

§6. The Study on Electron Impact Excitation Process for the Plasma Relevant Molecules including Vibrationally Excited Species

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Low energy electron impact excitation, fragmentation and ionization of methane (CH_4) are processes that have attracted a lot of research interest owing to their widespread use in chemical vapor deposition (CVD) and etching.

In the present work, we carry out experimental studies of negative ion formation from CH_4 due to electron impact in the incident energies of 4-20 eV. The negative ion measurements were performed using a quadrupole mass spectrometer, QMS, (SXP300, VG Gas-Analysis LTD). Further confirmation was done for CH_4 with a new QMS (HAL301 s/2, HIDDEN Analytical). Background pressures were of the order of 10^{-8} torr with the target gas beam off, and about 5×10^{-7} torr with the target gas beam on. The molecules were ionized by electrons emitted from a tungsten filament and accelerated to the required impact energy by electrodes in the QMS. The ions are focused onto the entrance of the QMS by a single electrostatic Einzel lens system. After mass selection, the ion current is amplified by the built-in electron multiplier in the pulse counting mode.

In Figure 1, the yields from the C^- , CH^- , CH_2^- and CH_3^- formations from CH_4 are shown as the relative negative ion formation cross sections versus impact energy. CH_2^- was observed to be the most abundant negative ion species produced from the dissociative electron impact of CH_4 . A resonance structure for this ion was observed at 11.6 eV. CH^- is next in intensity and has a resonance peaking at about 11.8 eV. The ions C^- and CH_3^- are all formed through very broad resonances and with low intensity. These results agree well with those of previous measurements¹⁾⁻³⁾ in relative intensities, but our results are shifted up in energy by about 1 eV.

We also have measured the negative ion formation from the carbonyl fluoride (F_2CO) molecule. This molecule has been expected as the new cleaning gas in the vacuum chamber of the plasma processing. To obtain the information on the fundamental process in the low temperature plasma, we measured the negative ions from F_2CO by low energy electron impact using above the Hiden-QMS.

From the mass spectrum at an electron energy of 3 eV, the F^- (19 amu), F_2^- (38 amu), and COF^- (47 amu) were observed clearly. We also measured the yield

from these negative ions as a function of impact energy. It was found that the relative negative ion formation cross sections for these ions were enhanced around 3.0 eV and peak energies were shifted toward lower impact energy sides as increasing the mass of negative ion from F^- to COF^- .

Now, we are developing the new crossed beam apparatus combined with the Hiden-QMS to investigate more fundamental processes of fragmentation by low energy electron impact.

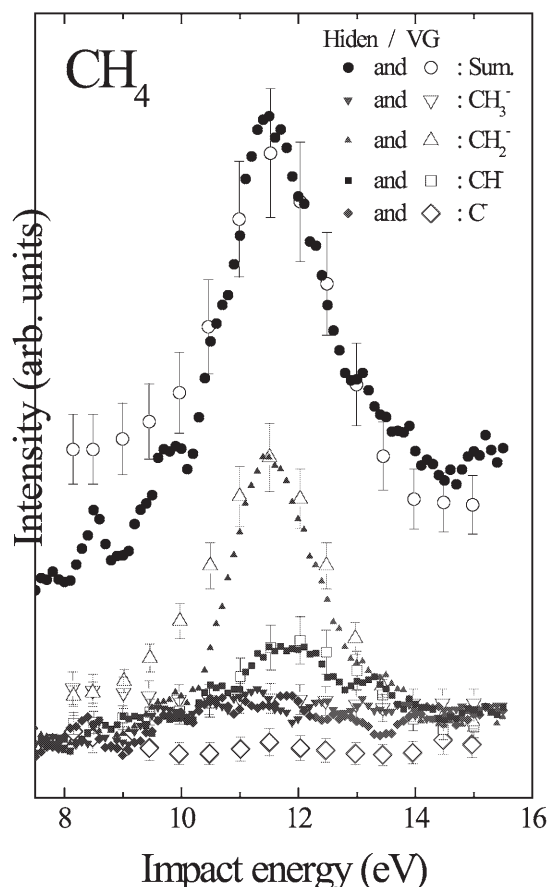


Fig. 1: C^- , CH^- , CH_2^- and CH_3^- formation through dissociative electron attachment to CH_4 . Error bars show the statistical uncertainties in these measurements.

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- 2) P. Potzinger and F. W. Lampe, J. Phys. Chem. **73** (1969) 3912.
- 3) Prashant Rawat et al., Int. J. Mass Spectrum. **277** (2008) 96-10