Fig. 1

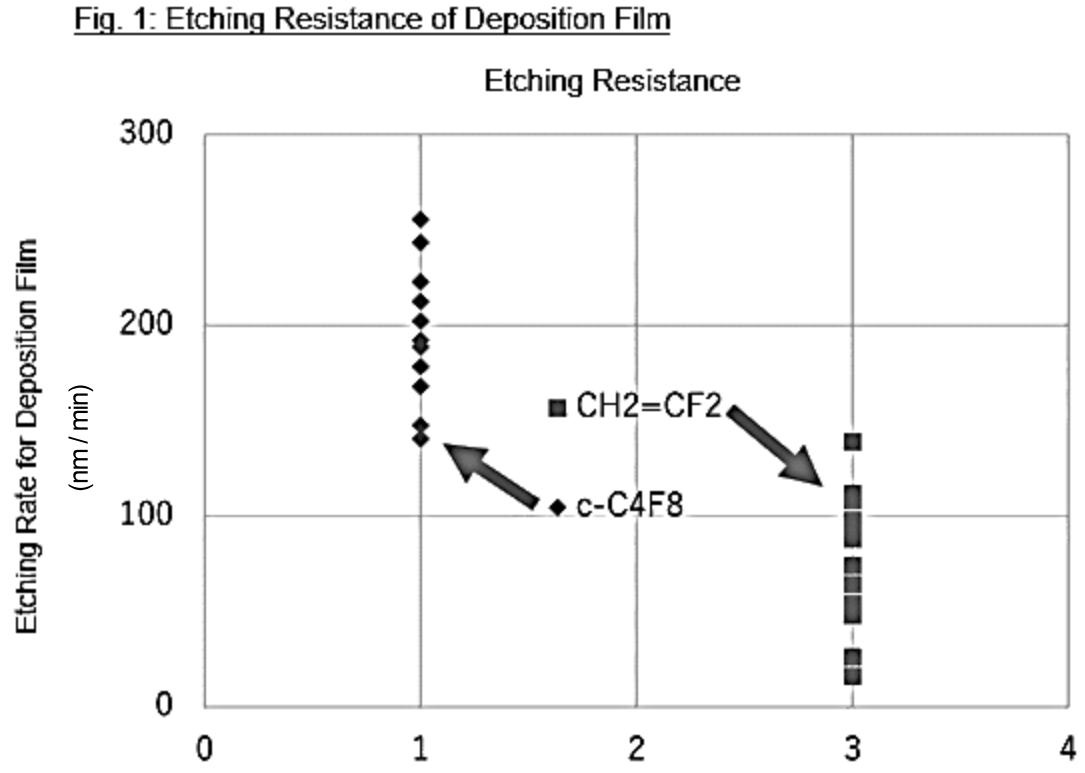


Fig. 1: Etching Resistance of Deposition Film
Etching Resistance
Etching Rate for Deposition Film
(nm / min)
300
200
100
0
0
1
2
3
4
CH2=CF2
c-C4F8

