PFCs in a Baker's Dozen - a Retrospective on the Technological and Non-technological Issues

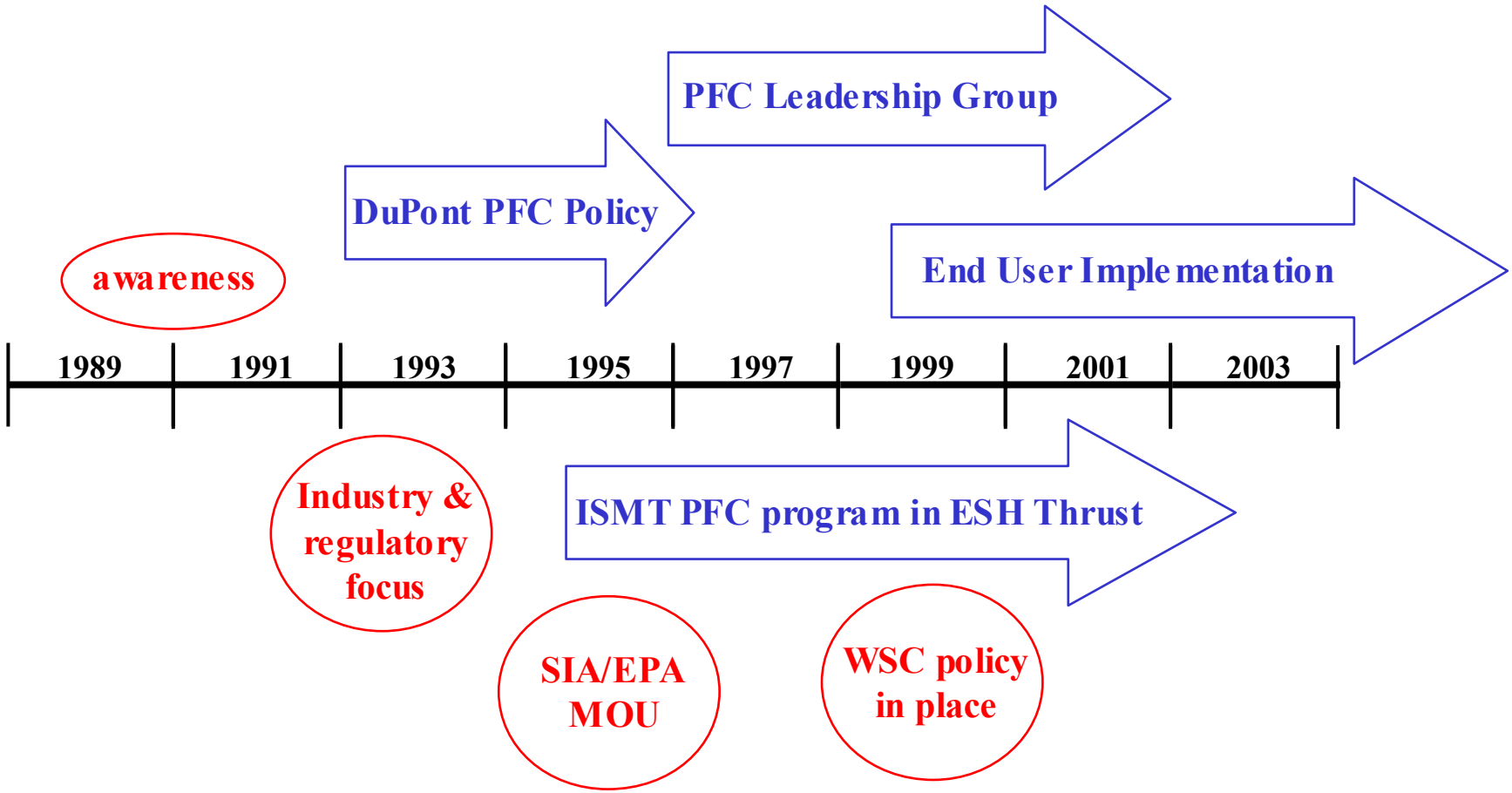
Mike Mocella

DuPont Electronic Gases

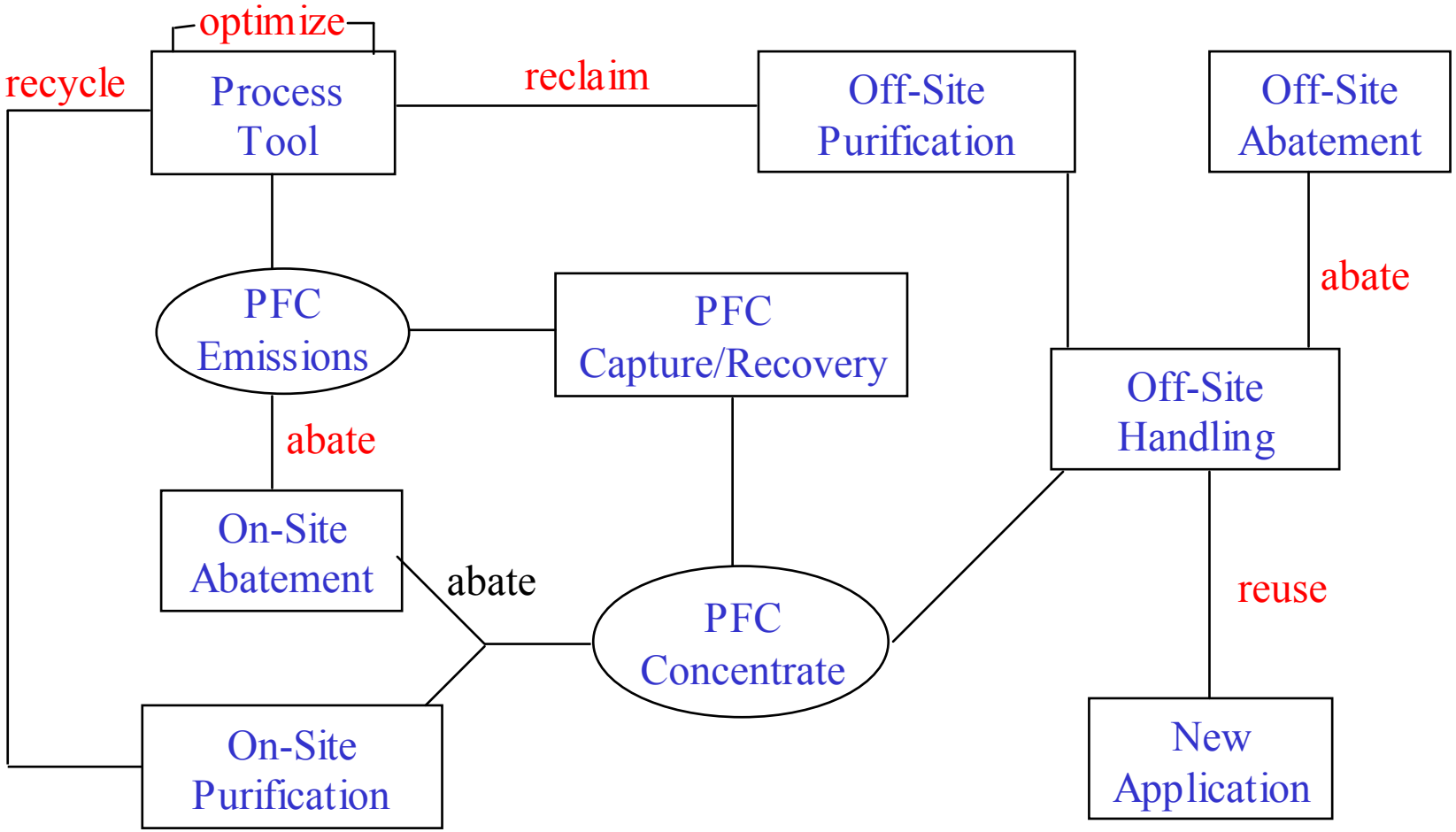
DUPONT

The miracles of science™

A PFC Timeline



Emission Control: A Holistic View



The miracles of science™

Optimize/Replace

- (PE)CVD chamber cleaning
  - C_2F_6 historically important
  - drop-in replacements available: C_3F_8, C_4F_8
  - low emission NF_3-based processes now standard
  - possible application of F_2?
- Dielectric Etching
  - CHF_3, C_2F_6, C_4F_8 historically important
  - trend to low F/C ratio compounds
  - simultaneous optimization of both process and ESH properties is challenging
  - likely need for abatement

