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10. Over a period of 3 years, three different operators have analyzed the National Bureau of Standards Nd shelf standard in our laboratory with identical results. Errors in the estimation of the Sm and Nd contents are 0.1 percent or less for the kimberlites and slightly higher (up to 0.3 percent) for the minerals in the xenoliths. The Sm and Nd blanks were within the range reported in (*9*).
11. The initial $^{143}Nd/^{144}Nd$ ratio, $I$, at a time ($T$) is calculated from the equation:

$$I = \left(\frac{^{143}\mathrm{Nd}}{^{144}\mathrm{Nd}}\right)_{\mathrm{measured}} - \left(\frac{^{147}\mathrm{Sm}}{^{144}\mathrm{Nd}}\right)_{\mathrm{measured}} (e^{\lambda T} - 1)$$

where the decay constant $\lambda = 6.54 \times 10^{-12}$ year$^{-1}$.
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# Flash X-ray Microscopy

Abstract. *Soft x-ray contact microscopy, utilizing single-shot exposures of ~ 60 nanoseconds duration in polymethyl methacrylate, has been realized with a resolution of 300 angstroms. The radiation spectrum is intense in the "window" between 23 and 44 angstroms where water is transparent compared to biological materials, and therefore permits viewing of wet samples.*

Recent interest in the x-ray microscopy of biological objects has been fostered by the high-resolution (≤ 100 Å) capabilities of contact microscopy in which x-ray resists are used in combination with the comparatively short exposure times (minutes) realizable with synchrotron sources (*1*). Development of synchrotron sources to provide intense soft x-ray flux is well under way (*2*). The operating region for soft x-ray microscopy has been defined and comparisons made with competitive microscopies, such as electron microscopy (*3*).

The present work with a new soft x-ray source (*4*) extends the high-resolution x-ray microscopy technique in several important respects. Exposure times have been drastically reduced: single-shot flash x-ray exposures of ~ 60 nsec duration have been obtained. Because of the charge states of the emitting element ($C^{4+}$ and $C^{5+}$), the dominant x-ray emission wavelength is optimum for high-resolution work (*1*). Moreover, emission is not restricted to a single wavelength, but contains a band that has been found to be of advantage in minimizing diffraction effects as well as facilitating high contrast in thin regions while avoiding excess opacity in dense regions (*5*). Also, the shifted line emission, as compared to solid target emission, occurs within the "window" region for wet-sample viewing; that is, within the wavelength region for which water is transparent in comparison with biological materials. Therefore, x-ray microscopy of living organisms may be realizable, one possibility being the microscopic study of radiation damage to cellular structures. The source spectrum (*4*) contains very little hard x-ray emission. Hard components have been found to be detrimental to resolution as well as damaging to the specimen (*1*). The small source size (*4*) (~ 200 μm) eliminates penumbral blurring. Finally, the x-ray source is very compact and inexpensive.

The work reported here is based on utilization of a novel x-ray tube (see Figs. 1A and 2A). The tube comprises a discharge capillary for producing, by erosion of several monolayers of the capillary wall, a dense, high-temperature plasma. Typically, for microscopy, a polyethylene capillary is employed with graphite electrodes. A carbon plasma with an electron density of ~ $3 \times 10^{19}$ cm$^{-3}$ and a temperature of 35 to 40 eV is produced, the dominant charge state being $C^{4+}$. In addition, the tube contains a rod cathode for launching an intense electron beam (5 to 10 kA at 30 to 100 kV) into the plasma to enhance the soft x-ray emission. A special diode configuration was used to obtain clean operation of the beam-plasma system. The entire tube can be self-triggering or can rely on a single trigger electrode if a predetermined pulse time is desirable. Both the plasma discharge and the electron beam are driven by simple capacitance

