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Total cross section measurements for positrons and electrons colliding with molecules: I. SiH_4 and CF_4*

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Abstract. Total cross sections (TCSs) for 0.7–400 eV positrons and 1.0–400 eV electrons colliding with mono-silane (SiH_4) and tetrafluouromethane (CF_4) molecules have been obtained by relative measurements. The TCS curve of e^+–SiH_4 with a broad minimum around 3.5 eV is fundamentally similar to that of e^+–CH_4. TCSs of e^+–SiH_4 below 20 eV are higher than the theoretical values. The TCS curve of e^+–CF_4 is different from the curve of e^+–SiH_4. The TCS data of e^-–SiH_4 from 3 to 20 eV are lower than the theoretical data from 3 to 20 eV. The TCS curve of e^-–SiH_4 shows the shape resonance at 3.1 eV, and is also similar to that of CH_4. Also, the TCS curve of e^-–CF_4 has more complicated structures.

1. Introduction

Mono-silane (SiH_4) and tetrafluoromethane (CF_4) molecules are important gases in the semiconductor industry. Recently, the electron scattering by SiH_4 and CF_4 gases has experimentally and theoretically attracted much interest in relation to reactive plasma phenomena. Total cross section (TCS) data on positron and electron collisions with SiH_4 and CF_4 molecules are few. A comparison of the positron and electron TCS for SiH_4, CF_4, and CH_4 molecules is of great interest, because these molecules have the same molecular structure. The positron collision data, moreover, are useful as a test of various approximations used for the theory of electron collisions in polyatomic molecules. These molecules exhibit a very high polarizability and a large number of electrons. Therefore, we have much interest in the theoretical work on positron and electron scattering by these molecules.

Jain (1986) calculated the TCS of e^+–SiH_4 in a model of the spherical-complex-optical-potential (SCOP) for 1–400 eV. Gianturco *et al* (1987) used a parameter-free model potential for the calculation. Recently, Jain and Gianturco (1991) calculated TCS for e^+–SiH_4 using new positron correlation polarization potentials below the positronium formation threshold. Moreover, TCS data have been presented by Baluja and Jain (1992) for 10–5000 eV positron scattering by several diatomic and polyatomic molecules, including SiH_4 and CF_4, by the spherical complex optical potential composed of the new positron correlation polarization potential.

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For electron scattering, the differential cross section (DCS) measurements which are the vibrationally elastic scattering and integral cross sections for SiH_4 and CF_4 molecules have been performed by Tanaka *et al* (1990), Boesten *et al* (1992) and Mann and Linder (1992), respectively. TCS measurements for CF_4 have been presented by Jones (1986) and Szmytkowski *et al* (1992). Zecca *et al* (1992a, b) have presented experimental TCS data for SiH_4 and CF_4 molecules. Theoretical studies for SiH_4 molecules have been presented by Tossell and Davenport (1984), Jain (1987), Jain *et al* (1987), Yuan (1989), and Jain and Baluja (1992).

In this paper, TCS for 0.7–400 eV positrons and 1.0–400 eV electrons colliding with SiH_4 and CF_4 molecules obtained by relative measurement are presented. The measured data are compared with experimental and theoretical data. Preliminary data for e^+–SiH_4 and e^+–CF_4 were reported elsewhere (Mori *et al* 1985, Sueoka 1987). The positron and electron scattering TCS data were roughly corrected by forward scattering.

2. Experimental procedure

2.1. Apparatus and projectiles

A straight-type TOF apparatus with a retarding-potential method (RP-TOF) was used in TCS experiments for positrons and electrons colliding with SiH_4 and CF_4. A schematic

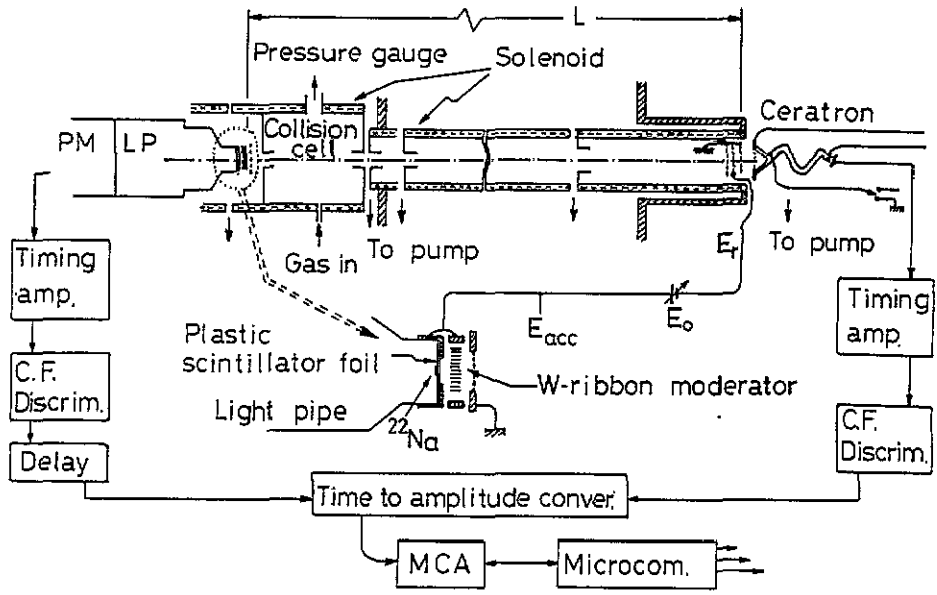

Figure 1. Schematic diagram of the experimental arrangement.

diagram of the experimental arrangement is shown in figure 1. The experimental procedure and the data analysis are carried out in much the same way as the previous work (Sueoka and Mori 1986, hereafter referred to as I).

