RECENT PROGRESS IN ABSOLUTE TOTAL CROSS SECTION MEASUREMENTS FOR ELECTRON SCATTERING FROM MOLECULAR TARGETS IN LOW AND INTERMEDIATE ENERGY RANGE

Cz.Szmytkowski, P.Możejko

Atomic Physics Division, Department of Atomic Physics and Luminescence,
Faculty of Applied Physics and Mathematics, Technical University of Gdańsk,
ul. Gabriela Narutowicza 11/12, 80-952 Gdańsk, Poland
e-mail: czsz@mif.pg.gda.pl

Recent absolute total cross section measurements for electron scattering from molecular targets of plasma interest and molecular compounds of great importance in manufacturing of electronic microcircuits: XY_4 (X = Si, Ge; Y = H, F, Cl), XF_6 (X = S, W), C_2F_6, Si_2H_6 and C_6Y_6 (Y = H, F) are reviewed.

Introduction

Electron scattering on atoms and molecules is an important tool in investigation of interaction of electrons with matter. Absolute total cross section (TCS) for electron collisions with atom and molecules contains information of all possible (elastic and inelastic) processes which occur in collision phenomena and thus is valuable and useful quantity which may be used in atomic and molecular physics, low temperature plasma, astrophysics and etc. Moreover experimental absolute TCS obtained with high accuracy serve as a quantitative test for different theoretical approaches to scattering processes.

XY_4 (X = C, Si, Ge; Y = H, F, Cl)

The first experimental measurements of absolute TCS for e^- - SiH_4 collisions were performed by Wan et al. [1] in the low energy range (0.2-12 eV) and by Zecca et al. [2] for high-impact energies (75-4000 eV). Normalized data were presented by Sueoka et al. [3] for energies from 1 eV to 400 eV. Recently, Szmytkowski et al. [4] reported absolute TCS for impact energy range from 0.6 eV to 250 eV. All TCSs are in good agreement with respect to shape.

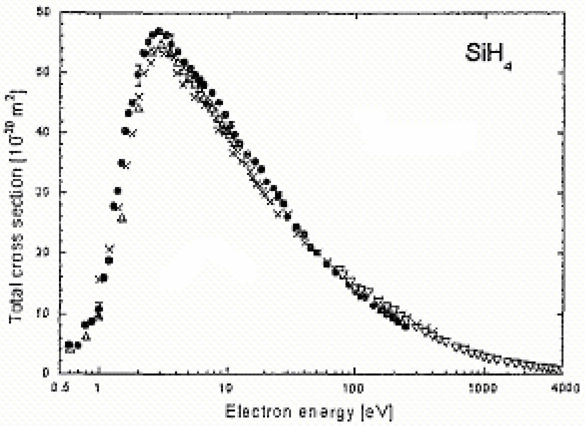

Fig 1. Total cross section for electron scattering on silane molecules: (×), [1]; (∇), [2]; (Δ), [3] (•), [4].

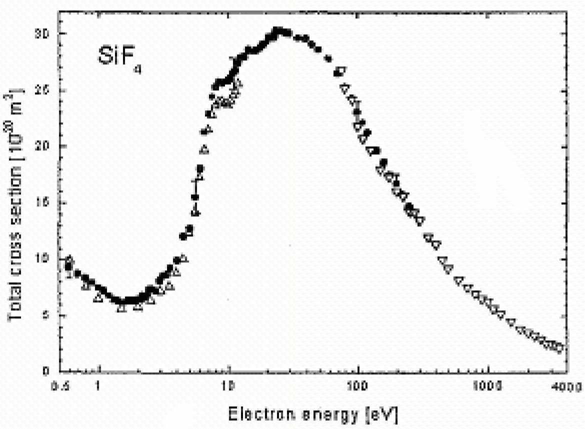

Fig 2. Total cross section for electron scattering on SiF_4 molecule: (Δ), [1]; (•), [5]; (∇), [5].

TCS for electron collisions with SiF_4 molecules were measured with trochoidal spectrometer by Wan et al. [1] for energies between 0.2 and 12 eV and in joined Gdańsk-Trento transmission experiment [5] for energies ranging from 0.6 eV up to 3500 eV. At about 1.5 eV Ramsauer minimum is visible in TCS function. A broad maximum of TCS is reached at 24 eV. Above 100 eV TCS falls monotonically.

The first absolute TCS for electron $SiCl_4$ collisions was measured by Wan et al. [1] for energies between 0.2 and 12 eV. Możejko et al. [6] determined absolute TCS in two distinct transmission experiments for impact energies ranging from 0.3 eV up to 4000 eV.