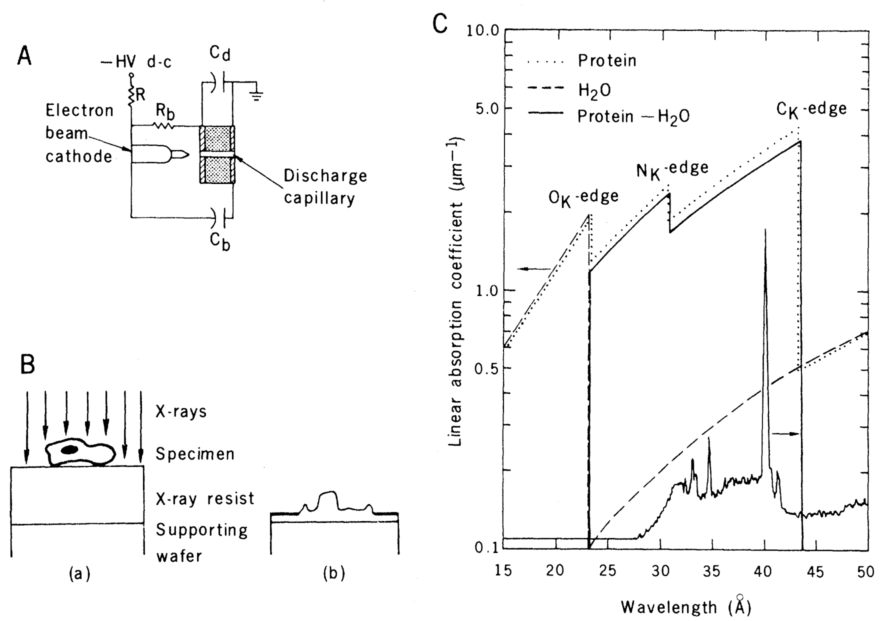


Fig. 1. (A) Device schematic showing charging resistor ($R$), discharge and beam capacitors ($C_d$ and $C_b$, respectively), beam isolation resistor ($R_b$), and beam cathode and discharge capillary positioning. (B) Irradiation of the x-ray resist through the specimen (a), and the replica after development of the resist (b). (C) Superposition of densitometer trace of x-ray output as a function of wavelength with the absorption characteristics of protein, water, and protein minus water. Strong x-ray emission is seen to occur in the water window between 23 and 44 Å, allowing wet-sample viewing.


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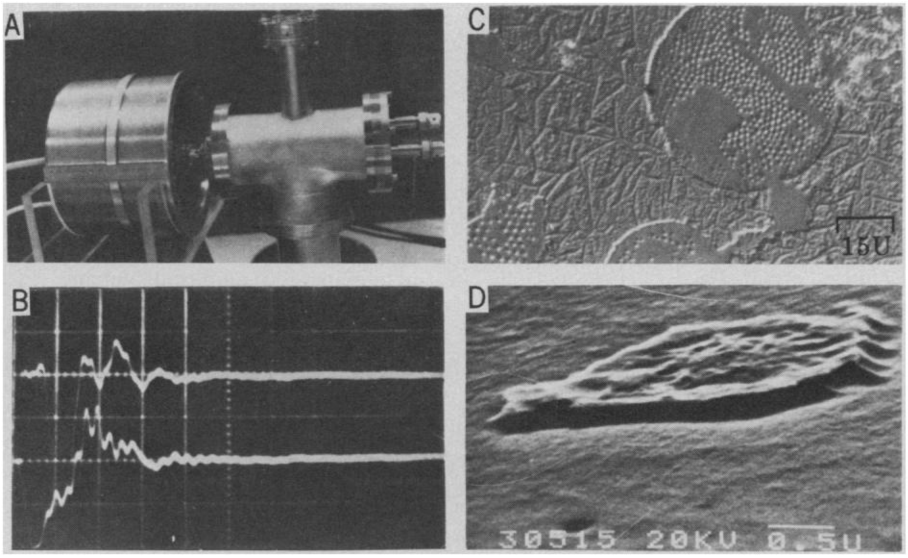


