

Fluorocarbon Gases for Advanced Dielectric Etch Applications: A Chemical Manufacturer's Perspective

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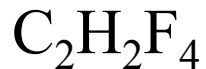
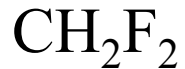
No one ever asks ...

Why are my
dielectric etch
gases so cheap?

But the reason is ...

Fluorocarbon etch gases have been either large-volume industrial products, or co-products in such processes

Products



Co-products



The current challenge

- Damascene processing requires high selectivity etching of silicon dioxide versus closely-related compounds (especially silicon nitride)
- This requires precise control of the relative fluoropolymer formation rates on the films
- It is commonly believed that compounds with F/C ratios of 2 and below best serve this requirement

Summary of options at $F/C \leq 2$

- PFCs (perfluorocompounds)
- HFCs (hydrofluorocompounds)
- OFCs (oxyfluorocompounds)
- UFCs (unsaturated fluorocompounds)

Availability & economics of these gases may not follow the traditional (existing product/co-product) model

PFC options

Compound	Availability	Applications
C_2F_6 (116)	Commercial, product	numerous – see Application Guide*
c- C_3F_6 (C216)	Not commercial	
C_3F_8 (218)	Commercial, co-product	JVST B, 14, 3470 (1996); JVST A, 14, 1092 (1996)
c- C_4F_8 (C318)	Commercial, co-product	numerous – see Application Guide*

* www.dupont.com/zyron

HFC options

Compound	Availability	Applications
CH ₂ F ₂ (32)	Commercial, product, flammable	numerous – see Application Guide*
CH ₃ F (41)	Commercial, product, flammable	US 6,025,255; US 5,942,446; US 5,906,948
CH ₂ FCF ₃ (134a)	Commercial, product	multiple – see Application Guide*
H ₃ CCF ₃ (143a)	Commercial, product, flammable	
H ₃ CCHF ₂ (152a)	Commercial, product, flammable	JJAP, 39, 4666 (2000)
F ₃ CCH ₂ CF ₃ (236fa)	Commercial, product	US 6,183,655; US 6,120,697
CF ₃ CH ₂ CHF ₂ (245fa)	Commercial, product	US 6,120,697
F ₃ C(CHF) ₂ CF ₂ CF ₃ (4310mee)	Commercial, product	

* www.dupont.com/zyron

OFC options

Compound	Availability	Applications
$\text{CF}_3\text{CF}(\text{O})\text{CF}_2$ (HFPO)	Manufactured, product; toxic	US 5,928,963
$(\text{CF}_3)_2\text{CO}$ (HFA)	Manufactured, product; highly toxic	
$\text{C}_4\text{F}_8\text{O}$	Commercial, co-product	
$\text{C}_2\text{F}_2\text{O}_2$ (oxalyl fluoride)	Potentially	JECS, 148, G141 (2001); WO 99/34429

A substantial number of fluorocompounds containing ether (C-O-C) and carbonyl (C=O) linkages are reported in Japanese studies

UFC options

Toxicity concerns are typically larger for this class versus the others

Compound	Availability	Applications
C_2F_2	No, unstable	
C_2F_4 (TFE)	Manufactured, product; reactivity	US 5,874,013; JVST B, 18, 166 (2000); JVST A, 14, 2127 (1996); R. Chatterjee et al, SEMICON Southwest 2001 PFC Seminar
$CF_3CF=CF_2$ (HFP)	Commercial, product	multiple – see Application Guide*
$CF_3OCF=CF_2$ (PMVE)	Manufactured, product	CA 134, 230651
$F_2C=CF_2CF=CF_2$	Commercial, co-product	US 6,174,451
$(CF_3)C=CH_2$	Commercial, product	
c- C_5F_8	Commercial, intermediate	US 6,159,862; US 6,069,092
$F_3CC(F)=C(F)CF_2CF_3$ (PF2P)	Manufactured, intermediate	

* www.dupont.com/zyron

Conclusions

- Many compounds available at $F/C \leq 2$
- Compound uniqueness versus process development flexibility/options?
- The attributes of optimum compounds for advanced dielectric etch are not well understood or predictable
- Empirical process development seems likely to continue as a dominant process specification methodology