The career of a chemist

A customer and a question and an answer and a solution

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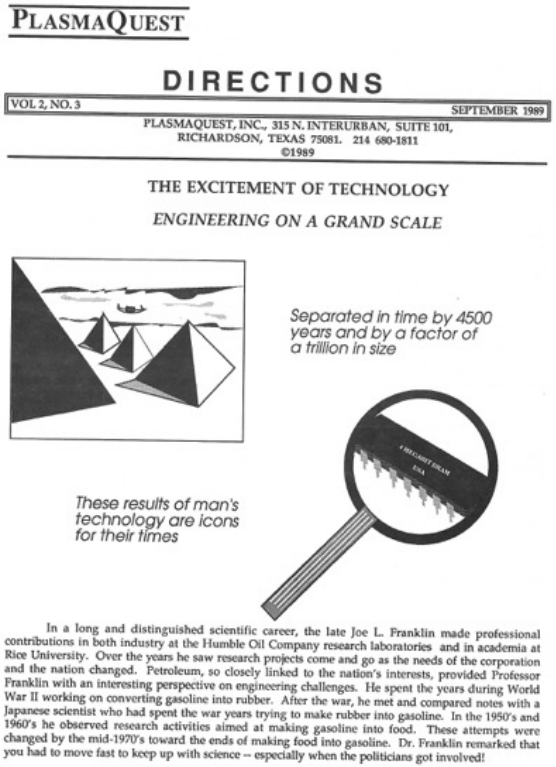
Scale and the Icons of Their Times



PLASMAQUEST

DIRECTIONS

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THE EXCITEMENT OF TECHNOLOGY

ENGINEERING ON A GRAND SCALE

Separated in time by 4500 years and by a factor of a trillion in size

These results of man's technology are icons for their times

In a long and distinguished scientific career, the late Joe L. Franklin made professional contributions in both industry at the Humble Oil Company research laboratories and in academia at Rice University. Over the years he saw research projects come and go as the needs of the corporation and the nation changed. Petroleum, so closely linked to the nation's interests, provided Professor Franklin with an interesting perspective on engineering challenges. He spent the years during World War II working on converting gasoline into rubber. After the war, he met and compared notes with a Japanese scientist who had spent the war years trying to make rubber into gasoline. In the 1950's and 1960's he observed research activities aimed at making gasoline into food. These attempts were changed by the mid-1970's toward the ends of making food into gasoline. Dr. Franklin remarked that you had to move fast to keep up with science -- especially when the politicians got involved!

The Pyramids of Ancient Egypt

The Conquest of the Isthmus of Panama

The Mobilization of World War II

The Race to the Moon

The Semiconductor Wafer Fab

Nomura's "Road to Wealth" poster debuted in 1970.

Gas Phase Chlorine Agents

- Cl_2
- HCl
- Cl_2O
- $ClONO_2$
- CCl_4
- BCl_3
- $SiCl_4$

Emerald Dawn, Kim Poor, 1989.

This scene shows a hypothetical planet with a chlorine/fluorine/neon atmosphere. Such a mixture may glow green in the morning twilight.

At UC Irvine, with Professor F.S. Rowland

What happens to chlorine in the stratosphere at night in the polar winter? – Chlorine nitrate

- 1975 – only two sources in the literature:
  - 1930's German
  - 1967 US – Rocketdyne Corporation
- Importance in the polar stratosphere in winter as a sink for chlorine atoms in ozone depletion
- Key data required: UV-Vis spectrum to determine its rate of solar photolysis, and rate of destruction by atomic oxygen.
  - Synthesis required scaling to produce mole quantities
    - $ClF + HNO_3$
    - $Cl_2O + N_2O_5$

