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X-RAY MICROSCOPE - A LITERATURE REVIEW

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ABSTRACT:

X-ray microscopes produce enlarged images of small objects.This microscope makes use of the emission of X-ray from a point source to cast an enlarged image on a phosphor screen. Microscope is an instrument that produces magnified images of small objects, permitting the observer an extremely close view of small structures at a scale suitable for examination and analysis .Recently, most of the soft X-ray microscopes use a synchrotron radiation source to provide the X-ray. X-rays penetrate objects far easier compared to visible light.Thus X-ray microscopes can image the interior of samples which seems opaque for visible light. X-ray microscopes have excellent powers of penetration due to radio waves that can pass easily through most matter, excluding good conductors such as metals.They allow us to study the bulk regions of thick samples in their natural environment. A major disadvantage of x-ray microscopy compared to electron microscopy is its inability to produce real-space images of the objects that are being focused ,there are no appropriate lenses available. The aim of this review article is to analyse the applications of X-ray microscopes in various fields.

INTRODUCTION

X-ray microscopes produce magnified images of small objects.This microscope utilizes the emission of X-ray from a point source to cast an magnified image on a phosphor screen. An effective X-ray microscope was created in 1951 by English physicists Ellis Coslett and William Nixon(1,2). Early X-ray microscopes by Paul Kirkpatrick and Albert Baez utilized grazing incidence reflective X-ray optics to focus the X-rays (3,4).X-ray microscope utilizes electromagnetic radiation from the soft X-ray band to produce magnified images of objects. Since X-rays penetrate almost all objects, there is no need to specially prepare them for X-ray microscopy observations (5,6). With the applications proceeding to develop, X-ray microscopy has become a routine, utilized in environmental science and soil sciences, geo-and chemical cosmology, macro molecular sciences, biology and material sciences (7).

A cryogenic object chamber has been carried out on the x-ray microscope (8). First experiments have shown that at cryogenic temperatures the structural stability of biological specimens is increased by three orders of magnitude in comparison with unfixed wet specimens at room temperature(9).X-ray microscopy can perform at higher resolution due to its shorter wavelength than light microscopy (10). X-ray microscopy offers better imaging resolution than light microscopy, and exceptional ability of nondestructive three-dimensional imaging of hydrated biological cells, corresponding to existing light and electron microscopy (11,12). X-ray microscopes have excellent powers of penetration due to radio waves that can pass easily through most matter, excluding good conductors such as metals (13). X-rays are difficult to be focused with ordinary lenses(14). Using Fresnel lenses made of very thin circular concentric slits in a strongly absorbing material,both hard and soft rays can be focused (15,16). A major disadvantage of x-ray microscope compared to electron microscopy is its inability to produce real-space images of the materials that are being examined,there are no appropriate lenses available (17,18).The spatial resolution of a microscope is limited by the wave nature of light.The resolution better than about half the wavelength cannot be attained. That is the reason why X-ray microscopy imaging technique has been developed (19,20)

The aim of the study is to determine and analyse whether the x-ray microscope can be used extensively replacing the other type of microscope.

MICROSCOPE

Microscope is an instrument that produces magnified images of small objects, permitting the observer an extremely close view of small structures at a scale suitable for examination and analysis (21). It helps us to observe objects that are too small to be seen by the naked eye. Microscopy is the science of examining small objects and structures using such an instrument (22). Microscopic means invisible to the eye unless aided by a microscope (23). A microscope is generally viewed as an assembly of lenses used to give an image of small objects at high spatial resolution.high spatial resolution means that it is a finer resolution than that can be resolved by the naked human eye (24).

X-RAY MICROSCOPE

At present , most of the soft X-ray microscopes utilize a synchrotron radiation source to provide the X-ray(25). X-rays have the advantage of having a short frequency and can penetrate through thick samples (26).X-ray microscope, have excellent powers of penetration due to radio waves that can pass easily through most matter, excluding good conductors such as metals (27). They allow us to study the bulk regions of thick samples in their natural environment (28).The resolution of X-ray microscopy lies between optical microscopes and the electron microscope. It has an advantage over conventional electron microscopy in that it can view biological samples in their natural state (29,30)

X-RAY VS LIGHT MICROSCOPE

X-rays penetrate objects far easier compared to visible light.Thus X-ray microscopes can image the interior of samples which seems opaque for visible light (31,32). X-ray microscopes can attain higher optical resolution than microscopes using visible light (33).The lightmicroscope also called an optical microscope is a type of microscope that generally utilizes visible light and a system of lenses to generate magnified images of minute objects (34). Optical microscopes are the earliest design of microscope and were possibly invented in their present compound form in the 17th century (35,36). Light microscopes are complex tools with many adjustable components they find it challenging to view the internal structures.whereas x ray microscope can view the internal structures (37). X-rays do not reflect or refract easily, and they are invisible to the human eye (38) whereas the visible light gets reflected easily (39).

