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Chapter 1 : Imaging the Anterior Segment: Ultrasound Biomicroscopy

The frequencies of the ultrasound waves are measured in Mega-hertz, are inversely proportional to the wavelength, and range between and MHz for visualization of epidermis, dermis, and.

High-frequency ultrasound biomicroscopy UBM is a noninvasive diagnostic tool for in vivo imaging of the anterior segment. The echoes are translated into voltages, amplified, and converted into pixel intensity to create a two-dimensional cross-sectional image. The cost of UBM technology was long prohibitive for physicians not in large academic practices. As the price of equipment decreases, however, high-frequency UBM is finding its way into more and more private clinical offices. Unfortunately, the low resolution of the MHz system is inadequate for diagnostic utility in the anterior segment. UBM uses a higher frequency MHz , which allows for better image resolution and increased magnification. Anterior segment optical coherence tomography provides excellent views of the anterior chamber, but the technology cannot acquire images behind the heavily pigmented posterior surface of the iris, because the coherent light is absorbed by the iris pigment epithelium. The traditional UBM examination uses an open plastic shell to contain the coupling fluid and provide the standoff needed to overcome the near-field artifact. The patient must be in the supine position to prevent the fluid from spilling out of its well. This examination requires a skilled technician to obtain quality images and also to take care not to abrade the cornea or conjunctiva with the edge of the plastic shell or the moving nub of the UBM probe. When the clinician is attempting to examine structures posterior to the limbus, the patient must move his or her eye, and abrasions are more likely. Pushing the cover against the eye generates positive pressure to maintain space between the ultrasound transducer inside the bag and the ocular surface outside the bag , thus overcoming near-field artifact Figure 1. In primary angle closure, forward bowing of the iris is typically evident. Posterior synechiae may even be detectable. With plateau iris, UBM generally demonstrates an anteriorly rotated ciliary body with obliteration of the ciliary sulcus and a flat central iris plane1,3,6 Figure 2. If their angles do not open sufficiently after only iridotomy, clinicians can reexamine these patients with UBM to help decide if they also need an iridoplasty to prevent an angle-closure attack. Changes in ambient lighting cause identifiable anatomical alterations in the iridocorneal angle. As expected, imaging with UBM has revealed a narrowing of the angle in scotopic compared to photopic conditions. Iris cysts are commonly discovered with UBM. They are usually insignificant but sometimes may narrow the anterior chamber angle or displace the crystalline lens or an IOL Figure 3. Malignant glaucoma is characterized by a forward movement of the iris-lens diaphragm, absence of iris bowing, a very shallow anterior chamber, and possible contact between the ciliary processes and the lens equator. A dynamic scan with UBM can be quite useful for diagnosing cyclodialysis clefts, which are not always visible on gonioscopy. Anterior suprachoroidal effusions may be difficult to identify by indirect ophthalmoscopy. Additionally, because the water-filled probe cover is so well tolerated by patients, it can be used to image the fragile tissue of a filtering bleb or the posterior end of a tube shunt2 Figures 4 and 5. With UBM, the cornea surgeon can look behind a densely opaque or edematous cornea to evaluate if penetrating keratoplasty will benefit the patient. If zonular dehiscence is suspected in an eye with a visually significant cataract, UBM allows the surgeon to identify the extent of zonular loss preoperatively. Finally, UBM can help ophthalmologists evaluate and manage ocular and even adnexal tumors. Detecting and measuring the extent of iris and ciliary body melanomas can be difficult with a clinical examination alone. As this clinical diagnostic tool becomes more affordable, the examination becomes increasingly comfortable for patients, and practitioners gain greater familiarity with its potential applications, UBM will likely become more and more popular in comprehensive ophthalmology offices. He acknowledged no financial interest in the product or company mentioned herein. Bell may be reached at ; nicholas. Nagi may be reached at kundandeep. Ursea R, Silverman R. Anterior segment imaging for the assessment of glaucoma. New technology for examining the anterior segment by ultrasonic biomicroscopy. J Cataract Refract Surg. Ishikawa H, Schuman JS. Ophthalmol Clin North Am. Ultrasound biomicroscopy in the subtypes of primary angle closure glaucoma. Ultrasound biomicroscopy in plateau iris syndrome. Invest Ophthalmol Vis Sci.

