



Scanning Microscopes Using X Rays and Microchannels

In principle, resolutions of the order of nanometers could be attained.

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Scanning microscopes that would be based on microchannel filters and advanced electronic image sensors and that utilize x-ray illumination have been proposed. Because the finest resolution attainable in a microscope is determined by the wavelength of the illumination, the x-ray illumination in the proposed micro-

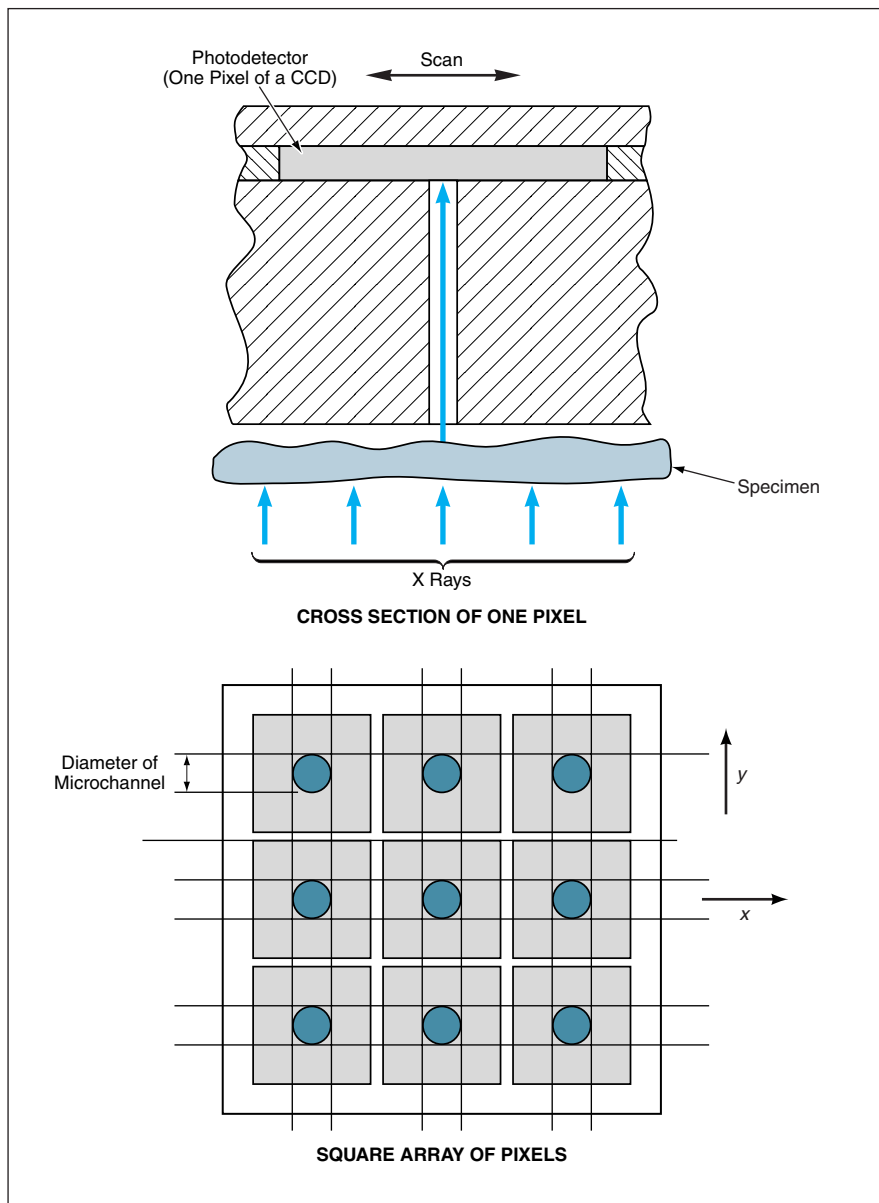
scopes would make it possible, in principle, to achieve resolutions of the order of nanometers — about a thousand times as fine as the resolution of a visible-light microscope. Heretofore, it has been necessary to use scanning electron microscopes to obtain such fine resolution. In comparison with scanning electron microscopes,

the proposed microscopes would likely be smaller, less massive, and less expensive. Moreover, unlike in scanning electron microscopes, it would not be necessary to place specimens under vacuum.