A radioisotope ^{22}Na with an activity of about 50 μCi was used as a positron source. A set of tungsten ribbons baked at about 2100 °C was used as a moderator for slow positrons. A radioisotope ^{137}Cs with an activity of 40 μCi using secondary electrons emitted from the same tungsten moderator surfaces was used as an electron source.

The incident energy in the electron experiments is corrected by the addition of 0.6 eV as $E_\perp$ to $E_\parallel$, where $E_\perp$ and $E_\parallel$ indicate the energy perpendicular and parallel to the direction of the flight path, respectively. The correction value, 0.6 eV, is determined by observing the energy shift of the shape resonance in electron scattering by N_2, CO and CO_2 molecules. For positron beams, on the other hand, the energy scale correction was not performed for lack of an energy standard. It was confirmed by other experiments that the mean value of $E_\perp$ for the positrons is lower than that for electrons.

2.2. Collision gases

For the safe treatment of mono-silane gas, which are ignitable and poisonous, the gases were passed through sodium hydroxide water, diluted with N_2, and then exhausted into the atmosphere. After the experiment, the gases in the gas reservoir and in the rotary pumps were carefully exhausted. Tetrafluoromethane (CF_4) is no trouble in the experiment.

The pressure in the collision cell is measured by a Baratron (#220 BHS) and stabilized automatically within about 0.3%. The pressure independence of TCS for electrons and positrons using the same experimental system has been verified for various gases over a wide enough pressure range and reported in previous papers (see, for instance, I). In this report, rather rough measurements for e^-–SiH_4 only are presented,

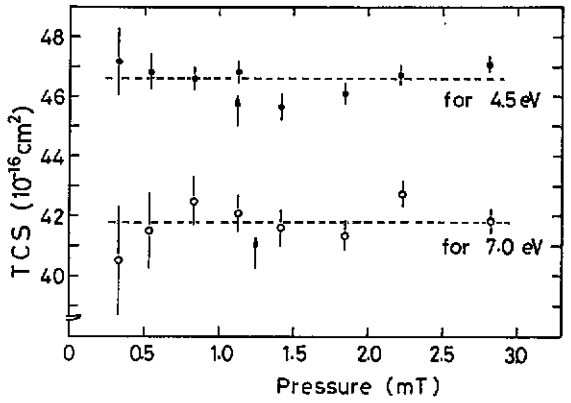

Figure 2. Total cross sections for e^-–SiH_4 plotted against collision gas pressure. The beam-intensity attenuation (I_v/I_0) of 3 is shown by arrows. Error bars show only the statistical error.

as shown in figure 2. Those for CF_4 were not measured. As seen in the figure, in the results summing up the data for 4.5 eV and 7.0 eV electrons, the pressure independence is confirmed well.

2.3. Retarding-potential TOF method and check by inelastic scattering spectra

The retarding potential time-of-flight method (in I) is used to eliminate the contribution of inelastic collisions with large energy loss, and to decrease the influence from forward scattering due to elastically scattered positrons with reduced axial velocity resulting from angular deflection. The retarding potential is selected as 1.5 eV lower than the accelerating potential E_{acc} for positrons, and equal to E_{acc} for electrons.

The typical width of the energy spectrum of positron beams is about 2 eV (FWHM). That of the electron beams is about 1.5 eV (FWHM) with a large tail on the high energy side, as shown in I. TCS measurements in our system are performed by a retarding potential method. To realize this method, it is a necessary condition that the collision gases do not have large energy structures in the range below the energy width of the projectile-beam. The loss spectra by positron impact on SiH_4 and CF_4 molecules were obtained by the TOF method described by Katayama *et al* (1987). As shown in

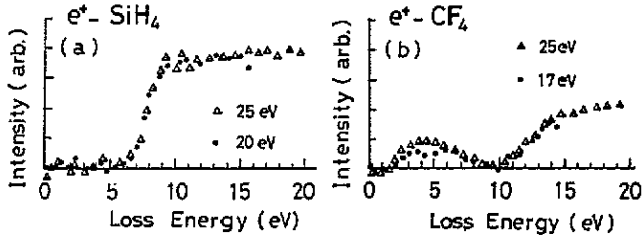

Figure 3. Energy loss spectra of positrons colliding with: (*a*) SiH_4 for the primary beam energy of 20 eV (●), 25 eV (△); and (*b*) CF_4 for 17 eV (●), 25 eV (△).

figures 3(*a*) and (*b*), the main energy structure on SIH_4 rises above 7.5 eV. The results are consistent with the electron impact data of Tronc *et al* (1989). In the TCS measurements for SiH_4, the effect of decreasing TCS due to inelastic scattering is negligible. On the other hand, the weak energy loss structures on e^+–CF_4 rise at 1.7 eV as shown in the figure. We assume the inelastic scattering cross section for electron impact is the same as the cross section for positron impact. The corrections to TCS due to the effect of the inelastic scattering are roughly 0.3% for e^+–CF_4 at maximum and negligible for e^-–CF_4.