Chapter 2 : A MHz ultrasound biomicroscope. (Book,) [calendrierdelascience.com]

A MHz ultrasound biomicroscope Abstract: The development of higher frequency ultrasound imaging systems affords a unique opportunity to visualize living tissue at the microscopic level. This work was undertaken to assess the potential of ultrasound imaging in vivo using the MHz range.

Lens Clinical applications UBM is a useful tool for evaluating the presence of narrow anterior chamber angles, angle closure glaucoma, and pathology of the ciliary body. While it can be an alternative to gonioscopy, which can be subjective and difficult to perform with varying interpretations depending on slit lamp light intensity, it is an expensive technology and is more often used as an adjunct test to follow up on abnormal gonioscopic findings. Studies have shown moderate agreement between UBM and gonioscopy for evaluating the anterior angle [3]. UBM is frequently used in research to better understand the angle and can be used for qualitative analysis of the anterior chamber angle ACA. Analysis and interpretation of images begins with identification of the scleral spur, a protrusion of the sclera into the anterior chamber that attaches anteriorly to the trabecular meshwork. UBM can describe the presence of angle closure glaucoma, which is indicated by irido-corneal contact anterior to the scleral spur. It can also distinguish between different types of angle closure, including pupillary block, plateau iris, and other causes. It may also elucidate causes of open angle glaucoma, such as pigment dispersion syndrome, if reverse pupillary block is seen on scans. Angle opening distance AOD , the perpendicular distance between the trabecular meshwork at a point um anterior to the scleral spur, and the iris. These measurements may be used to monitor changes in the ACA over time, assess the effect of drug instillation, and evaluate changes in glaucoma patients post-operatively [6]. Additionally, UBM can be used for imaging of the cornea. Pathologies that can be identified include keratoconus, corneal dystrophies, edema, and scars. It can also be used to resolve different layers of the cornea and visualize LASIK flaps post-operatively [7]. However, downsides compared to AS-OCT include the need for a water-bath immersion, longer image acquisition times, and the need for a skilled operator. A study comparing the two techniques demonstrated relative agreement in measurements of the anterior chamber [10]. Additional Resources American Academy of Ophthalmology. American Academy of Ophthalmology, Subsurface ultrasound microscopic imaging of the intact eye. From Pearls of Glaucoma Management. Anterior chamber angle assessment using gonioscopy and ultrasound biomicroscopy. Ultrasound biomicroscopy of anterior segment structures in normal and glaucomatous eyes. Quantitative assessment of the anterior segment using ultrasound biomicroscopy. Ophthalmol Clin North Am. Ultrasound biomicroscopic assessment of the cornea following excimer laser photokeratectomy. J Cataract Refract Surg. High resolution ultrasound of the eye â€” a review. Comparison of anterior segment optical coherence tomography and ultrasound biomicroscopy for assessment of the anterior segment.

Chapter 3 : Ultrasound Biomicroscopy - EyeWiki

A MHz Ultrasound Biomicroscope Donald Andrew Knapik Master of Science, Department of Medical Biophysics University of Toronto Clinical ultrasound imaging systems capable of producing rcal-time, economical, cross.

