Title

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In the study of radiation sensitive materials in an electron microscope a limit to resolution is imposed when the number of electrons required to record an image is greater than the number required to destroy the specimen. This limitation is conveniently expressed in the equation due to Glaeser (1973):

$$d \geq \frac{1}{c} \cdot \frac{5}{\sqrt{fN_{cr}}} \qquad (1)$$

where d is the size of the object detail, c the contrast of the object feature, f the detection efficiency of the recording device and N_{cr} the critical exposure, is the number of electrons in unit area which will destroy the specimen.

Since the radiation dose deposited in a thin material decreases as the energy of the irradiating electron increases, there will be advantages to be gained from the application of very high voltage electron microscopes, if the energy dependence of the other terms in (1) are favorable.

Cosslett (1974) has shown experimentally that for certain photographic emulsions f is relatively insensitive to electron energy at least to 700 keV. Assuming that the specimen thickness is adjusted to give constant contrast the behavior of d may therefore be assessed from measured values of the critical exposure.

Values of the critical exposure for the amino-acid 1-valine, which suffers principally ionization damage, have been obtained in the energy range 50 to 3000 keV. These values and the associated d values employing c = 0.1 and f = 0.25 are displayed in Fig. 1. The measurement of the critical exposure is achieved by measuring the total electron exposure sufficient to destroy the diffraction pattern of the material, Fig. 2. Conventional techniques of selected area diffraction were employed and details of the measurement of the electron exposures are described by Howitt (1975).

Assuming that the energy required to destroy the material is directly proportional to the energy lost by this primary beam the behaviour of the electron exposure required to deposit this critical energy can be calculated from the equations of Bethe (1933). Such comparisons predict an approximate β^2 dependence of the critical exposure. This behaviour and that of the more exact calculation of the linear energy transfer are shown for comparison in Fig. 1.

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4. Bethe, M. A.: Handbook Phys. 24, (1), 273 IV Strosstheorie (1933).

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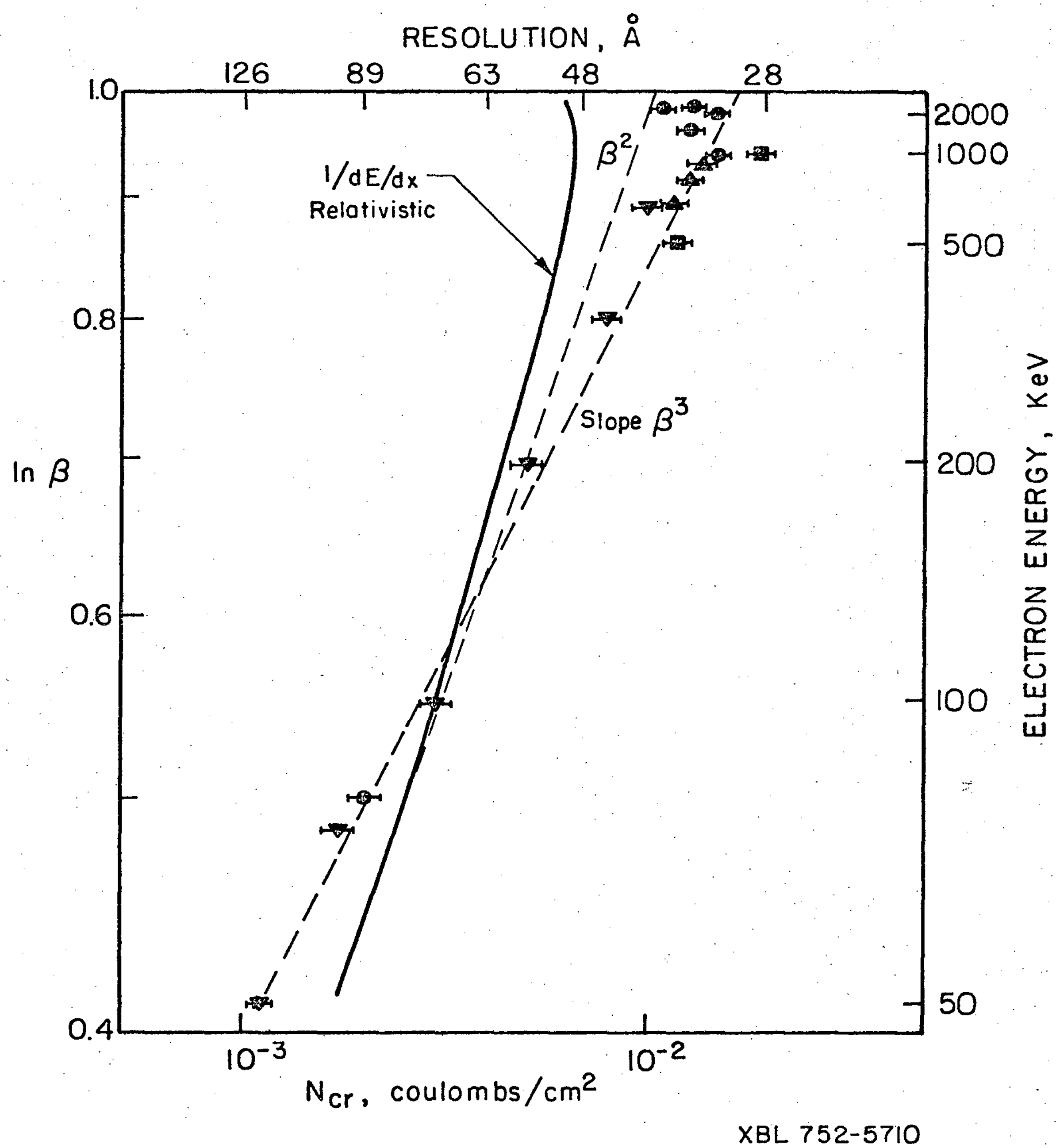