The proposed microscopes are closely related to the ones described in several prior *NASA Tech Briefs* articles; namely, "Miniature Microscope Without Lenses" (NPO-20218), *NASA Tech Briefs*, Vol. 22, No. 8 (August 1998), page 43; and "Reflective Variants of Miniature Microscope Without Lenses" (NPO-20610), *NASA Tech Briefs*, Vol. 26, No. 9 (September 2002) page 6a. In all of these microscopes, the basic principle of design and operation is the same:

The focusing optics of a conventional visible-light microscope are replaced by a combination of a microchannel filter and a charge-coupled-device (CCD) image detector. A microchannel plate containing parallel, microscopic-cross-section holes much longer than they are wide is placed between a specimen and an image sensor, which is typically the CCD. The microchannel plate must be made of a material that absorbs the illuminating radiation reflected or scattered from the specimen. The microchannels must be positioned and dimensioned so that each one is registered with a pixel on the image sensor. Because most of the radiation incident on the microchannel walls becomes absorbed, the radiation that reaches the image sensor consists predominantly of radiation that was launched along the longitudinal direction of the microchannels. Therefore, most of the radiation arriving at each pixel on the sensor must have traveled along a straight line from a corresponding location on the specimen. Thus, there is a one-to-one mapping from a point on a specimen to a pixel in the image sensor, so that the output of the image sensor contains image information equivalent to that from a microscope.

The upper part of the figure depicts a one-pixel portion of a proposed scanning microchannel-type microscope that would utilize x-ray illumination. The lower part of the figure shows a simple square pixel pattern. The CCD could be coated with a phosphor to increase its response to x-ray photons. Provided that the



X-Rays From the Specimen would travel through the microchannels to the photodetectors. The microchannels would define resolution elements. In both the x and y directions, the microchannel plate and photodetectors would be scanned over one pixel pitch, in increments of the microchannel diameter, to acquire high-resolution specimen-image data.

x-ray wavelength was small enough, the diameter of the microchannel would define the resolution element. The microchannels would be much narrower than the CCD pixels. Preferably, the pixel pitch would be an integer multiple of the diam-

eter of a microchannel. Hence, one would acquire a set of high-resolution image data by recording the CCD output while scanning (more precisely, stepping) the specimen under the microchannel plate in increments of the microchannel

diameter along both perpendicular axes (x and y) of the pixel pattern.

This work was done by Yu Wang of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-20873

Slotting Fins of Heat Exchangers To Provide Thermal Breaks

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Heat exchangers that include slotted fins (in contradistinction to continuous fins) have been invented. The slotting of the fins provides thermal breaks that reduce thermal conduction along flow paths (longitudinal thermal conduction), which reduces heat-transfer efficiency. By increasing the ratio between transverse thermal conduction (the desired heat-transfer conduction) and longitudinal thermal conduction, slotting of the fins can be exploited to (1) increase heat-transfer efficiency (thereby reducing operating cost) for a

given heat-exchanger length or to (2) reduce the length (thereby reducing the weight and/or cost) of the heat exchanger needed to obtain a given heat-transfer efficiency. By reducing the length of a heat exchanger, one can reduce the pressure drop associated with the flow through it. In a case in which slotting enables the use of fins with thermal conductivity greater than could otherwise be tolerated on the basis of longitudinal thermal conduction, one can exploit the conductivity to make the fins longer (in the trans-

verse direction) than they otherwise could be, thereby making it possible to make a heat exchanger that contains fewer channels and therefore, that weighs less, contains fewer potential leak paths, and can be constructed from fewer parts and, hence, reduced cost.

This work was done by Timothy D. Scull of United Technologies for Johnson Space Center. For more information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-22784

Methane Clathrate Hydrate Prospecting

Methane hydrate deposits would be detected indirectly through thermal, magnetic, and electric measurements.

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A method of prospecting for methane has been devised. The impetus for this method lies in the abundance of CH₄ and the growing shortages of other fuels. The method is intended especially to enable identification of subpermafrost locations where significant amounts of methane are trapped in the form of methane gas hydrate (CH₄·6H₂O). It has been estimated by the U.S. Geological Survey that the total CH₄ resource in CH₄·6H₂O exceeds the energy content of all other fossil fuels (oil, coal, and natural gas from non-hydrate sources). Also, CH₄·6H₂O is among the cleanest-burn-

ing fuels, and CH₄ is the most efficient fuel because the carbon in CH₄ is in its most reduced state. The method involves looking for a proxy for methane gas hydrate, by means of the combination of a thermal-analysis submethod and a field submethod that does not involve drilling. The absence of drilling makes this method easier and less expensive, in comparison with prior methods of prospecting for oil and natural gas.

The proposed method would include thermoprospecting in combination with one more of the other non-drilling measurement techniques, which could in-

clude magneto-telluric sounding and/or a subsurface-electrical-resistivity technique. The method would exploit the fact that the electrical conductivity in the underlying thawed region is greater than that in the overlying permafrost.

This work was done by N. Duxbury of Caltech and V. Romanovsky of the University of Alaska at Fairbanks for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at www.techbriefs.com/tsp under the Physical Sciences category. NPO-30257