SCANNING ACOUSTIC MICROSCOPE

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ABSTRACT

The acoustic microscope - an instrument based on acoustic radiation at microwave frequencies - is designed for viewing the microscopic detail exhibited in the elastic properties of a given object. The most significant and the most recent improvement has been the introduction of mechanical scanning. With this innovation there has been substantial improvement in the resolving power since the new instrument has made it possible to work in liquid water with sound frequencies above 1000 MHz. The resolution in a carefully constructed instrument at these frequencies approaches that of the optical instrument and it permits one to observe both the internal details of biological cells and the fine structure of integrated circuits. Even though the resolving power is not yet equal to the value that is achieved with optical waves it does bring into view an interesting part of the microscopic world.

The response of biological material to elastic waves is distinct and different. It is this difference which should be exploited to obtain information and detail that complements and increases the value of the images recorded in optical micrographs. At this early stage it is apparent that the contrast in unstained tissue sections and individual cells for acoustic waves is much greater than it is for optical waves.

In the scanning version the acoustic beam is introduced into the liquid cell from a sapphire crystal through a spherical lens formed at the crystal-liquid interface. The object, or specimen, to be viewed is fastened to a membrane of mylar as stretched over a metal ring. It is then immersed in the liquid cell and physically translated through this cell in a raster pattern. After traversing the specimen the scattered acoustic energy is collected by a second spherical lens placed symmetrical to the first lens in such a way that the two lenses have a common focal point. The acoustic energy which varies in intensity as a result of the motion of the specimen through the narrow waist of the focused acoustic beam is converted to an electrical signal with an appropriate piezoelectric film. The signals are then displayed on a conventional TV monitor scope. The raster pattern of the monitor is synchronized with the motion of the mylar membrane and the displayed image is an accurate reproduction of the acoustic response of the specimen.

The major portion of the work with the scanning acoustic microscope has been with the transmission mode wherein the acoustic attenuation of the sample is displayed in the micrograph. A number of fixed tissue sections for a variety of biological specimens have been surveyed in this manner. Among these are the human lung tissue, the rat kidney, tissue from the human breast and from the human spleen. The details visible in the optical microscope are clearly displayed in the acoustic micrographs within the limits as imposed by the resolution. The results show that high contrast is, indeed, obtainable in unstained tissue sections and in other material. In particular, the red blood cell (erythrocyte) shows strong contrast to its background. This is a result of large acoustic absorption of hemoglobin - a known property from the work at low frequencies. With white blood cells the acoustic contrast is less pronounced but still adequate to reveal internal detail.