It is the simplest method of imaging an eye affliated with opacities such as a cataract or vitreous hemorrhaging. Ophthalmologic ultrasound usually employs frequencies of up to 10 million Hertz 10 MHz , but frequencies in the range of 50 to MHz are used in ultrasound biomicroscopy of the eye. Humans cannot hear sounds that emit a frequency of greater than 20, Hertz. An ultrasound image is created by a transducer or probe that transforms electric energy to sound energy, which then penetrates the ocular tissue. The energy that is reflected off the tissue i. Purpose The purposes of ophthalmologic ultrasound are to study ocular anatomy and to diagnose pathology of the eye. There are many different types of ophthalmologic ultrasound. They include A-scans, B-scans, 3-D scans, duplex ultrasonography, and ultrasound biomicroscopy. The A-scan ophthalmologic ultrasound is used to measure the axial length of the eye and the thickness of the lens of the eye. The most common use of an A-scan, along with keratometry, which measures the curvature of the anterior surface of the cornea, is to determine the power of the intraocular lens to be implanted following cataract extraction. A B-scan ophthalmologic ultrasound gives images of the structures throughout the orbit. The B-scan is used by the ophthalmologist in some intraocular surgeries, such as in placement of a radioactive plaque to treat a retinal tumor, and in the extraction of a foreign body that has penetrated the globe. In cryotherapy, the clinical use of low temperatures, ophthalmologic ultrasound imaging helps guide the probe used to treat retinal tears in the presence of vitreous hemorrhaging. It is also used preoperatively in patients with dense cataracts to rule out pathology of the posterior pole, and to evaluate resorption of vitreous hemorrhages in diabetic retinopathy. B-scan ultrasonography can locate retinal and choroidal detachments and is used to assess drusen, or calcium deposits on the optic nerve and to locate intraocular tumors. The B-scan also can detect changes in structure of the posterior sclera, but because of its limited resolution, anterior scleral pathology is difficult to assess. The new-generation B-scans can assess optic nerve cupping, changes of the optic nerve seen in glaucoma. Color doppler and duplex ophthalmologic ultrasonography are helpful in the assessment of glaucoma, and in diagnosis of ocular tumors and diseases of the anterior segment. Since they evaluate blood flow and resistance through the intraocular blood vessels, Doppler and duplex ultrasonography can be employed in the diagnosis of a central retinal artery or vein occlusion, and in the diagnosis of temporal arteritis. Temporal arteritis is an inflammation of the temporal artery which can affect vision. Restriction of blood flow through other ocular vessels affected in temporal arteritis can also be observed by duplex ultrasonography. A 3-D ophthalmologic ultrasound gives the eye care practitioner a 3-D image of the eye, facilitating the diagnosis of a retinal detachment, intraocular tumors, or enlargement of the extraocular muscles. The 3-D ultrasound can be utilized prior to refractive surgery, to assess corneal thickness and irregularities in the corneal surface, and to determine with accuracy the depth of the anterior chamber before implantation of an intraocular lens. Ultrasound biomicroscopy is employed to assess the normal spatial relationships among anterior segment structures of the eye such as the iris, ciliary processes, and the layers of the cornea. It is also used to assess pathology of the eye and adnexa. Applications of ultrasound biomicroscopy include: Ultrasound biomicroscopy can image the position of implants such as an intraocular lens placed in the eye after cataract surgery, or a filtering bleb, placed intraocularly after glaucoma surgery. It can image tumors of the iris and ciliary body, detect anterior segment abnormalities, and isolate foreign bodies that penetrate the globe. With the higher resolution of ultrasound biomicroscopy, scleral pathology, such as scleritis, an inflammation of the sclera, is detectable. Telesonography is a method of using ultrasound to diagnose medical conditions from a remote site. Ophthalmologic ultrasound images can be transmitted via the Internet with this technology. Description The images formed by ophthalmologic ultrasound must be resolvable. Resolution is the ability of the eye to distinguish between objects. Resolution can be linear, which determines how far apart two objects are from each other, or contrast, which determines the differences of shades of gray between objects. The higher the frequency employed, the greater the resolution, i. A frequency