2.4. Data analysis

The true time spectrum is computed from raw TOF data in a multi channel analyser by the method of Coleman *et al* (1974). The TCS Q_t is given as follows:

$$Q_t = (1/nl)\ln(I_v/I_g) \tag{1}$$

where n is the density in the collision gas and l is the effective length of the collision cell derived by the normalization of the TCS in e^+–N_2 at intermediate energies (50–400 eV) to the data of Hoffman *et al* (1982). I_v and I_g are net counts separated from the accidental coincidences in the vacuum and gas runs.

2.5. Effect of a magnetic field

A magnetic field by solenoid coils is used parallel to the flight path for the transportion of projectiles. However, the field should be weak, because the magnetic field increases the forward scattering. A weaker field, 9 G for positrons and 4.5 G for electrons, is applied only in the region of the collision cell. On the main flight path, stronger fields of 45 G for e^+ and 23 G for e^- were applied.

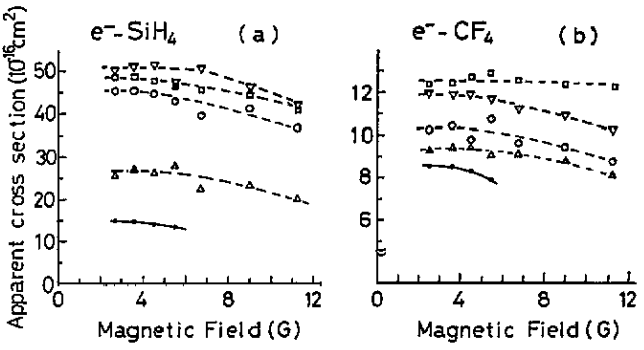

Figure 4. Apparent cross sections for electrons colliding with SiH_4 (*a*) and CF_4 (*b*) plotted against the magnetic field. ●, 1.0 eV; △, 1.4 eV; ○, 2.0 eV; ▽, 3.1 eV; □, 4.0 eV.

The magnetic-field dependence of TCS for electrons was measured in the low-energy range. The results for SiH_4 and CF_4 are shown in figures 4(*a*) and (*b*), respectively. The dependence of the TCS for electrons on the field strength is much weaker than for the other TCS measurements such as for positron and electron–C_6H_6 (Sueoka 1987, Sueoka and Hamada 1992). The magnetic field applied here may be allowable.

2.6. Corrections for e^-–TCS by scattering at apertures and for forward scattering for e^-–TCS and e^+–TCS

Projectiles are not narrow beams but wide (8 mm diameter), and are transported under the weak magnetic field. Some of them scattered elastically go into the detector with or without scattering on the aperture of the collision cell or on the aperture for the differential pumping. This phenomenon decreases the TCS value. Using the differential cross section data for e^-–SiH_4 of Tanaka *et al* (1990) below 100 eV and Jain (1987) above 100 eV, the contribution of unscattered projectiles was estimated quantitatively (Hamada and Sueoka 1994). For the correction for e^-–CF_4, the experimental data for the differential cross sections of Boesten *et al* (1992) and Sakae *et al* (1989) were used.

The contribution of forward scattering is more important than scattering on the apertures. The correction is not only performed for electron scattering, but also for positron scattering by assuming the same differential cross section data for e^- scattering. The effect of the potential E_0 related to the retarding potential illustrated in figure 1 is taken into account, being important. Namely, inelastic scattering and large angle scattering of elastic scattering are eliminated by E_0.

The reason for the smaller correction at low energies is the weak forward peaking scattering as shown in figures 4(*a*) and (*b*). Namely, the dependence of the apparent cross sections on the magnetic field are weak. The 'averaged' maximum angle of forward scattering is approximately for electron scattering as follows (because the maximum angle depends on the scattered position in the collision cell); 14.6° at 4.0 eV; 11.0° at 10 eV; 5.1° at 50 eV; 5.1° at 200 eV. For a check of the correction calculation, moreover, the magnetic dependence of TCS shown in figures 4(*a*) and (*b*) was obtained with fairly good agreement by the correction calculation.

3. Results

The TCS data for electrons colliding with SiH_4 and CF_4 are different from the preliminary data (Mori *et al* 1985). The TCS data for positrons are the same as the preliminary data. The corrections due to forward scattering were already performed on the data shown in figures 5–9 and tables 1–4.