Chamber clean drop-ins: C_4F_8 vs. C_2F_6

- Novellus Concept-1 (200mm)
  - DOE (% O2, flowrate, Pressure)
    - > 80 % Reduction PFC Emissions (kg CE)
    - > 60 % Reduction in Gas Consumption (wt)
  - Ref: CVD Chamber Cleaning: A Critical Comparison…, *Semicon West 2000*
- AMAT P-5000 (DxL)
  - DOE (% O2, flowrate, Pressure)
    - > 60-90 % Reduction in PFC Emissions
    - > 60 % Reduction in Gas Consumption (wt)
  - Ref: *ISMT Tech Transfer Report #01024083A-TR (with Infineon Tech)*

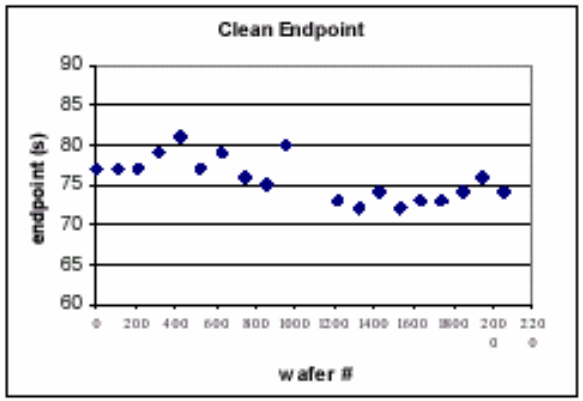
End user drop-in studies: AMD

	C4F8	C3F8
HP EP Clean Time	13:32	13:37
LP Clean Time	3:02	7:16
Total Time	16:34	20:53
Cost per Wafer	$0.073	$0.276
Emissions	0.13	1

Results based on 50 wafer test lots on 1.15µm silane oxide

End user replacement studies - I

DxL Evaluation Results



Recipe (sccm)	1400	1050	700
Percent Decrease in NF_3		25	50
Avg. QMS Clean Time (s)	80	102	124
Percent Increase (%)		27	54
Average F_2 Emission (scc)	2335	1716	1063
Percent Decrease (%)		27	54

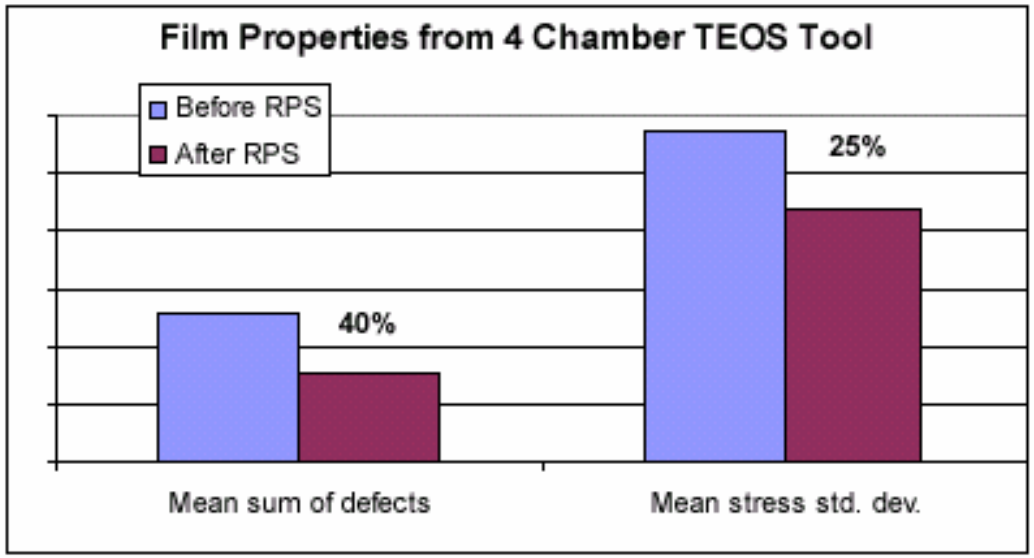
Clean time with baseline Remote Clean process 65% faster (with 20% overetch) than in-situ C_2F_6