of 10 Mhz gives a resolution of micrometers, but resolution as small as 20 micrometers is possible with a Mhz transducer. An A-scan ophthalmologic ultrasound produces a one-dimensional display of intraocular structures. It can employ either applanation or water immersion techniques. The applanation probe, or transducer, touches the cornea of the eye, while the immersion probe is mounted in a water bath surrounding the eye and never compresses the globe. Because the applanation probe applies more pressure to the eye, it can underestimate axial length. Since the probe of the water immersion unit is not in direct contact with the eye, and the sound waves must pass through water before reaching the back of the eye, it is more difficult to judge the layers of the internal eye with this technique, especially when a dense cataract is present. The B-scan ophthalmologic ultrasound produces a two dimensional real time image. Usually an applanation probe is used, but a water bath technique may give better resolution, important in location of small foreign bodies. In B-scan ultrasound exams the probe is oriented perpendicular to the structure being examined. The images of B-scans are displayed on a video monitor, and can be recorded. The 3-D ophthalmologic ultrasound produces its image as the probe passes over the eye at numerous angles, and then combines these slices of the eye to produce an image larger than that formed by the B-scan. A 3-D ultrasound can reproduce an image in less than 12 seconds, but it is not a real time image. The anterior segment cannot be imaged well by 3-D ultrasonography. Doppler ultrasonography assesses blood flow in the eye. Duplex ultrasonography combines the B-scan with the Doppler ultrasonography. The color duplex ultrasound is superimposed with color, allowing the examiner to assess blood flow direction, identify blood vessels, and calculate velocity of blood flow. These techniques, when applied to the eye, assess blood flow through ocular blood vessels. Ultrasound biomicroscopy uses higher frequencies and thus can image the structures of the eye with greater resolution than a B-scan ultrasound and gives the eye care practitioner a real-time image. Ultrasound biomicroscopy can penetrate the eye only up to 5 mm and thus cannot image the posterior pole. The average length of the eye is 25 mm. Precautions Special care is needed when performing an ophthalmologic ultrasound on a ruptured globe. Preparation Ophthalmologic ultrasounds are usually performed in the supine position lying down and in dim light. An eye cup may keep the eye open or the probe may be held against the eyelid. With the water immersion technique a plastic bag with a hole large enough for the eye and lids to protrude, is placed around the eye. A protective contact lens may be placed on the eye. The patient is given a target on the ceiling on which to fixate, with the eye not being examined. The probe is covered with a coupling gel, and then applied in various directions across the eye, perpendicular to the internal structures of interest. An eye cup, filled with the methyl cellulose, can be held over parts of the ocular adnexa, such as over a closed eye for examination of the lids, when structures external to the globe are examined. Aftercare The patient should be instructed not to rub the eyes for 20 to 30 minutes after an ophthalmologic ultrasound and warned that vision might be slightly compromised for the same time frame. Complications There are no known complications from ophthalmologic ultrasound when used for these time periods, and at levels indicated for ultrasound of the orbit and when performed by trained personnel. Results The results of ophthalmologic ultrasounds are immediately available to the doctor. Abnormal results indicate an underlying problem and may require further testing and treatment. Angleâ€” Part of the eye through which fluid leaves the eye. Anterior segmentâ€” The front part of the eye, that includes the sclera, the cornea, the tear film, the angle of the eye, the iris, and the ciliary body and its processes. Cataractâ€” Opacification clouding of the lens of the eye that occurs as a result of aging, disease, or trauma. Choroidâ€” Layer of the eye, rich in blood supply, that is found between the retina and the sclera. Ciliary body processesâ€” Structures of the eye that form the fluid of the anterior chamber and the vitreous. Corneaâ€” Transparent tissue on the front of the eye that focuses light into the eye through the pupil. Extraocular musclesâ€” The six muscles which are used to voluntarily move the eye. Glaucomaâ€” An ocular disease characterized by loss of visual field and damage to the optic nerve. It is often associated with increased intraocular pressure, but not in all cases. Intraocularâ€” Within the eyeball. Lensâ€” Intraocular structure in the eye that focuses light onto the retina. Ophthalmologistâ€” A medical doctor with residency training in medical and surgical management of eye disease. Optic nerveâ€” Large nerve in the back of the eye through which visual stimuli leave the orbit, to the occipital lobe where vision is processed. Optometristâ€” An eye care doctor specifically trained in all aspects of vision and eye care. Optometrists are licensed in all states to

diagnose and treat eye disease. Orbitâ€" The bony cavity of the skull that holds the eyeball. Posterior poleâ€" The posterior part of the eye that includes the retina and the vitreous. Radiologistâ€" A physician trained in radiology, the use of radiant energy, to diagnose and treat diseases. Retinaâ€" The inner part of the eye where the photo-receptors are located. Scleraâ€" Tough white membrane covering the outer part of the eye, not covered by the cornea. It encircles the inside of the eye and is continuous with the optic nerve. Vitreousâ€" A nonvascular gelatinous material found behind the posterior capsule of the lens. Health care team roles A sonographer, a medical professional trained in sonography, can do an ophthalmologic ultrasound, but in an ophthalmic practice the ultrasound is done by an ophthalmic technician or the doctor. The ultra-sound image is always interpreted by a doctor, such as an ophthalmologist, an optometrist, or a radiologist. Ultrasound Biomicroscopy of the Eye. Chung, Hak Sung, et. Cite this article Pick a style below, and copy the text for your bibliography.

Chapter 4 : Glaucoma Today - High-Frequency UBM (October)

Note: Citations are based on reference standards. However, formatting rules can vary widely between applications and fields of interest or study. The specific requirements or preferences of your reviewing publisher, classroom teacher, institution or organization should be applied.