3.1. Positron scattering at low energies

The TCS data for positrons with energies below 20 eV scattering on SiH_4 are presented in figure 5 along with the preliminary data (Mori *et al* 1985), and the theoretical data

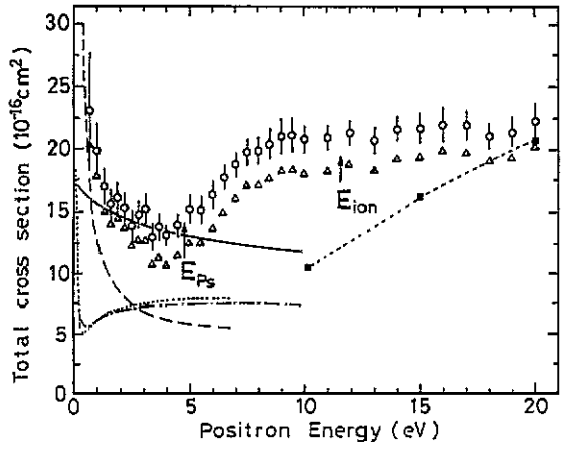

Figure 5. Total cross sections for positrons with energies below 20 eV colliding with SiH_4 molecules. Experimental points: ○, this experiment; △, the preliminary data (Mori *et al* 1985). Theoretical data: ——, static only and —·—, static + polarization potential of Gianturco *et al* (1987); – – –, MECOP; -----, PCOP of Jain and Gianturco (1991); – – – ■ – – –, Baluja and Jain (1992). Arrows indicate the positronium formation threshold (E_{Ps}) and ionization potential (E_{ion}). Error bars show the error values in table 1.

of Gianturco *et al* (1987), Jain and Gianturco (1991) and Baluja and Jain (1992). In the data of Gianturco *et al* (1987), the curves by the potential of static only, static plus polarization potential, and static plus polarization potential of Jain and Thompson (1983) are presented. In the data of Jain and Gianturco (1991), the data by the modified electron correlation polarization (MECOP) potential and the positron correlation polarization (PCOP) potential are shown. A broad minimum of the TCS curve for e^+–SiH_4 is observed between 3 and 5 eV. The minimum value is about 13.5×10^{-16} cm^2. However, no theory for e^+–SiH_4 explains well the experimental data at low energies yet. TCSs for e^+ scattered on many molecules including SiH_4 and CF_4 have been calculated by Baluja and Jain (1992), using a local spherical complex optical potential in the very wide range of 10–5000 eV. The theoretical data in all cases coincide roughly with the experimental data at the higher energies.

The TCS data for e^+–CF_4 are also presented in figure 6 along with the preliminary data (Mori *et al* 1985) and the theoretical data of Baluja and Jain (1992). The TCS curve of e^+–CF_4 shows a simple line-like shape. The minimum for e^+–CF_4 may be near 1 eV, but we are not sure.

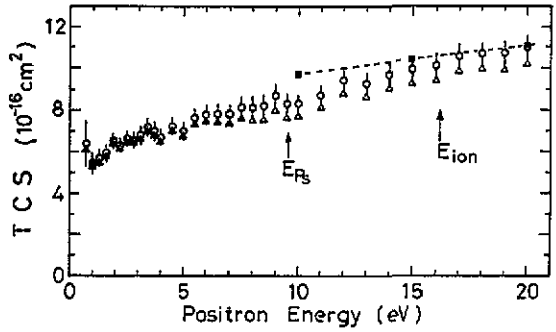

Figure 6. Total cross sections for positrons with energies below 20 eV colliding with CF_4 molecules. Experimental points: ○, this experiment; △, the preliminary data (Mori *et al* 1985). Theoretical data: - - - ■ - - -, Baluja and Jain (1992). Arrows indicate the positronium formation threshold (E_{Ps}) and ionization potential (E_{ion}). Error bars show the error values in table 2.

An increase of TCS due to the positronium formation was observed in the e^+–SiH_4 curve at $E_{Ps}=4.8$ eV, similar to e^+–CH_4 at $E_{Ps}=5.8$ eV (see, for instance, the data in I). However, the increase for e^+–CF_4 was not distinct at $E_{Ps}=9.4$ eV. In the whole range, the shape of TCS-curve of e^+–SiH_4 is rather similar to that of e^+–CH_4. As deduced from the energy loss spectra for SiH_4 in figure 3(*a*) and of Tronc *et al* (1989), the contributions of excitations are shown in the TCS curve at 8–13 eV.

