International Tables for Crystallography (2006). Vol. C, Figure 4.2.5.1, p. 236.

Table 4.2.4.3. *Mass attenuation coefficients (cm^2 g^{-1}) (cont.)*

Radiation	Energy (MeV)	97 Berkelium	98 Californium
Ag $K\beta_1$	2.494E−02	6.66E+01	7.35E+01
Pd $K\beta_1$	2.382E−02	7.52E+01	8.24E+01
Rh $K\beta_1$	2.272E−02	8.51E+01	9.26E+01
Ag $K\bar{\alpha}$	2.210E−02	6.10E+01	6.92E+01
Pd $K\bar{\alpha}$	2.112E−02	1.03E+02	1.11E+02
Rh $K\bar{\alpha}$	2.017E−02	1.02E+02	1.25E+02
Mo $K\beta_1$	1.961E−02	1.25E+02	1.34E+02
Mo $K\bar{\alpha}$	1.744E−02	4.90E+01	5.00E+01
Zn $K\beta_1$	9.572E−03	1.86E+02	2.08E+02
Cu $K\beta_1$	8.905E−03	2.26E+02	2.49E+02
Zn $K\bar{\alpha}$	8.631E−03	2.46E+02	2.70E+02
Ni $K\beta_1$	8.265E−03	2.77E+02	3.01E+02
Cu $K\bar{\alpha}$	8.041E−03	3.52E+02	3.60E+02
Co $K\beta_1$	7.649E−03	3.57E+02	3.66E+02
Ni $K\bar{\alpha}$	7.472E−03	3.62E+02	3.86E+02
Fe $K\beta_1$	7.058E−03	4.22E+02	4.48E+02
Co $K\bar{\alpha}$	6.925E−03	4.43E+02	4.69E+02
Mn $K\beta_1$	6.490E−03	5.26E+02	5.52E+02
Fe $K\bar{\alpha}$	6.400E−03	5.92E+02	6.07E+02
Cr $K\beta_1$	5.947E−03	6.64E+02	6.87E+02
Mn $K\bar{\alpha}$	5.895E−03	6.78E+02	7.03E+02
Cr $K\bar{\alpha}$	5.412E−03	8.52E+02	8.71E+02
Ti $K\beta_1$	4.932E−03	1.09E+03	1.10E+03
Ti $K\bar{\alpha}$	4.509E−03	1.04E+03	1.05E+03

involve the use of filters, mirrors, and Laue and Bragg crystal monochromators, chosen so as to provide the best compromise between flux and spectral purity in a particular experiment. In other chapters, authors have discussed the use of techniques to improve the spectral purity of X-ray sources. This section does not purport to be a comprehensive exposition on the topic of filters and monochromators. Rather, it seeks to point the reader towards the information given elsewhere in this volume, and to add complementary information where necessary. A search of the Subject Index will find references to filters and monochromators that are not explicitly mentioned in the text of this section.

The ability to select photon energies, or bands of energies, depends on the scattering power of the atoms from which the monochromator is made and the arrangement of the atoms within the monochromator. The scattering powers of the atoms and their dependence on the energy of the incident photons were discussed in Sections 4.2.3 and 4.2.4 and are discussed more fully in Section 4.2.6. In brief, the scattering power of the atom, or *atomic scattering factor*, is defined, for a given incident photon energy, as the ratio of the scattering power of the atom to that of a free Thomson electron. The scattering power is denoted by the symbol $f(\omega, \Delta)$ and is a complex quantity, the real part of which, $f'(\omega, \Delta)$, is related to the elastic scattering cross section, and the imaginary part of which, $f''(\omega, \Delta)$, is related directly to the photoelectric scattering cross section and therefore the linear attenuation coefficient μ_l.

At an interface between, say, air and the material from which the monochromator is made, reflection and refraction of the incident photons can occur, as dictated by Maxwell's equations. There is an associated refractive index n given by

$$n = (1 + \chi)^{1/2}, \qquad (4.2.5.1)$$

where

$$\chi = -(r_e\lambda^2/\pi)\sum_j N_j f_j(\omega, \Delta), \qquad (4.2.5.2)$$

r_e is the classical radius of the electron, and N_j is the number density of atoms of type j.

An angle of total external reflection α_c exists for the material, which is a function of the incident photon energy, since $f_j(\omega, \Delta)$ is a function of photon energy. Thus, a polychromatic beam incident at the critical angle of one of the photon energies (E) will reflect totally those components having energies less than E, and transmit those components with energies greater than E. Fig. 4.2.5.1 shows calculations by Fukumachi, Nakano & Kawamura (1986) for the reflectivity of single layers of aluminium, copper and platinum as a function of incident energy for a fixed angle of incidence (0.2°). For the aluminium specimen, the reflectivity curve shows the rapid decrease in reflectivity as the critical angle is exceeded. The reflectivity in this region varies as E^{-2}. The effect of increasing atomic number can be seen: the higher the atomic factor $f(\omega, \Delta)$, the greater the energy that can be reflected from the surface. Also visible are the effects of the dispersion corrections $f'(\omega, \Delta)$ and $f''(\omega, \Delta)$ on reflectivity. For copper, the K shell is excited, and for platinum the $L_{\rm I}$, $L_{\rm II}$ and $L_{\rm III}$ shells are excited by the polychromatic beam.

Interfaces can therefore be used to act as low-pass energy filters. The surface roughness and the existence of impurities and contaminants on the interface will, however, influence the characteristics of the reflecting surface, sometimes significantly.

4.2.5.2. *Mirrors and capillaries*

Whilst neither of these classes of X-ray optical device is strictly speaking a monochromator, they nevertheless form component parts of monochromator systems in the laboratory and at synchrotron-radiation sources.

4.2.5.2.1. *Mirrors*

In the laboratory, mirrors are used in conjunction with conventional sealed tubes and rotating-anode sources, the emission from which consists of *Bremsstrahlung* upon which is superimposed the characteristic spectrum of the anode material (Subsection 2.3.5.2). The shape of the *Bremsstrahlung* spectrum can be significantly modified by mirrors, and the intensity emitted at harmonics of the characteristic wavelength can be

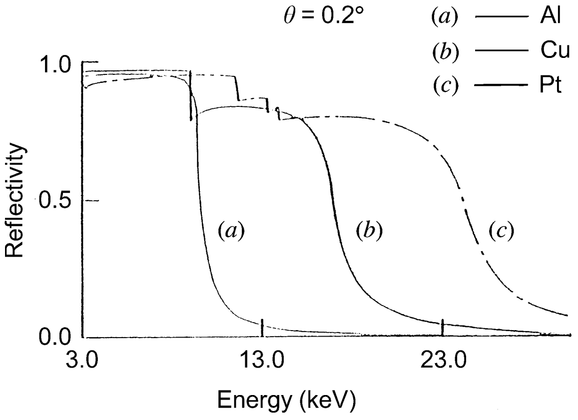

Fig. 4.2.5.1. The variation of specular reflectivity with incident photon energy is shown for materials of different atomic number and a constant angle of incidence of 0.2°. (*a*) Aluminium: note the rapid decrease of reflectivity with energy. (*b*) Copper: the sudden decrease of reflectivity is due to the modification of the scattering-length density owing to absorption at the K-absorption edge. (*c*) Platinum: the three discontinuities in the reflectivity curve are due to absorption at the $L_{\rm I}$-, $L_{\rm II}$-, and $L_{\rm III}$-absorption edges.

references