Reduced NF_3 flow decreases F_2 emissions with a clean time still faster than in-situ C_2F_6

As presented by Laura Mendicino at the SEMICON Southwest 2001 PFC Seminar

End user replacement studies - II

4 Chamber (tool) Performance



- Analysis conducted on aggregate data from 4 chambers
- 16% improvement in TEOS film thickness uniformity
- 29% improvement in silane film thickness uniformity
- 67% decrease in mean sum of defects in silane films

As presented by Laura Mendicino at the SEMICON Southwest 2001 PFC Seminar

DUPONT

The miracles of science™

Options for Captured Streams

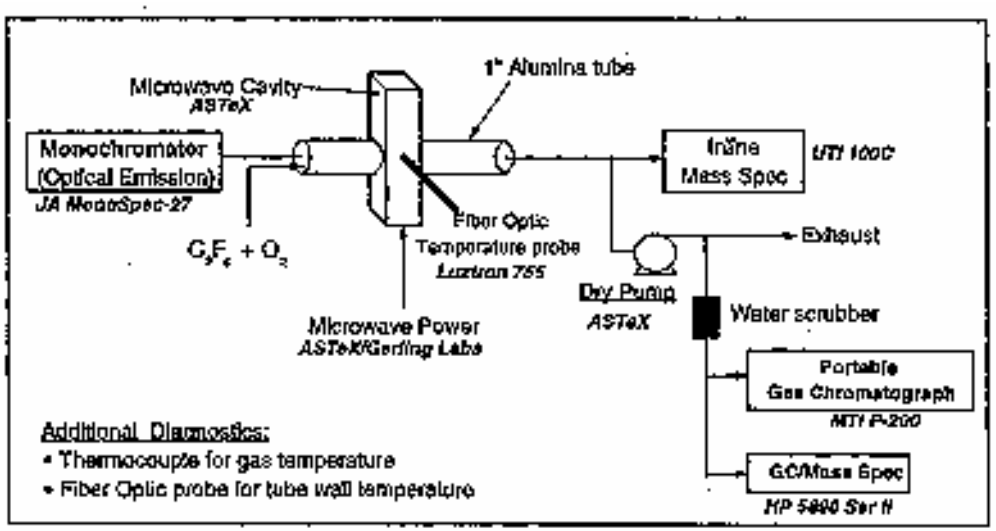
	Vol. %	Source
C_2F_6	55.2	etch/clean process gas
CF_4	22.0	etch/clean process gas and/or by-product
N_2	7.9	dry pump purge & ballast
SF_6	2.3	etch process gas
CHF_3	4.8	etch process gas and/or by-product
NF_3	3.1	etch/clean process gas
C_2F_4	3.3	etch process by-product
CO_2	0.8	etch/clean process by-product
CH_3F	0.3	etch process gas and/or by-product
C_3F_8	0.1	clean process gas
C_2HF_5	0.1	etch process gas and/or by-product
H_2O	0.1	process or process gas trace component

as presented at May, 1998, Monterey PFC Conference

- Both membrane and cryogenic recovery systems developed
- Results for "strawman" composition:
  - $3/kg for off-site abatement
  - $6/kg added cost for reclaim

Plasma Abatement

- Program at MIT (H. Sawin) giving first published results on high density plasmas for PFC abatement
- Several technologies now commercially available