3.2. Electron scattering at low energies

The TCS for electrons with energies below 20 eV colliding with SiH_4 are shown in figure 7 along with the integral cross sections of the experimental data of Tanaka *et al* (1990)

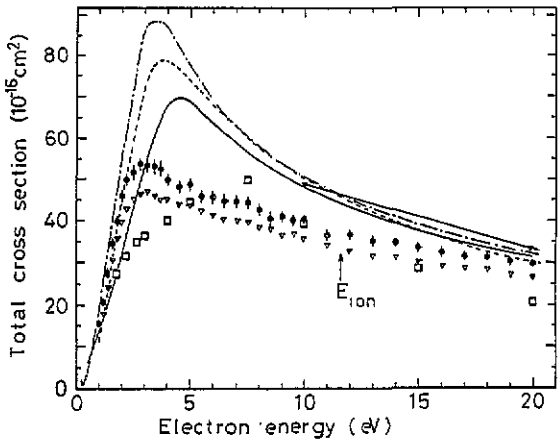

Figure 7. Total cross sections for electrons with energies below 20 eV colliding with SiH_4 molecules. Experimental data: ○, this experiment; ▽, the preliminary data (Mori *et al* 1985); □, the integral cross section of Tanaka *et al* (1990). Theoretical data: — · —, SEP model and ——, SHP model of Jain *et al* (1987); -----, Yuan (1989); — ▼ —, Jain and Baluja (1992). In the curve for SEP of Jain *et al*, the Ramsauer–Townsend minimum is shown at 0.3 eV. Arrow and symbol E_{ion} indicate the ionization threshold. Error bars show the error values in table 3.

and the theoretical data of Jain *et al* (1987) and Yuan (1989). Jain *et al* (1987) calculated the TCSs in various models including the static plus modified semiclassical exchange plus polarization (SEP) potential, and the static plus free electron-gas exchange by the version of Hara plus polarization (SHP) potential models. Yuan's theoretical data shown in figure 7 were calculated by the orthogonalization modified semiclassical exchange (OMSCE) potential. The values of all theoretical data are much higher than the experimental data, though the latter increased to the preliminary data mainly by the correction of forward scattering (see parentheses in the tables). The data for the multiple scattering-X_α calculation of Tossell and Davenport (1984) show very high values (not depicted in figure 7). The maximum of the data is 146.5×10^{-16} cm^2 at 2.45 eV. We do not understand why the peak position of the shape resonance does not coincide with the experimental data. In the measurements, the determination of the peak position of the simple and large peak is rather certain.

The Ramsauer–Townsend minimum in the TCS of e^-–SiH_4 is shown below 1 eV in the calculation of Jain *et al* (1987). The experimental data are not inconsistent with the result above, though the data are missing in this range. The TCS curves for both e^+–SiH_4 and e^-–SiH_4 are fundamentally similar to those for CH_4 (see in *I*). The physical features of the positron and electron are scattering on SiH_4 can be revealed by a treatment similar to that for CH_4, as in the work of Jain and Gianturco (1991).

The values of TCS for 1.0–20 eV electrons colliding with CF_4 are presented in figure 8 along with the experimental data of Jones (1986), Szmytkowski *et al* (1992), the

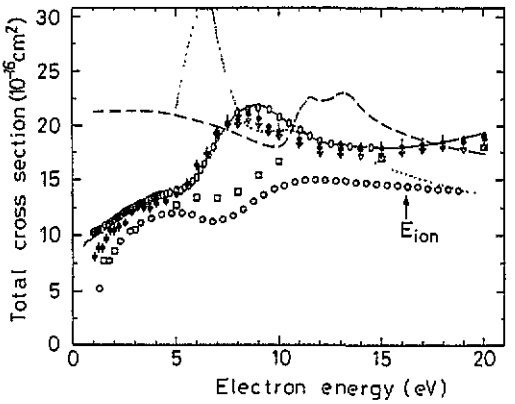

Figure 8. Total cross sections for electrons with energies below 20 eV coliding with CF_4. Experimental TCS data: ●, this experiment; ○, Jones (1986); ——, Szmytkowski *et al* (1992); ▽, the preliminary data (Mori *et al* 1985). Experimental data for the integral cross section: □, Boesten *et al* (1992); ○, Mann and Linder (1992). Theoretical data: – – –, Winstead *et al* (1993); -----, Huo (1988). The arrow and the symbol E_{ion} indicate the ionization threshold. Error bars show the error values in table 4.

preliminary data (Mori *et al* 1985), the experimental integral cross sections of Boesten *et al* (1992) and Mann and Linder (1992), and the theoretical data of Huo (1988) and Winstead *et al* (1993). In the low energy range, the present data coincide well with the data of Jones and of Szmytkowski *et al*. For e^-–CF_4, a bump and the main peak in the TCS curve are seen at about 3 eV and 8.5 eV, respectively. The TCS value at the peak of e^-–SiH_4 is roughly twice that of e^-–CF_4 and e^-–CH_4.