At GE Lighting Research, Cleveland OH

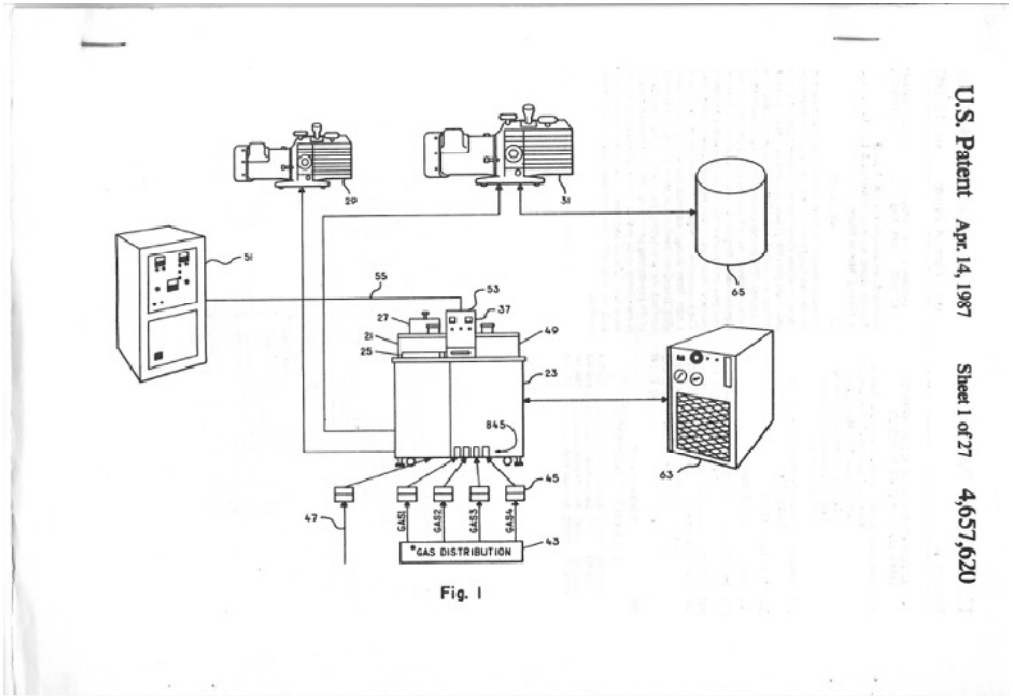
Why do Sylvania metal halide lamps work better than ours?

- Tungsten-halogen incandescent lamps use HBr and a quartz bulb to recycle evaporated tungsten from the wall to the filament in a van Arkel DeBoer transport process.
- Metal halide lamps are a complex electrochemical system consisting of thoriated W, Th, Sc, Na, I, Hg, SiO_2, and Ar in the presence of an electric arc in a high pressure fused silica vessel.
  - Excess iodine suppresses Th transport. Adding Cd to the dose captures free iodine and allows the Th transport cycle to maintain a low work function cathode, improving maintenance. US patent 4,360,756

At TI, Houston and Dallas

How do you scale anisotropic dry etching?

- Oxide, poly, aluminum
- Single wafer or batch?
- RIE or “plasma”?
- Applied Materials, Lam Research, TI Process Automation Center
- The reality: The leader in a technology must lead in R&D spending



At MTI, Richardson

How do you rapidly strip photoresist?

Use the afterglow of a microwave plasma in O2/N2O

Key insights:
Microwave plasma much more efficient than an RF plasma at dissociating O2