Fig. 1. The variation of the critical exposure of ℓ-valine with electron energy.

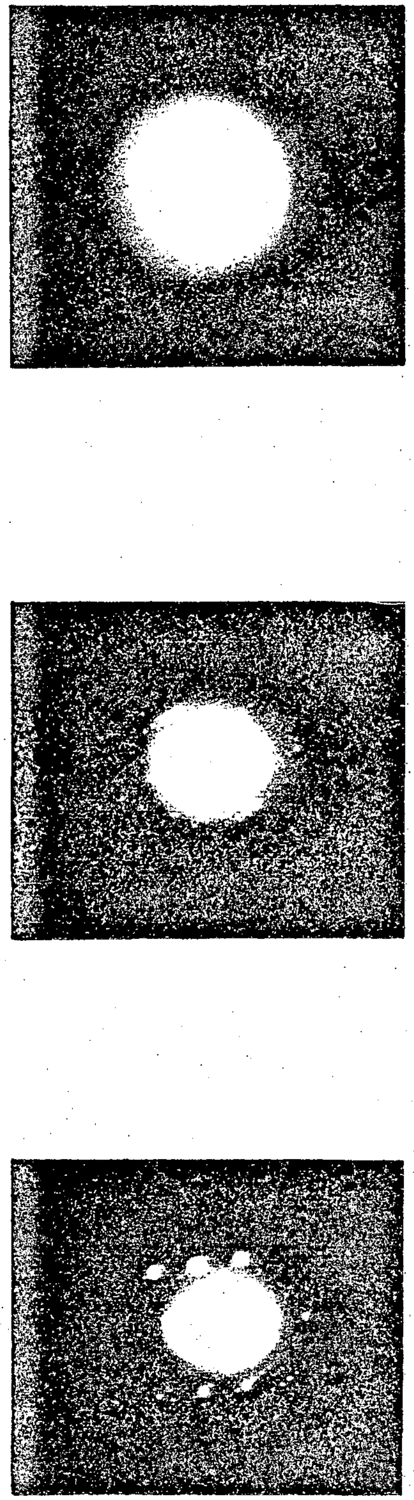

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Fig. 2. Electron diffraction patterns from a crystal of ℓ-valine recorded at intervals of half the critical exposure.

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