Fig. 2

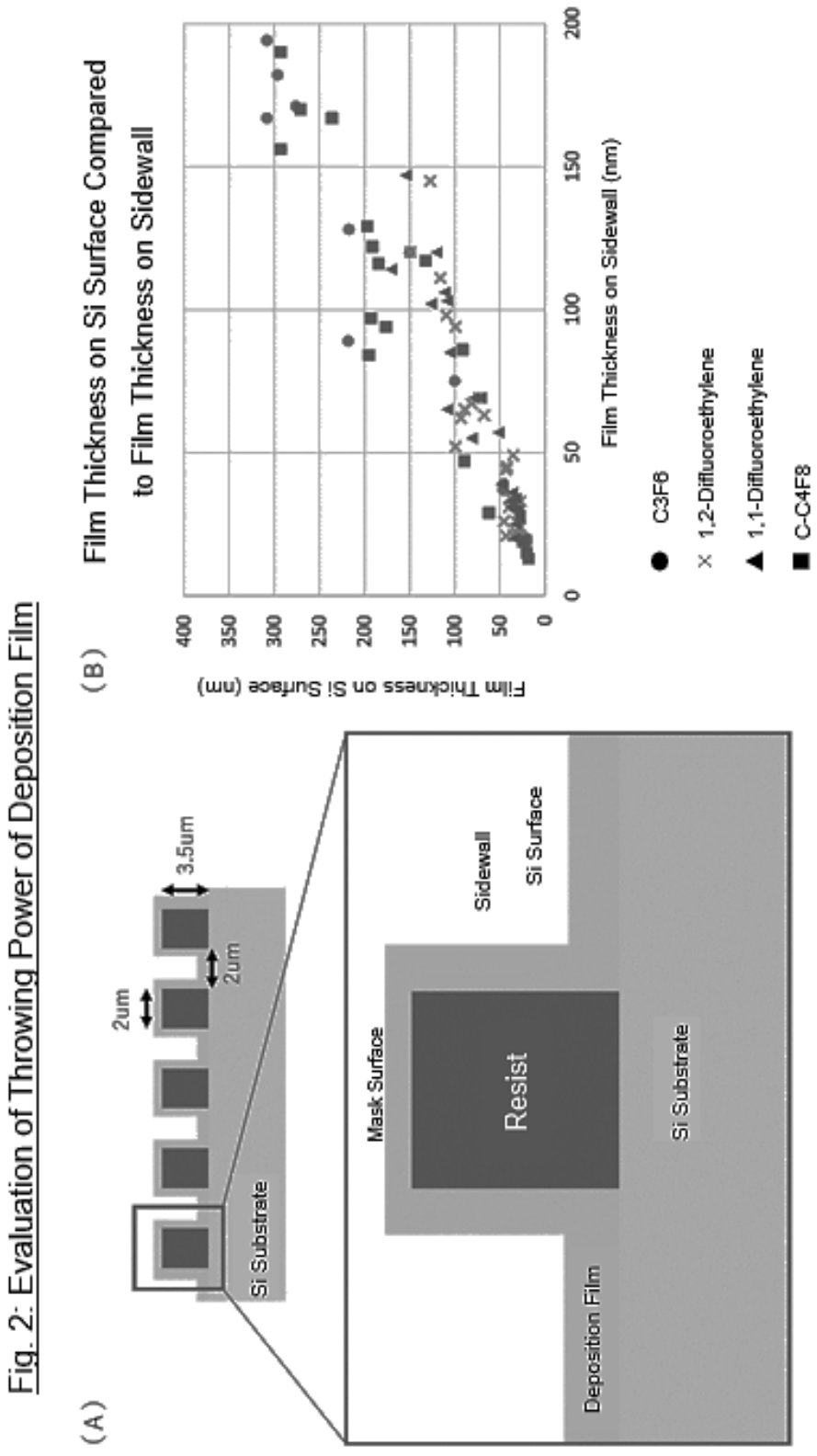


Fig. 2: Evaluation of Throwing Power of Deposition Film
(A)
2um
2um
3.5um
Si Substrate
Mask Surface
Resist
Sidewall
Si Surface
Si Substrate
Deposition Film
(B)
Film Thickness on Si Surface Compared to Film Thickness on Sidewall
Film Thickness on Si Surface (nm)
Film Thickness on Sidewall (nm)
0
50
100
150
200
250
300
350
400
C3F6
1,2-Difluoroethylene
1,1-Difluoroethylene
C-C4F8