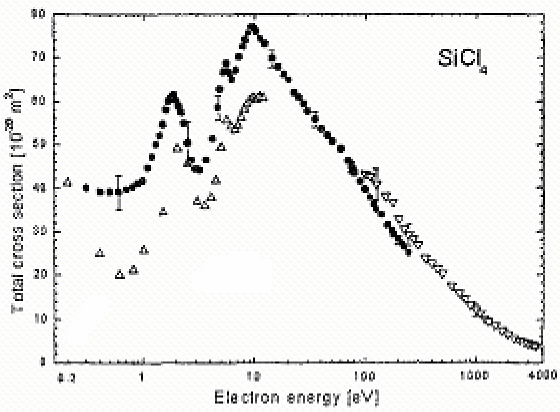

Fig 3. Total cross section for electron scattering on $SiCl_4$ molecule: (Δ), [1]; (•), [5]; (∇), [5].

The TCS function shows two very distinct resonant-like features: the strong peak at 1.9 eV and much broader main maximum centered near 10 eV with some additional substructure close to 5 eV. The first structure may be attributed to a short-lived resonant state created when the incident electron is captured into an unoccupied t_2 orbital of the $SiCl_4$ molecule.

Absolute TCSs for electron collisions with germane molecule were measured by Karwasz [7] at intermediate and high impact energies (75-4000 eV) and by Możejko et al. [8] for low and intermediate impact energies (0.75-250 eV). The main feature of TCS is the maximum at 3.8 eV. This structure is partly attributable to the existence, between 3 and 4 eV, of a short-lived resonant state created by capture of an extra electron into the lowest unoccupied orbital of the molecule [8].

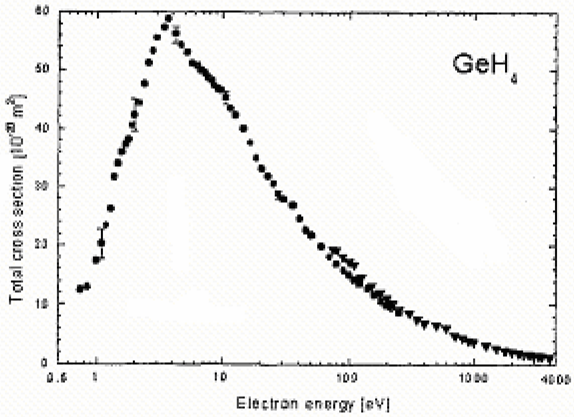

Fig 4. Absolute total cross section for electron scattering on GeH_4 molecule: (•), [8]; (▼), [7].

Absolute measurements for GeF_4 and $GeCl_4$ molecules at electron impact energies between 0.5 eV and 250 eV were reported by Szmytkowski et al. [9] and Szmytkowski et al. [4], respectively. Below 3 eV the TCS function for GeF_4 molecules is dominated by a step rise towards low energies. At energies above the minimum at 3 eV the TCS shows another enhancement spanned up to about 70 eV on which some resonant-like features are visible: the maximum centered near 6.5 eV and two weak peaks at 16 and 25 eV, respectively. TCS function for $GeCl_4$ molecule is dominated by two distinct maxima: the first is centered near 1.7 eV and the second is located near 10 eV.

XF_6 (X = S, W)

The first absolute TCS for SF_6 molecule were reported by Kennerly et al. [10] for impact energies from 0.5 to 100 eV. TCS below 1 eV were measured by Ferch et al. [11], and for energies between 0.25 and 25 eV by Romanyuk et al. [12]. Intermediate energy TCS (1-500 eV) was determined by Dababneh et al. [13]. High energy data (75-4000 eV) was measured with Ramsauer-type apparatus by Zecca et al. [14]. Absolute TCS for impact energies ranging from 0.5 eV to 250 eV was measured using electrostatic electron spectrometer by Kasperski et al. [15]. A number of resonant structures visible from thermal energies up to near 30 eV [11,12,15].

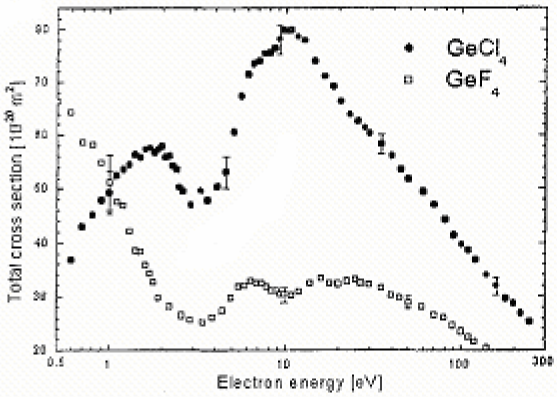

Fig 5. Absolute total cross section for electron scattering on $GeCl_4$ and GeF_4 molecules: (•), [4]; (□), [9].