SOFT X-RAY MICROSCOPE

Soft x-ray microscopy can convey 30-nm goals pictures of hydrated cells up to roughly 10 microns thick, and endeavors towards obtaining higher resolution (40,41).Microscopy with soft x rays needs intense X-ray sources just as high resolution X-ray lens.Intense X-radiation is produced by the synchrotron radiation of electron storage rings. Soft X-rays have properties which make them well suited for tomographic imaging of cells (42). It is used to image at high spatial and temporal resolution microscopic structures with applications to magnetism,materials and environmental science and biology (43,44).

RECENT advances in X-ray Microscope

X ray imaging can be carried out utilizing both soft and hard X rays. Hard X rays have frequency lesser than 0.2 nm, while soft x rays have frequency longer. Hard X rays have a significant penetrating power and greater energy but can cause more harm to the sample during imaging. Recently, scientists made use of soft X rays, which have wavelengths ranging from 1 to 10 nm, to achieve the highest resolution ever in X ray microscopy (45,46).The high-penetrating power of hard X-rays and neutrons are considered the recent advances in instrumentation and computational methods (47,48).They are expected to increase the growth of novel imaging approaches, making microradiography and computed microtomography unique tools to note the internal structures of materials undergoing processes such as melting, vesiculation, growth, dissolution or reaction of crystalline phases, fluid flow.

APPLICATION OF X-RAY MICROSCOPE

X-ray microscopy that is recently developed and widely utilized in analysis of biological specimens shows to have possible future directions in application to biomedical science (49).Three-dimensional X ray microscopy has proved to be extremely useful in the field of medicine, and it has applications in developmental biology, imaging of soft tissues, biomaterials science,in vivo imaging. It is utilized to envision the structure of various tissues during development, biopsy samples, in model organisms and humans (50,51).

ADVANTAGES OF X-RAY MICROSCOPE

X-ray microscopy has a lot of the advantages of electron microscopy, with the advantage of lesser damage to the sample and greater tolerance of wet samples but usually involve spectroscopic measurements (52,53). By using photography, microscopes, X-rays,we are able to get a clear images of the inner workings of the human body(54,55).X-rays produces fluorescence in almost every materials, and these emissions can be analyzed to determine the chemical elements of an image object (56,57). Another advantage is it is used to generate diffraction patterns.Diffraction patterns are processes that are used in X-ray crystallography (58). The fact that X-ray microscopy can produce higher resolution than can the best optical microscope is giving motivation to the field of research (59,60)

FUTURE SCOPE

The future microscopist may find himself replaced from the more standard tasks of focusing, alignment, image recording and even basic interpretation by the electronic robot. On the other hand, he will gain access to a more extensive and more progressively complex scope of physical and chemical phenomena governing the interaction between the specimen and the radiations he uses to examine its microscopic structure and properties. Digital X-rays disclose to us in excess to a visual test, however much greater clarity might be needed.This brings in serious strain on the dentist's back, neck, and shoulders. Whereas dental microscope lets dentists sit up straighter, preventing strain.X-ray microscopes are utilized in environmental science and soil sciences, geo-and chemical cosmology, macro molecular sciences, biology and material sciences.

CONCLUSION

Three-dimensional X ray microscopy proved to be invaluable in the field of medicine,applications ,developmental biology,imaging of soft tissues,biomaterials and in in vivo imaging X-ray microscopy takes advantages above other techniques due to high penetrating depth of X-ray radiation.X ray microscopy can be used to analyse thick samples with great resolution.X-ray microscopy spectromicroscopy- full-field transmission X-ray microscopy provides multiple wavelength imaging. Since resolution is more important than anything else for diagnosis,we can ignore its limitations and use the technology for the benefit of mankind.

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