Fig. 3

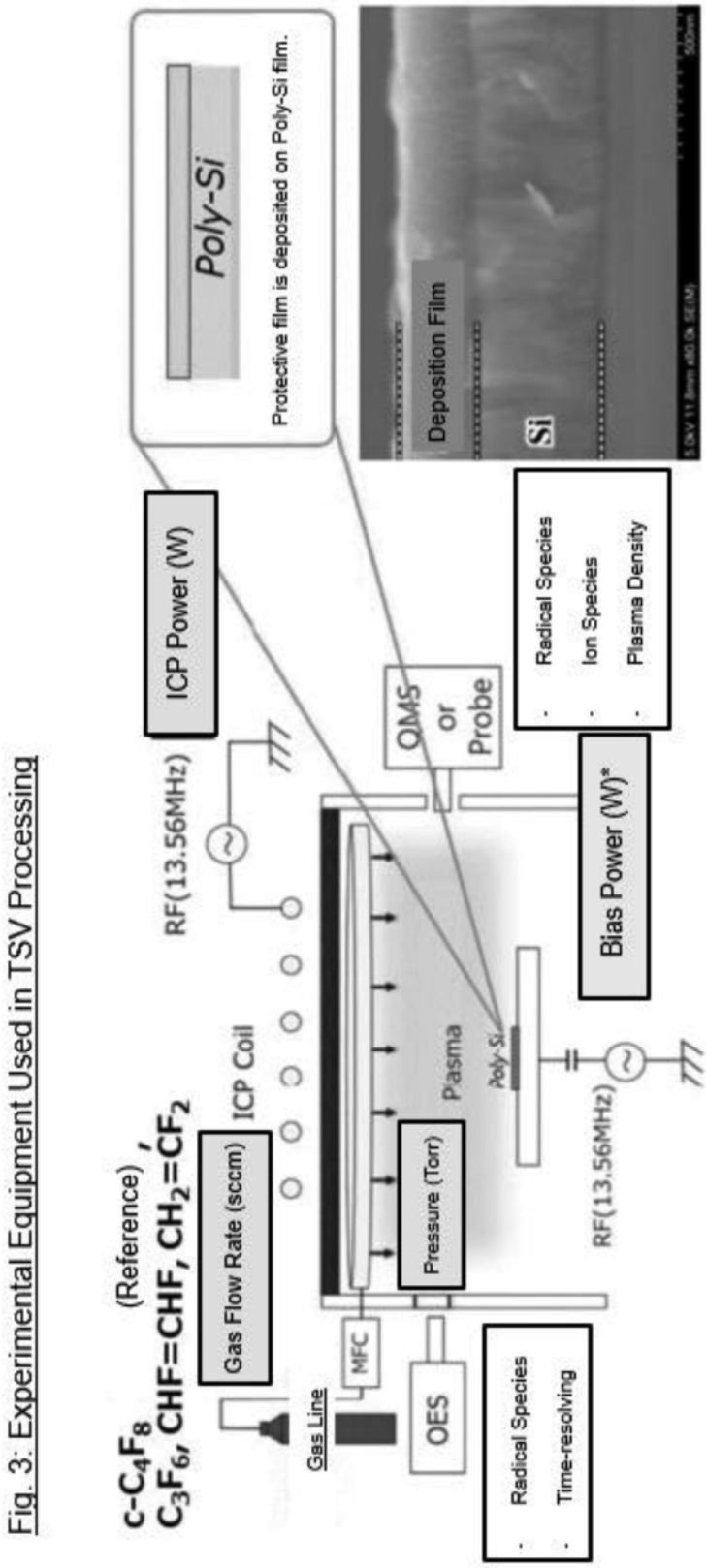


Fig. 3: Experimental Equipment Used in TSV Processing
c-C4F8 (Reference),
C3F6, CHF=CHF, CH2=CF2
Gas Flow Rate (sccm)
ICP Coil
Gas Line
MFC
OES
Radical Species
Time-resolving
Pressure (Torr)
Plasma
Poly-Si
RF(13.56MHz)
RF(13.56MHz)
ICP Power (W)
Bias Power (W)*
QMS or Probe
Radical Species
Ion Species
Plasma Density
Poly-Si
Protective film is deposited on Poly-Si film.
Deposition Film
Si

Fig. 4

Fig. 4: Distribution of Deposition Rate (DR)
(Construction of Digital Twin Using Prediction Model)

