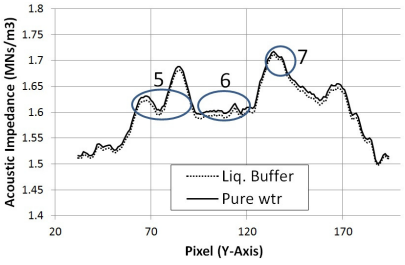
A Trace in Acoustic Impedance Along a Line





Either Buffer Liquid or Pure water can be used as a reference

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Collaborative research and Cooperation are Welcome

Terima kasih
atas perhatiannya

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