Determination of the optimum sample thickness to calculate the dielectric function of SiC

Dieter Hinderks, Helmut Kohl

Physikalisches Institut und Interdisziplinäres Centrum für Elektronenmikroskopie und Mikroanalyse (ICEM), Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany

dieter.hinderks@uni-muenster.de
Keywords: Kramers-Kronig, dielectric function, EELS

At the calculation of the dielectric functions from EEL-spectra many error sources occur. Two of them are that on the one hand a thick sample causes multiple scattering (see Figure 2) and on the other hand a very thin sample exhibits surface effects in the spectra (see Figure 3). To obtain a reliable result for the dielectric function it is necessary to find an expression for the ideal sample thickness so that neither multiple scattering nor surface effects carry to much weight.

Therefore spectra of SiC samples were recorded at different sample thicknesses. If the sample thickness is not known, it can be calculated using the Kramers-Kronig Sum Rule [1]. The effect of multiple scattering can directly be seen. To get an good overview about the surface effects, the surface loss function can be estimated from the dielectric function. So at first an expression for the dielectric function has to be derived.

The single scattering distribution is obtained via matrix deconvolution. After aperture correction and normalization the spectrum equals the imaginary part of the reciprocal dielectric function. To obtain the whole dielectric function one can derive the real part through a Kramers-Kronig transformation. It is possible to implement this by two Fourier transforms where after one transformation the sine coefficients are transformed to cosine ones [2]. Finally an expression for the complete dielectric function can be derived and thus we can calculate the surface loss function.

Now the relationship between the sample thickness and the surface loss function can be compared to the relation between the sample thickness an the multiple scattering. As a optimum result one can determine a thickness to obtain an reliable expression for the dielectric function. Therefore it is possible to derivate a ideal sample thickness by taking care of the thickness dependence of multiple scattering and surface plasmons. After recording a low loss spectrum of a sample with this thickness, one can calculate the dielectric function with reduced error.

1. R.F. Egerton, EELS in the Electron Microscope, Plenum Press, New York (1986).
2. D.W. Johnson A Fourier series method for numerical Kramers-Kronig analysis, Great Britain (1975)
3. H. Raether, Excitation of Plasmons an Interband Transitions by Electrons, Springer Tracts in Modern Physics Vol. 88 (1980)

DOI: 10.3217/978-3-85125-062-6-071, © Verlag der TU Graz 2009

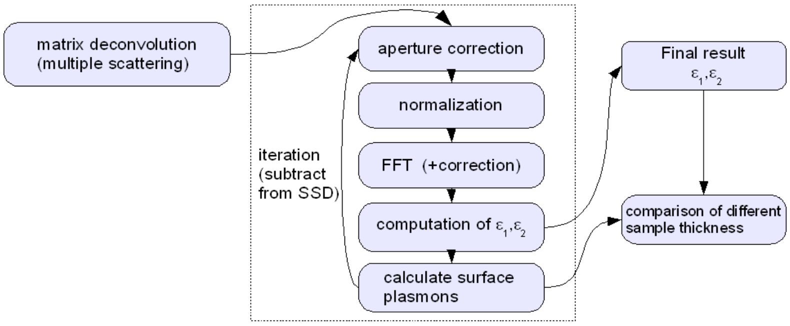

Figure 1. A schematic block diagram from the functionality of the used routine. Every box represents a basic step. Not only at the end but also after every iteration it is possible to analyze the calculated surface plasmons.