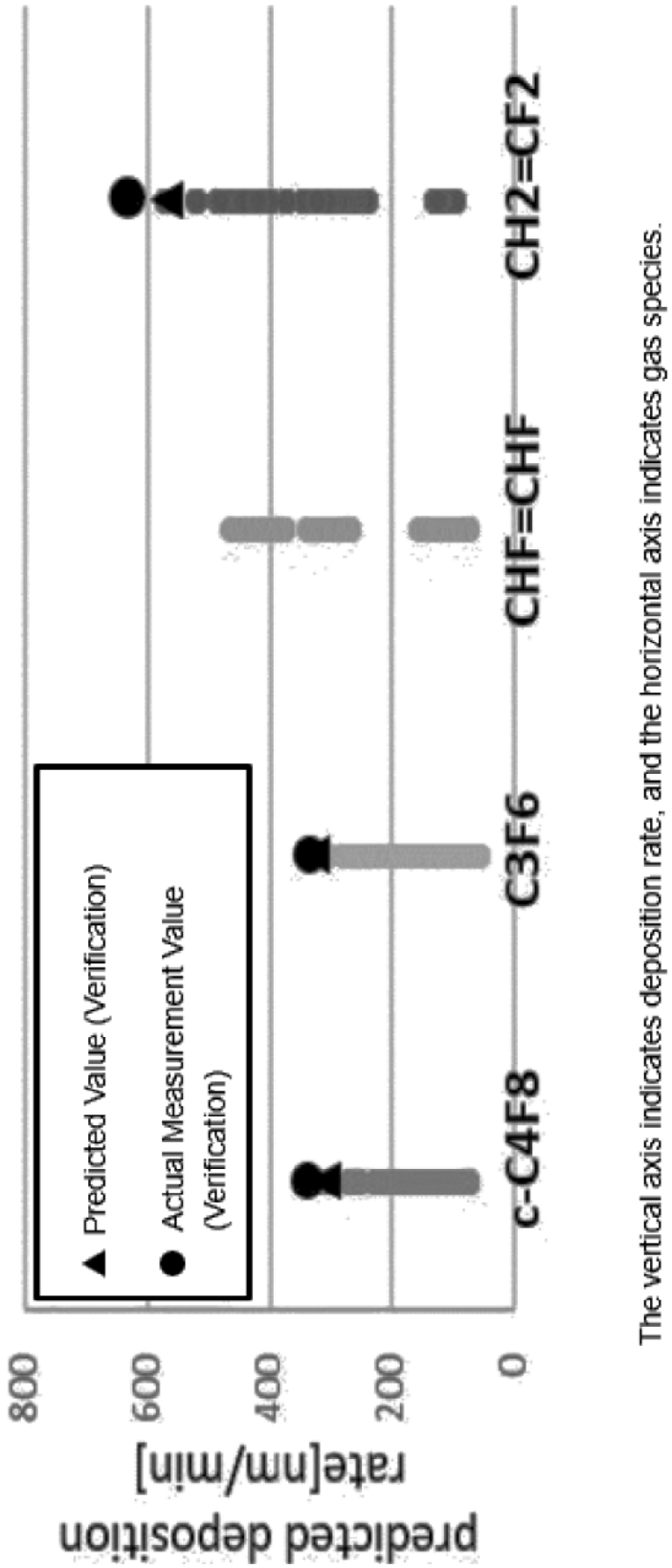


Fig. 5

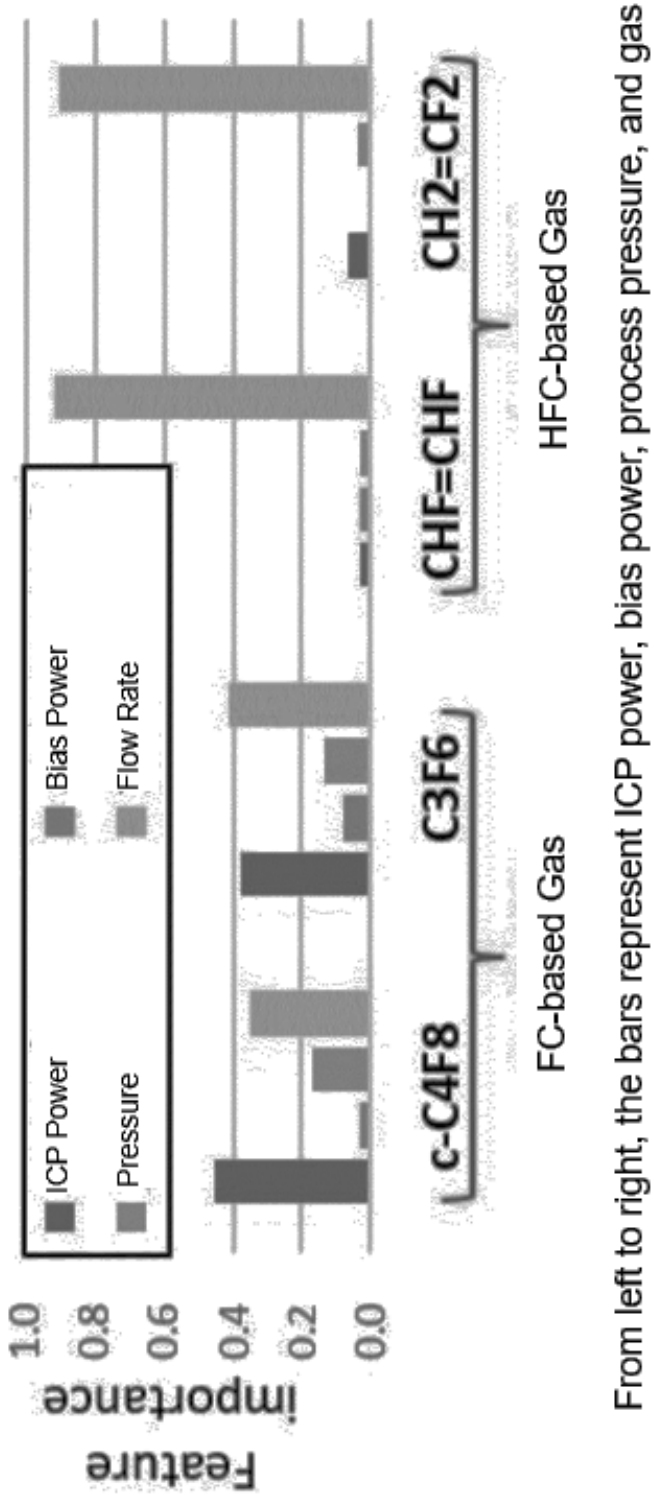
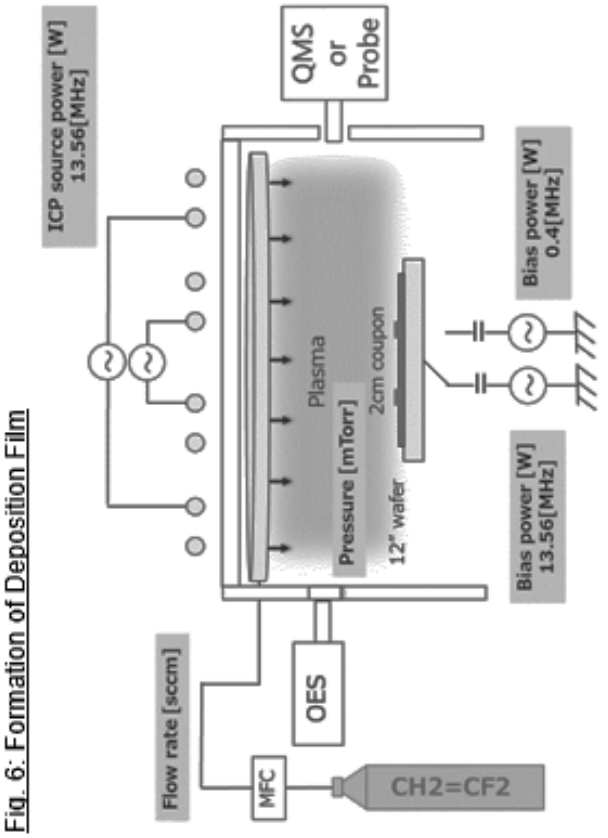



Fig. 5: Equipment Parameters That Affect Deposition Rate (DR)

From left to right, the bars represent ICP power, bias power, process pressure, and gas flow rate.