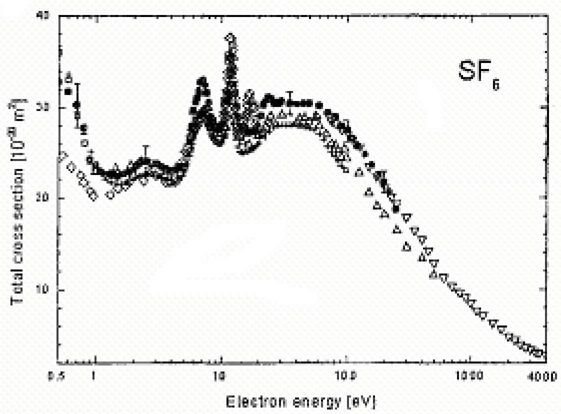

Fig 6. Total cross section for electron collisions with SF_6 molecules: (+), [10]; (□), [11]; (◊), [12]; (Δ), [13]; (∇), [14]; (•), [15].

Absolute TCSs for WF_6 molecules were measured with electrostatic electron spectrometer by Szmytkowski et al. [16] for energies between 1 eV and 250 eV and by Karwasz *et al.* [17] with magnetic Ramsauer spectrometer for energies form 75 eV up to 3500 eV. TCS shows a prominent resonant-like peak centered at 3 eV and a very broad enhancement in the energy range from 20 eV to 70 eV.

C_2F_6 and Si_2H_6

The first, normalized, TCS for e^- - C_2F_6 collisions was obtained with time-of-flight technique, for energies ranging from 0.9 to 20 eV, by Sueoka *et al.* [18]. Sanabia *et al.* [19] determined absolute TCS from near-thermal energies to 20 eV with trochoidal spectrometer. Absolute TCS for energies ranging from 0.5 eV to 250 eV was measured with electrostatic 127° electron spectrometer by Szmytkowski *et al.* [16].

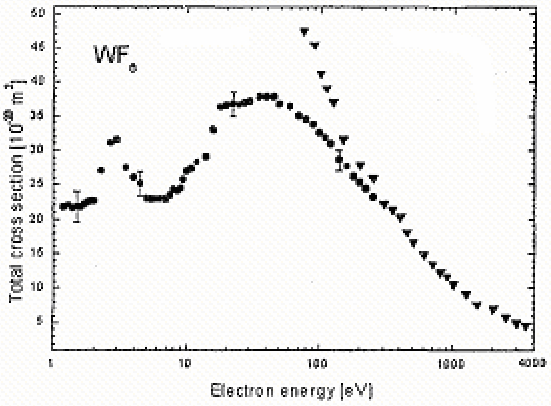

Fig 7. Absolute total cross section for electron collisions with WF_6 molecules: (•), [16]; (▼), [17].

The cross section for C_2F_6 has two resonant structures at 5 and 9 eV and a very broad hump ranging from 20 to 60 eV.

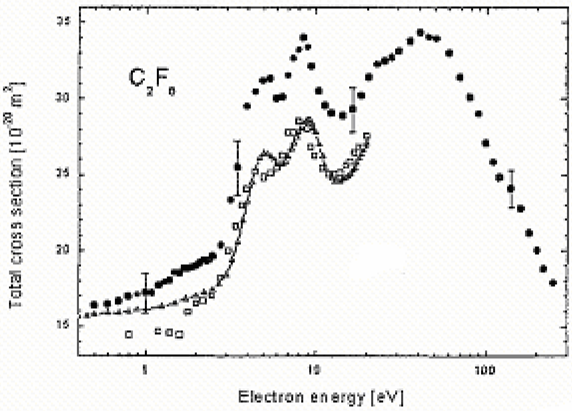

Fig 8. Total cross section for electron collisions with C_2F_6 molecules: (□), [18]; (-Δ-), [19]; (•), [16].

The first absolute TCS for electron scattering on disilane (Si_2H_6) molecules was measured in a linear electron transmission experiment for impact energies between 2 eV and 370 eV by Szmytkowski *et al.* [20].