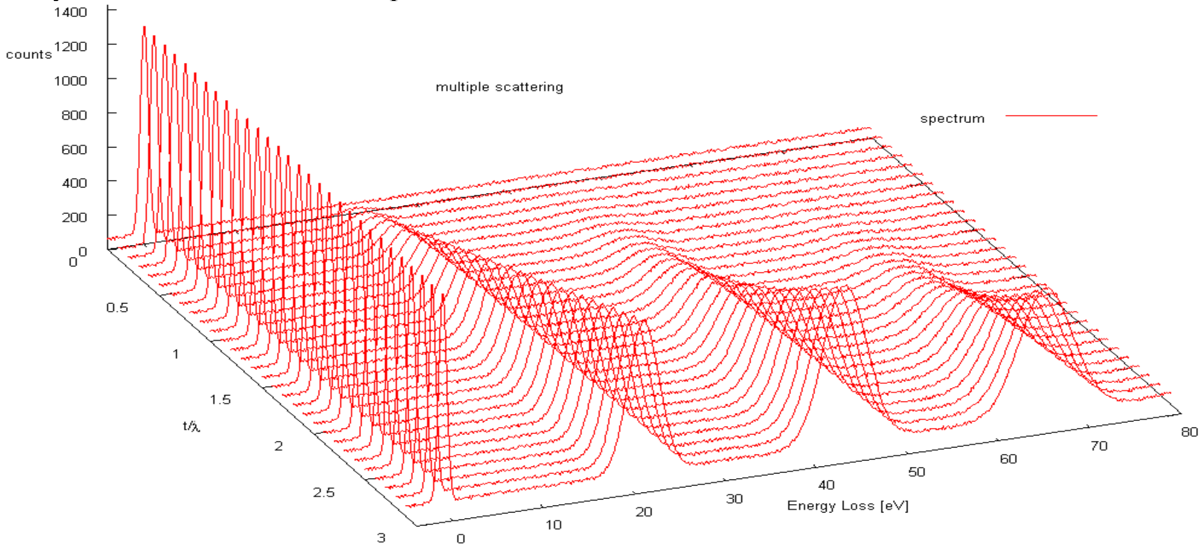

Figure 2. Calculated plot of multiple-scattering occurring at a SiC sample. As parameter the ratio between sample thickness and free path of the electrons is used. At 0eV the zero loss peak and at 22,1 eV the single plasmon scattering peak are visible.

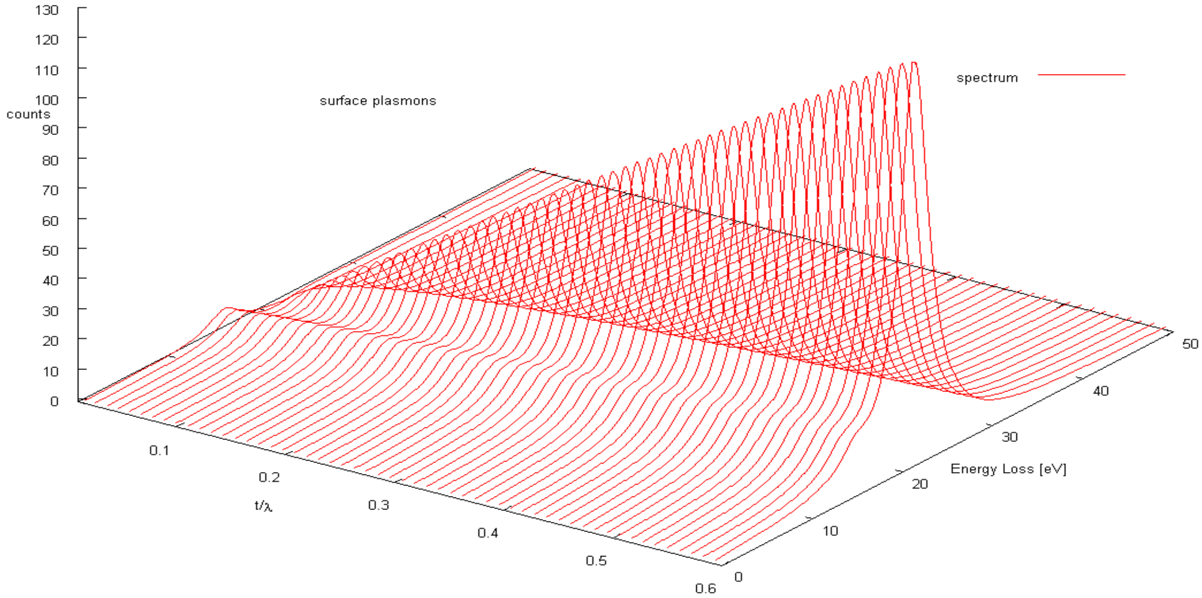

Figure 3. Calculated single scattering spectrum of the volume and surface plasmons at a SiC sample as a function of the ratio between sample thickness and free path of the electrons.

DOI: 10.3217/978-3-85125-062-6-071,