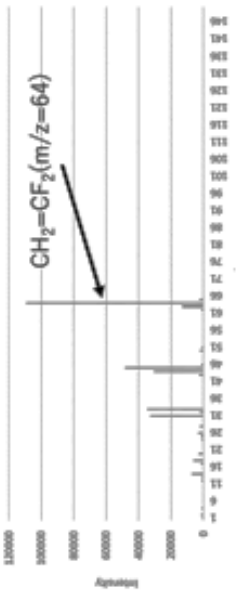
Fig. 6

Fig. 6: Formation of Deposition Film




Radicals in plasma were measured by using QMS.

Radical Measurement with QMS ($CH_2$=$CF_2$)




Neutral particles with a mass number in the range of 1≤m/z≤150 were measured, and each measured strength was multiplied by √m, thereby correcting the mass dependence of the measurement sensitivity of the QMS.

Experimental range

| ICP source power [W] | Bias power [W] | Pressure [mTorr] | Flow rate [sccm] | ESC [°C] |
|---|---|---|---|---|
| 900-2700 | 0 | 10-60 | 60-175 | -10 |

Parameters were changed, and deposition rates (DR) were obtained.

Fig. 7: Correlation between (Relative Strength of $CH_2=CF_2$ (m/z=64)) × (Source Power Density Squared) and Deposition Rate (DR)

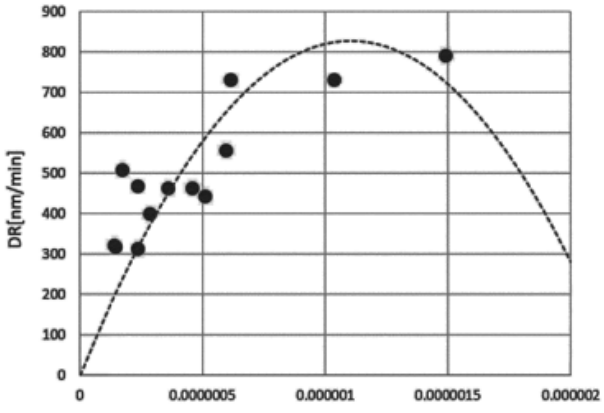
Relative strength: relative strength refers to a relative strength determined by dividing the radical strength of desired m/z by the sum of radical strengths of mass numbers in the range of $1 \leq m/z \leq 150$.

Radical strength: (measured strength of each mass number (m/z)) × (√m)

Radical strength represents a value determined by multiplying the measured strength of each mass number (m/z)) by √m to correct the mass dependence of QMS measurement sensitivity.

m: the mass number (molecular weight) of measured neutral particles

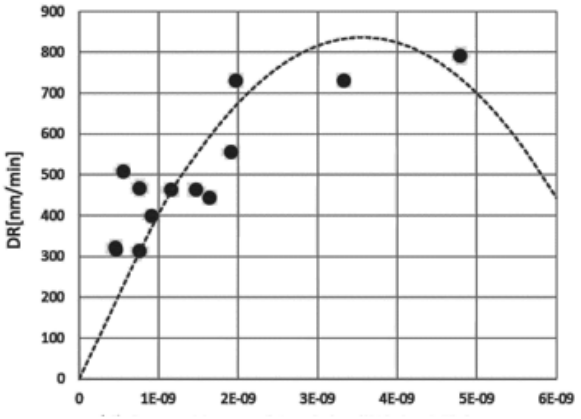
z: the charge state of particles ionized within the QMS




(Relative peak intensity of radical density of deposition gas)

× (source power density squared)

*Source power density: area




(Relative peak intensity of radical density of deposition gas)

× (source power density squared)

*Source power density: volume