Received May 10; Accepted Jun 1. To view a copy of this license, visit http: Abstract High resolution ultrasonic imaging requires high frequency wide band ultrasonic transducers, which produce short pulses and highly focused beam. However, currently the frequency of ultrasonic transducers is limited to below MHz, mainly because of the challenge in precise control of fabrication parameters. This paper reports the design, fabrication, and characterization of sensitive broadband lithium niobate LiNbO3 single element ultrasonic transducers in the range of â€” MHz, as well as their applications in high resolution imaging. All transducers were built for an f-number close to 1. Resolutions better than 6. Ultrasonic biomicroscopy images of zebrafish eyes were obtained with these transducers which demonstrate the feasibility of high resolution imaging with a performance comparable to optical resolution. As one of the most important and well established tools, ultrasound imaging provides noninvasive valuable diagnostic information, especially in the form of cross-sectional images of soft tissues 1 , 2 , 3 , 4. Conventional ultrasonic imaging system typically works at frequencies below MHz, which provides tens of microns to millimeter spatial resolution 5 , 6 , 7. High resolution clinical imaging has shown promise in morphological studies of the living corneal epithelium, in visualizing epidermis, in pediatrics as well as in small animal imaging for drug and gene therapy. Visualization of the corneal epithelium provides insight into corneal diseases and the effects of photorefractive surgery, also visualization of the epidermis could permit early diagnosis of melanoma 8 , 9. Nevertheless, one of reasons that have prevented ultrasonic imaging resolution from further improving has been the unavailability of highly sensitive wide band ultrasound transducers at frequencies higher than MHz. To improve spatial resolution, one strategy is to increase the operating frequencies accompanied by a loss of penetration 10 , The axial resolution is determined by the pulse duration or the bandwidth of the pulse. The lateral resolution at the focal point is determined by the product of wavelength and the f-number, the ratio of the focal distance to the transducer aperture. For a fixed number of cycles per pulse, an increase in frequency would result in a reduction in wavelength and thus pulse length. To achieve high lateral resolution and adequate sensitivity, a highly focused, low f-number transducer design was implemented. Hence, the high frequency, low f-number imaging yields improved spatial resolution at the focal point at the expense of imaging depth 1 , 9 , In this paper, we report the design, fabrication, and characterization of press-focused LiNbO3 transducers at frequencies of â€” MHz. The high resolution imaging capability of the transducers was demonstrated by scanning a zebrafish eye. The fine structures of the eye were discernible with these ultrahigh frequency transducers. The photographs of the completed press-focused ultrahigh frequency LiNbO3 transducers were presented at bottom of Fig.

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Chapter 5 : Ophthalmologic Ultrasounds | calendrierdelascience.com

The ultrasound biomicroscope works on the principle of an ultrasound but at a higher frequency. The normal B scan probe works at a resolution of 10 to 12 Mhz while.

Go to Academy Store Learn more and Purchase. Ultrasound Biomicroscopy In the principle of ultrasonography, the depth of tissue structures is determined by directly measuring the time delay of returning ultrasound signal. Most ophthalmologists are familiar with B-scan ultrasonography techniques, which operate at lower sound frequencies 10 to 20 MHz and cannot resolve the thickness of the corneal epithelium or provide measurements of internal corneal layers. However, using a MHz imaging probe or high-frequency UBM, reproducible images of the cross-sectional anterior chamber anatomy with high resolution are achieved. Each has a tissue depth penetration of approximately 5 mm and can view structures through opaque media, unlike the OCT. Each requires contact with the eye, and a coupling medium is necessary such that scanning must be performed through an immersion bath. Each technique offers useful clinical features, although the arc scan technique seems to have higher resolution in the cornea and anterior segment. Each technique requires patient contact and the use of a coupling media to enhance image resolution. Image acquisition time depends upon the cooperation of the patient and the experience of the examiner. Each technique helps to study the anterior segment anatomy in great detail. The exact configuration of the iris, ciliary body, and ciliary processes can be defined. This is important for the refractive surgeon, who relies on accurate anterior chamber dimensions to prepare for phakic refractive implant surgery. White-to-white, sulcus-to-sulcus, and angle-width measurements are easily performed with UBM Figure 13 Figure These values can be quantified and compared after treatment. In contrast to anterior segment OCT and Scheimpflug imaging, which do not penetrate past the iris pigment epithelium to a large degree, these structures may be seen with UBM in the presence of opaque media. Moreover, in the management of uveitis, pars planitis snowbanks, supra-ciliary effusions, cyclitic membranes, and ciliary body detachments can be visualized with UBM. Scleritis may be differentiated from episcleritis in certain cases. In the presence of trauma, it is often difficult to visualize the iris and lens due to the presence of hyphema. In this setting, UBM is helpful in studying the position of the lens, iris, and ciliary body, and the configuration of the anterior chamber angle. Angle recession and cyclodialysis clefts may be visualized. Most importantly, in the presence of dense corneal opacity, UBM is still able to evaluate the anatomy of the anterior segment before surgical intervention. The Artemis has a useful feature, in contrast to other UBM techniques, that allows it to resolve the epithelial layer of the cornea from the stroma. The advantage of linear UBM technology is a wider field or view. Limitations The main limitation of UBM is that it requires a water-bath coupling media and a very experienced examiner.