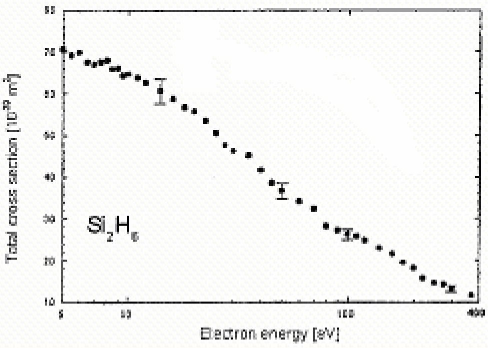

Fig 9. Absolute total cross section for electron scattering on Si_2H_6 molecules: (•), preliminary results [20].

C_6Y_6 (Y = H, F)

The first measurements of TCS for electron-benzene collisions were performed by Holst and Holtsmark [21] at impact energies between 0.5 and 25 eV. Normalized TCS was determined by Sueoka [22]. Absolute TCS was measured in electron-transmission experiments by Możejko et al. [23] for impact energies between 0.6 eV and 3.5 keV. The TCS for very low energies below 2 eV was measured by Gulley et al. [24]. The general character of all the TCS curves for benzene molecule is similar. The most prominent feature in the cross section is a broad maximum centered near 8.5 eV which may be in part due to short-lived resonances [23]. For energies above 10 eV, TCS decreases monotonically with energy.

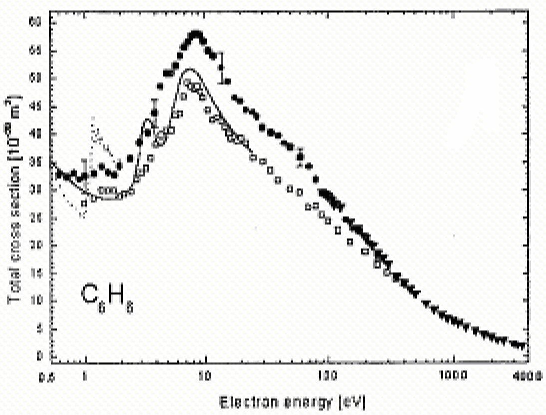

Fig 10. Total cross section for electron collisions with benzene molecules: (-), [21]; (□), [22]; (•), [23]; (▼), [23]; (···), [24].

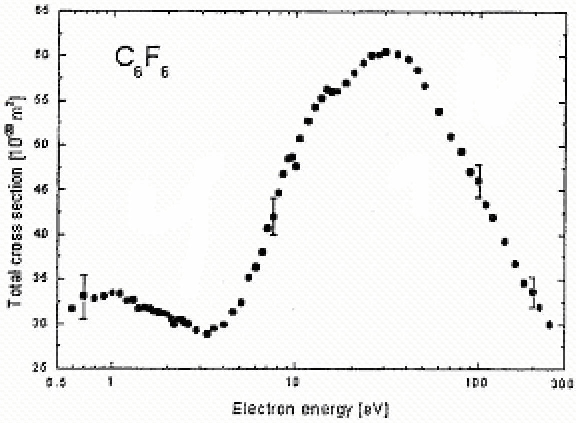

Fig 11. Absolute total cross section for electron collisions with C_6F_6 molecules: (•), [15].

Absolute TCS for electron scattering on hexafluorobenzene was measured for energies between 0.6 eV and 250 eV by Kasperski et al. [15]. TCS exhibits a very broad peak stretching from 10 to 100 eV with some weak features near 9.5 and 15 eV. Both features are attributable to resonant capture of an impinging electron in the field of an excited electronic state with formation of a temporary core-excited negative ion state.

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НОВІ РЕЗУЛЬТАТИ У ВИМІРЮВАННІ АБСОЛЮТНИХ ПОВНИХ ПЕРЕРІЗІВ ДЛЯ РОЗСІЮВАННЯ ЕЛЕКТРОНІВ НА МОЛЕКУЛЯРНИХ МІШЕНЯХ У ДІАПАЗОНІ НИЗЬКИХ І СЕРЕДНІХ ЕНЕРГІЙ

Ч.Шмитковський, П.Можейко

Підрозділ атомної фізики, кафедра атомної фізики і люмінесценції,,
Факультет прикладної фізики і математики, Ґданський технічний університет,
Ґданськ, Польща
e-mail: czsz@mif.pg.gda.pl

Проводиться огляд нових вимірювань абсолютних повних перерізів для розсіювання електронів на молекулярних мішенях, цікавих з погляду фізики плазми, та молекулярних сполуках, важливих для виробництва електронних мікросхем XY_4 (X = Si, Ge; Y = H, F, Cl), XF_6 (X = S, W), C_2F_6, Si_2H_6 і C_6Y_6 (Y = = H, F).