Fig. 2. (A) Laboratory arrangement (at left) showing the compactness of the device; a 6-inch (15-cm) ruler is shown beside the pulse unit. The specimen location is at the far right. (B) Time behavior of beam-discharge operation; the horizontal axis is 100 nsec per division. (Upper trace) Beam current at 2 kA per vertical division; (lower trace) beam current plus discharge current at 3 kA per vertical division. (C) Soft x-ray replica of a diatom as seen in optical microscopy by using a Leitz Orthoplan with interference contrast. (D) High-resolution sample viewing with a Hitachi S-500 scanning electron microscope. Scale bars in (C) and (D) are labeled in micrometers.

storage, both stages being chargeable from a common d-c supply. The time behavior of the operating device is shown in Fig. 2B; the beam current pulse (~ 60 nsec at full width at half-maximum) is shown on the upper trace and the beam current plus the discharge current is shown on the lower trace. X-ray pulse duration is less than the total current duration of ~ 100 nsec.

Single-shot exposures of objects placed directly on the resist surface were obtained (see Fig. 1B). The x-ray resist, polymethyl methacrylate, was spun onto the surface of a silicon wafer for mounting in the vacuum chamber. Development was in a 1 : 1 solution of methyl isobutyl ketone and isopropanol, development time being 3 to 6 minutes. Exposures were made at a distance of 22 cm from the output end of the flash x-ray tube, with the center of the wafer on axis with the tube. Penumbral blurring was thus less than 1 Å. Developed resists can be viewed with a high-resolution optical microscope, from which structures ~ 0.5 $\mu$m or greater in size are apparent (see Fig. 2C). Higher resolution observations were made by scanning electron microscopy following evaporation of a 50-Å palladium-gold overcoat (Fig. 2D). A resolution of ~ 300 Å was realized.

The spectral emission from the flash tube in the range useful for wet-sample viewing is indicated by a densitometer tracing in Fig. 1C. The spectrum was recorded on a 2.2-m grazing incidence vacuum spectrometer (McPherson model 247) with a platinum grating (300 lines per millimeter) and SWR (short-wavelength radiation) plates. Also shown in Fig. 1C are the absorption coefficients for water, protein, and the excess of protein over water. (Note that the curve for protein minus water is a strict subtraction of absorption coefficents, direct use of which in the exponential would imply equal path lengths in both materials.) The coincidence of the spectra with the wet-specimen window and their distribution within the window are such as to provide optimum contrast and maximum resolution (*1*, *3*). Thus, this source should be quite useful for wet-sample viewing.

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## Rainfall Changes in Summer Caused by St. Louis

Abstract. *Precipitation in and around St. Louis was investigated to study urban influences on summer precipitation conditions. Prerain winds were used to define the "downwind area" where influences would be greatest, and wind-sorted rains were combined into monthly and summer totals. Seventy-five percent of the 16 rain patterns revealed a rainfall maximization downwind of the city, and the rainfall in the downwind area was 22.7 percent more than the rainfall upwind of St. Louis where no urban influences existed. Various statistical tests of the summer rainfall distribution reveal the downwind rainfall to be significantly greater than elsewhere and supportive of other findings that St. Louis increases rainfall.*

Climatological research results of the past 20 years (*1*) have indicated that major urban areas influence clouds and precipitation. Sizable changes, > 10 percent, have been considered controversial (*2*). A major 5-year meteorological project was launched at St. Louis in 1971 to study intensively how an urban area modifies the atmosphere, how physical processes in clouds and rainfall are subsequently changed, and where any anomalous precipitation occurs (*3*). This experiment has provided a wealth of weather data and a variety of results that collectively indicated sizable (> 10 percent) localized increases in summer rainfall and storminess (*4*). It is difficult to evaluate inadvertent urban modification of rain because there is no randomization, and thus a "data analysis" approach that combines physical insight and statistical tests appears well suited (*5*).

A potentially definitive, yet simple physical-statistical test of the apparent urban-related rainfall increase at St. Louis is based on the determination of the placement and magnitude of maximum rainfall areas near St. Louis under differing wind directions. The basic hy-