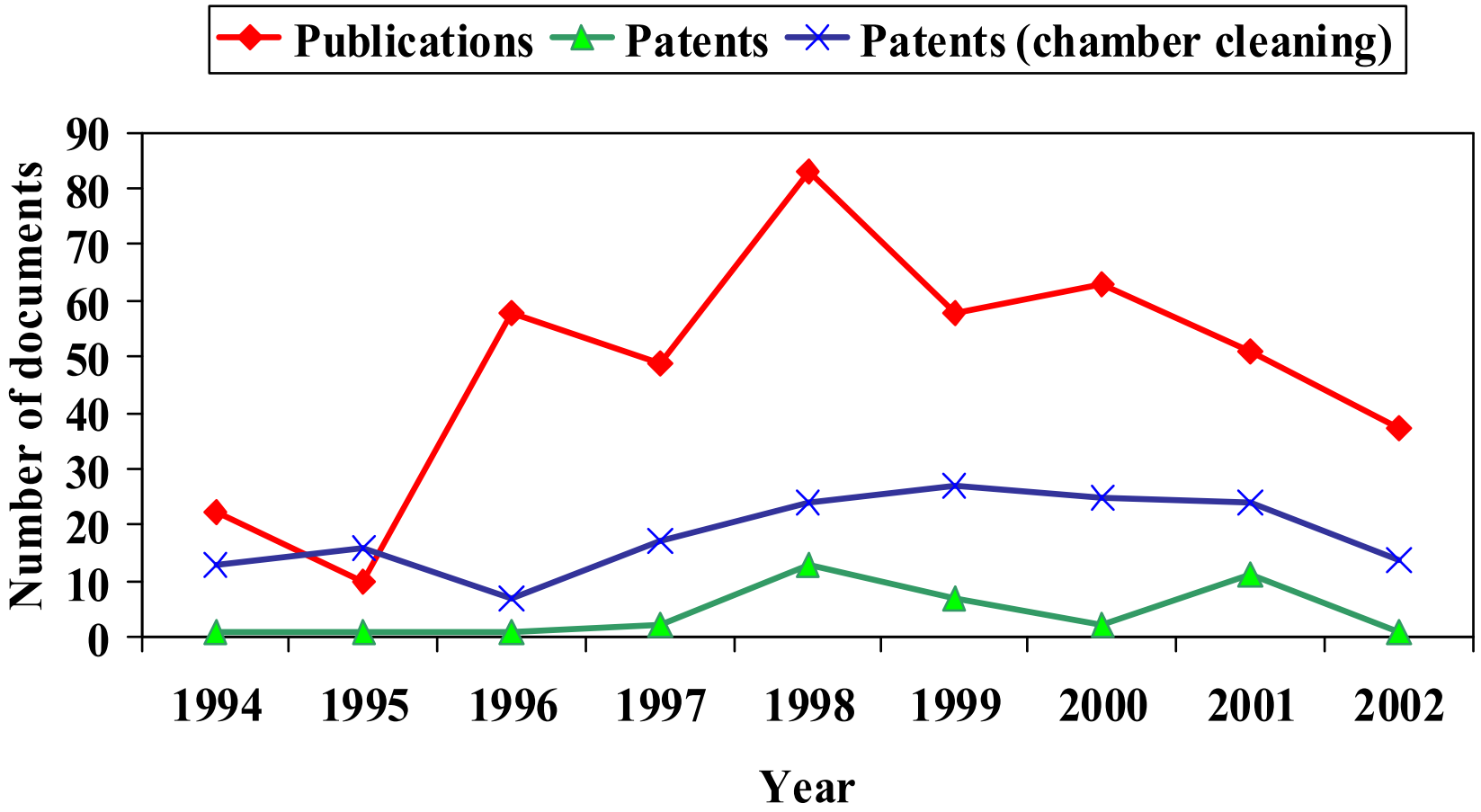


"Abatement of Perfluorocompounds (PFCs) in a Microwave Tubular Reactor using O_2 as an Additive Gas," V. Mohindra, H. Chae, H. Sawin, and M. Mocella, *IEEE Transactions on Semiconductor Manufacturing*, **10**, 399 (1997)

DUPONT

The miracles of science™

PFC emission reduction literature



The miracles of science™

Key Learnings

- Worldwide industry consensus to solve an ESH issue is possible - level playing field is critical
- ESH-driven technologies should desirably lead to process benefits - encourages early adoption
- Value for anticipating needs and working outside the usual regulatory process - get off the radar screen
- Possible extension of success to other issues, e.g., ESH chemical data assessment?