Chapter 6 : Ultrasound Biomicroscopes | calendrierdelascience.com

Very high frequency ultrasound (MHz) has had a significant impact upon clinical imaging of the anterior segment of the eye, offering an axial resolution as small as 30 Î¼m. Higher frequencies, while potentially offering even finer resolution, are more affected by absorption in ocular tissues.

Ultrasound biomicroscopy provides images in living eyes without affecting the internal relationships of the structures imaged and has proven valuable in clinical practice and research. How does Ultrasound Biomicroscopy work? The ultrasound biomicroscope works on the principle of an ultrasound but at a higher frequency. The normal B scan probe works at a resolution of 10 to 12 Mhz while the UBM probe works at a frequency of 35 - 50 Mhz or higher. The basic parts of a UBM are the same as that of a standard ultrasound and consist of a hand piece with transducer, a computer console which has the required hardware and software specific for the purpose, a monitor, a printer and a foot switch. The UBM software has special measuring features for measuring thickness of tissues or measuring angles. What types of disorders can be discovered using ultrasound biomicroscopy? Ultrasound biomicroscopy is a way to see the eye in great detail at the microscopic level. Any disorder that can be penetrated by high frequency sound and falls within the measureable wavelength of the ultrasound can be analyzed. UBM helps to study the angle in great detail. These structures can be seen in the presence of an opaque media. The angle can be quantified and the values can be followed up after treatment 2. UBM is helpful in the study of anterior uveitis. The presence of pars planitis, supra-ciliary effusion, cyclitic membranes and ciliary body detachments can be visualized on UBM. Anterior segment trauma is usually associated with hyphema. In presence of hyphema it is difficult to visualize the iris and lens. UBM is helpful to study the position of the lens the status of the iris, ciliary body and the configuration of the angle. Angle recession and Cyclodialysis cleft can be evaluated on UBM. In presence of dense Conjunctival and Adnexal Disease, ultrasound biomicroscopy can provide valuable information in the differential diagnoses of tumors such as iris tumors, ciliar body tumors, anterior segment tumors and cysts. Do I have to have anesthesia? UBM is done with the patient in the supine position and the eye is open. Since the piezoelectric crystal of the transducer is open it should not come in direct contact with the eye to prevent injury to the cornea. There is a special cup which fits in between the eyelids, keeping them open. The eye cup is filled with saline or sterile methylcellulose. The crystal of the transducer is placed in saline approximately 2 mm. This distance of 2 mm prevents injury to the cornea and also helps as a fluid standoff. The eye is scanned in each clock hour from the center of the cornea to the ora serrata. As for the sound, it must be noted that ophthalmologic ultrasound usually employs frequencies of up to 10 million Hertz 10 MHz , but frequencies in the range of 50 to MHz are used in ultrasound biomicroscopy of the eye. Humans cannot hear sounds that emit a frequency of greater than 20, Hertz. In order that an ultrasound image can be formed, a transducer or probe transforms electric energy to sound energy, which then penetrates the ocular tissue. The energy is not absorbed by the tissue as heat, nor is it scattered within the tissue, but is reflected off the tissue, forming the ultrasound image. How far in my eye can it see? The most important limitation of UBM is depth. UBM cannot visualize structures deeper more that 4 mm from the surface. The UBM has a low penetration because of high frequency and should be kept at least 11mm from the cornea.

Chapter 7 : Ultrasound Biomicroscopy (UBM) | What is Ultrasound Biomicroscopy?

The objective of the work reported here is to implement a realtime B-scan imaging system operating at frequencies in the MHz range with resolution approaching the size of single cells.

Chapter 8 : Development of a Bipolar Pulse Generator for High-Frequency Ultrasound Imaging System

For transducers "LN_" and "LN_", the measured center frequencies were close to the impedance resonant frequencies, while for transducer "LN_", the measured center frequency at focus point was MHz, lower than the simulated resonant

frequency MHz.