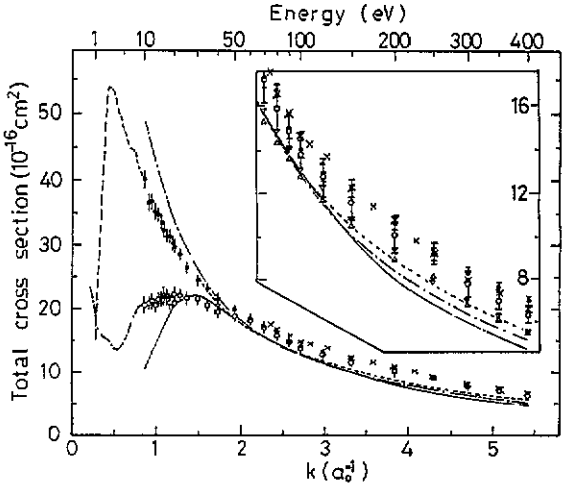

Figure 9. Total cross sections for positrons and electrons colliding with SiH_4 molecules plotted against wavenumber k extending to intermediate energies. Experimental points: O, —··—, e^+ data and ●, – – –, e^- data, this experiment; ×, Zecca *et al* (1992a). Theoretical data: for e^-, -----, SEPal model of Jain (1987), — · —, Jain and Baluja (1992); for e^+——, Baluja and Jain (1992). The data below 10 eV are modified to the visually fitted curves. The inset shows an enlargement in the ordinate at higher energies along with the preliminary data (Mori *et al* 1985): △, e^+ data and ▽, e^- data.

3.3. Scattering at intermediate energies

The TCS results for positrons and electrons colliding with SiH_4 extending to intermediate energies are presented in figure 9. The theoretical electron scattering data of Jain and Baluja (1992) and the SEPal model of Jain (1987), and the positron scattering data of Baluja and Jain (1992) are presented in the figure. The corrected present data are roughly coincident with the data of Zecca *et al* (1992a) at intermediate energies. A merging of the positron and electron TCS data is seen above 50 eV. However, the decreasing differences in e^- data and e^+ data with increasing energy is not certain for 50–400 eV. The correction due to forward scattering in this range is large for the present apparatus, because the DCS data above 100 eV are forward peaking (Jain 1987).

The TCS data for positrons and electrons colliding with CF_4 extending to intermediate energies are presented in figure 10 along with the experimental data of Szymtkowski *et al* (1992), Zecca *et al* (1992b), and the theoretical data for positrons of Baluja and Jain (1992). The merging of the positron and electron data is not seen here in the higher energy range. Large differences are evident. The data of both Szmytkowski *et al* (1992) and Zecca *et al* (1992b) are considerably higher than the present data in the intermediate energy range.

The values of total cross sections for positrons are given in tables 1 and 2. Those for electrons are given in tables 3 and 4. The correction values due to forward scattering by the calculation mentioned in 2.6 involved in TCS depend strongly on the differential cross section values and on the magnetic field. The uncorrected (i.e., preliminary) data values can be obtained by subtracting the corrections from the results in the tables.

For the evaluation of errors, the relative error, $\Delta Q_t/Q_t$, is obtained by linear addition of $\Delta I/I$, $\Delta n/n$ ($=0.3\%$) and $\Delta l/l$ ($=2\%$), where I means $\ln(I_v/I_g)$. The statistical errors

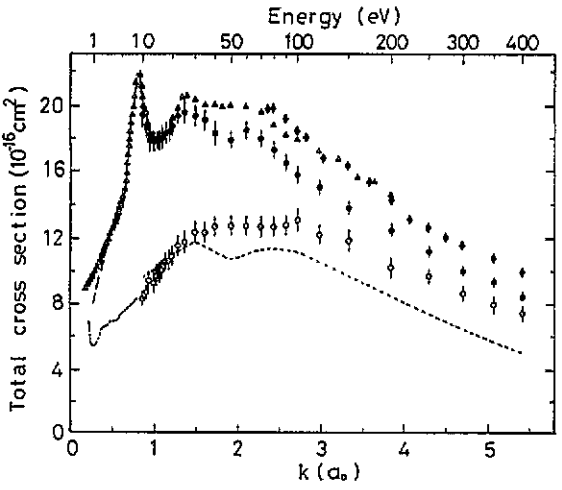

Figure 10. TCS data for positrons and electrons colliding with CF_4 plotted against wavenumber k extending to intermediate energies. Experimental points: ○, —··—, e^+ data ●, – – –, e^- data of this experiment; △, Szmytkowski *et al* (1992); ◆, Zecca *et al* (1992b). Theoretical data for e^+: ——, Baluja and Jain (1992). The data below 10 eV are modified to the visually fitted curves.

Table 1. Total cross section (TCS) for positron scattering on SiH_4 molecules. Numbers in parentheses are the corrections due to forward scattering. Errors correspond to the total error described in the text.

Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)
0.7	23.0 ± 4.7 (2.6)	7.5	19.7 ± 1.2 (2.7)	25	21.7 ± 1.1 (2.2)
1.0	19.8 ± 2.3 (2.0)	8.0	19.8 ± 1.2 (2.7)	30	21.5 ± 0.9 (2.3)
1.3	16.9 ± 1.5 (1.9)	8.5	20.4 ± 1.3 (2.7)	35	20.5 ± 0.9 (2.5)
1.6	15.6 ± 1.3 (1.5)	9.0	21.0 ± 1.5 (2.8)	40	19.5 ± 0.9 (2.7)
1.9	16.1 ± 1.3 (1.5)	9.5	21.2 ± 1.4 (2.8)	50	18.8 ± 0.8 (2.3)
2.2	15.3 ± 1.2 (1.5)	10.0	20.8 ± 1.2 (2.8)	60	18.3 ± 0.8 (2.1)
2.5	13.9 ± 1.2 (1.5)	11.0	21.0 ± 1.1 (2.7)	70	17.1 ± 1.0 (1.8)
2.8	14.8 ± 1.2 (1.9)	12.0	21.4 ± 1.1 (2.6)	80	15.8 ± 0.9 (1.5)
3.1	15.2 ± 1.2 (2.4)	13.0	20.7 ± 1.1 (2.4)	90	14.9 ± 0.8 (1.2)
3.4	13.0 ± 1.1 (2.3)	14.0	21.6 ± 1.1 (2.3)	100	13.8 ± 1.0 (1.0)
3.7	13.9 ± 1.1 (2.5)	15.0	21.6 ± 1.3 (2.2)	120	12.7 ± 0.9 (1.0)
4.0	13.1 ± 0.9 (2.4)	16.0	22.1 ± 1.5 (2.2)	150	11.6 ± 0.8 (1.1)
4.5	14.0 ± 0.9 (2.5)	17.0	21.9 ± 1.3 (2.2)	200	10.1 ± 0.9 (1.1)
5.0	15.2 ± 1.2 (2.6)	18.0	21.1 ± 1.1 (2.1)	250	9.2 ± 0.5 (1.1)
5.5	15.1 ± 1.0 (2.6)	19.0	21.4 ± 1.2 (2.0)	300	7.8 ± 0.6 (1.0)
6.0	16.4 ± 1.1 (2.6)	20.0	22.3 ± 1.4 (2.0)	350	7.0 ± 0.4 (0.9)
6.5	17.7 ± 1.1 (2.6)	22.0	22.0 ± 1.2 (2.1)	400	6.3 ± 0.4 (0.8)
7.0	18.7 ± 1.1 (2.7)				

due to the intensity in TCS measurements, I/I, are 3–6% for positron measurements and 0.6–1.5% for electron measurements, and involve the error by subtraction of the accidental coincidences in each channel. The errors in the forward scattering correction are not estimated. In the correction calculation, extrapolation or interpolating values

Table 2. Total cross section (TCS) for positron scattering on CF_4 moelcules. Numbers in parentheses are the corrections due to forward scattering. Errors correspond to the total error desribed in the text.

Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)
0.7	6.4 ±1.1 (0.3)	7.5	8.13±0.53 (0.51)	25	11.80±0.63 (1.04)
1.0	5.43±0.53 (0.14)	8.0	8.10±0.57 (0.56)	30	12.40±0.67 (1.30)
1.3	5.70±0.42 (0.23)	8.5	8.19±0.53 (0.62)	35	12.37±0.61 (1.52)
1.6	5.80±0.39 (0.13)	9.0	8.68±0.59 (0.69)	40	12.70±0.56 (1.44)
1.9	6.52±0.37 (0.12)	9.5	8.28±0.51 (0.61)	50	12.71±0.58 (1.35)
2.2	6.29±0.35 (0.12)	10.0	8.30±0.42 (0.56)	60	12.78±0.55 (1.86)
2.5	6.60±0.38 (0.13)	11.0	8.71±0.45 (0.56)	70	12.70±0.60 (1.95)
2.8	6.55±0.41 (0.14)	12.0	9.42±0.47 (0.57)	80	12.70±0.57 (2.00)
3.1	6.77±0.46 (0.15)	13.0	9.24±0.52 (0.58)	90	12.81±0.56 (2.09)
3.4	7.18±0.45 (0.17)	14.0	9.69±0.49 (0.60)	100	13.09±0.64 (2.18)
3.7	6.98±0.47 (0.18)	15.0	9.91±0.58 (0.61)	120	12.24±0.58 (2.14)
4.0	6 68±0.42 (0.18)	16.0	10.08±0.55 (0.63)	150	11.86±0.65 (2.09)
4.5	7.22±0.43 (0.20)	17.0	10.54±0.61 (0.66)	200	10.26±0.64 (1.74)
5.0	6.97±0.43 (0.21)	18.0	10.67±0.53 (0.69)	250	9.72±0.41 (1.48)
5.5	7.61±0.46 (0.25)	19.0	10.68±0.61 (0.72)	300	8.66±0.50 (1.26)
6.0	7.78±0.48 (0.30)	20.0	10.97±0.61 (0.75)	350	7.96±0.53 (1.19)
6.5	7.82±0.47 (0.36)	22.0	11.58±0.63 (0.86)	400	7.44±0.45 (1.16)
7.0	7.79±0.49 (0.43)				

Table 3. Total cross section (TCS) for electron scattering on SiH_4 molecules. Numbers in parentheses are the corrections due to forward scattering. Errors correspond to the total error described in the text.

Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)
1.0	15.7±0.7 (1.6)	7.0	44.6±1.4 (2.8)	25	26.4±0.9 (2.2)
1.2	20.7±0.8 (1.4)	7.5	44.4±1.4 (2.9)	30	26.4±0.8 (2.3)
1.4	27.5±1.0 (1.2)	8.0	42.6±1.5 (2.9)	35	23.2±0.7 (2.5)
1.6	34.5±1.2 (1.2)	8.5	40.5±1.7 (2.9)	40	21.8±0.8 (2.6)
1.8	39.8±1.3 (1.1)	9.0	41.1±1.3 (2.9)	50	20.0±0.6 (2.5)
2.0	45.9±1.4 (1.1)	9.5	40.1±1.3 (2.9)	60	18.6±0.6 (2.2)
2.2	49.9±1.5 (1.2)	10.0	40.3±1.3 (3.0)	70	17.3±0.5 (1.9)
2.5	51.7±1.7 (1.2)	11.0	36.7±1.3 (2.8)	80	16.5±0.5 (1.6)
2.8	53.8±1.6 (1.5)	12.0	36.8±1.2 (2.6)	90	15.0±0.5 (1.3)
3.1	53.2±1.7 (1.9)	13.0	35.3±1.3 (2.5)	100	14.1±0.4 (1.0)
3.4	53.1±1.7 (2.0)	14.0	34.9±1.1 (2.4)	120	13.0±0.4 (1.0)
3.7	52.6±1.8 (2.2)	15.0	33.6±1.2 (2.3)	150	12.2±0.4 (1.0)
4.0	49.9±1.5 (2.3)	16.0	32.5±1.3 (2.2)	200	10.6±0.3 (1.1)
4.5	48.1±1.6 (2.3)	17.0	31.6±1.1 (2.1)	250	9.2±0.3 (1.0)
5.0	48.7±1.4 (2.5)	18.0	31.4±1.1 (2.1)	300	8.3±0.3 (1.0)
5.5	46.0±1.5 (2.6)	19.0	30.3±1.1 (2.1)	350	7.6±0.2 (0.9)
6.0	45.6±1.6 (2.6)	20.0	29.8±1.1 (2.0)	400	7.0±0.2 (0.8)
6.5	44.7±1.6 (2.7)	22.0	28.5±0.9 (2.1)		

for the energy and angular values deduced from a small number of DCS values were used. The accuracy of the correction is rather poor. Especially for the positron data, a large ambiguity remains because the electron DCS values were used and a stronger magnetic field was used.

Table 4. Total cross section (TCS) for electron scattering on CF_4 molecules. Numbers in parentheses are the corrections due to forward scattering. Errors correspond to the total error describe in the text

Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)	Energy (eV)	TCS (10^{-16} cm^2)
1.0	8.07 ± 0.47 (0.09)	7.0	19.36 ± 0.70 (0.43)	25	19.59 ± 0.74 (1.01)
1.2	8.86 ± 0.43 (0.07)	7.5	20.29 ± 0.78 (0.51)	30	19.36 ± 0.66 (1.26)
1.4	8.89 ± 0.43 (0.06)	8.0	20.52 ± 0.74 (0.57)	35	19.09 ± 0.67 (1.50)
1.6	9.67 ± 0.46 (0.07)	8.5	21.01 ± 0.82 (0.65)	40	18.29 ± 0.79 (1.43)
1.8	10.41 ± 0.42 (0.07)	9.0	20.62 ± 0.80 (0.70)	50	17.89 ± 0.59 (1.30)
2.0	10.53 ± 0.39 (0.08)	9.5	19.90 ± 0.82 (0.64)	60	18.52 ± 0.54 (1.70)
2.2	10.81 ± 0.39 (0.09)	10.0	19.45 ± 0.72 (0.58)	70	17.96 ± 0.52 (1.76)
2.5	11.15 ± 0.43 (0.10)	11.0	18.66 ± 0.65 (0.60)	80	17.28 ± 0.54 (1.89)
2.8	12.09 ± 0.42 (0.11)	12.0	17.86 ± 0.71 (0.60)	90	16.50 ± 0.51 (2.02)
3.1	12.54 ± 0.44 (0.13)	13.0	17.73 ± 0.76 (0.59)	100	15.78 ± 0.50 (2.08)
3.4	12.49 ± 0.45 (0.14)	14.0	17.75 ± 0.64 (0.60)	120	15.03 ± 0.46 (2.07)
3.7	12.52 ± 0.53 (0.16)	15.0	17.81 ± 0.71 (0.61)	150	13.85 ± 0.42 (2.06)
4.0	12.92 ± 0.48 (0.18)	16.0	18.03 ± 0.78 (0.64)	200	12.52 ± 0.39 (1.72)
4.5	13.13 ± 0.46 (0.19)	17.0	18.26 ± 0.64 (0.66)	250	11.23 ± 0.34 (1.48)
5.0	13.67 ± 0.48 (0.20)	18.0	18.49 ± 0.72 (0.70)	300	10.09 ± 0.31 (1.25)
5.5	14.62 ± 0.56 (0.23)	19.0	18.42 ± 0.64 (0.71)	350	9.38 ± 0.30 (1.18)
6.0	16.27 ± 0.55 (0.28)	20.0	18 74 ± 0.64 (0.74)	400	8.49 ± 0.27 (1.15)
6.5	17.46 ± 0.65 (0.36)	22.0	19.42 ± 0.63 (0.85)		

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