Flux and not concentration determines rate of stripping

Adding a few percent of N_2O to the O_2 doubled the rate

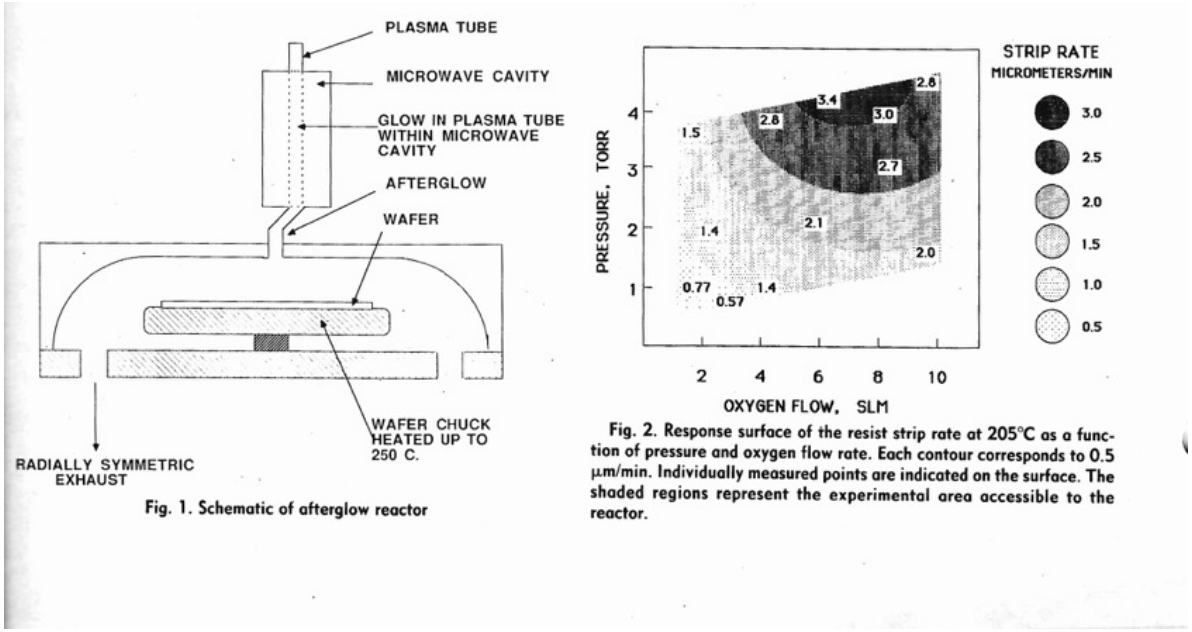


Fig. 1. Schematic of afterglow reactor

Fig. 2. Response surface of the resist strip rate at 205°C as a function of pressure and oxygen flow rate. Each contour corresponds to 0.5 μm/min. Individually measured points are indicated on the surface. The shaded regions represent the experimental area accessible to the reactor.

Spencer, Borel, and Hoff, J. Electroch. Soc., 133:1922 (1986)

At PlasmaQuest

How do etch HgCdTe? *…Asked LTV*

The Paneth Mirror experiment showed the way

This was a direct extension of the MTI AfterGlo™

Methyl source: F + CH_4

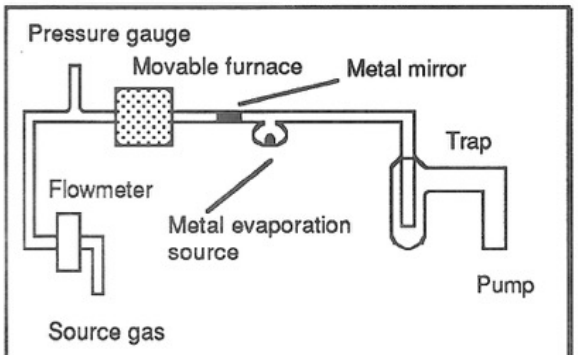


Fig. 1. Schematic of the Paneth experiment. This schematic also shows an evaporative source for mirror deposition.

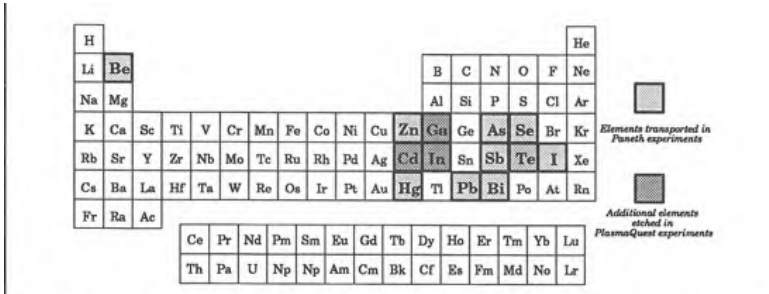


Fig. 3. The periodic chart highlighting those elements which have been etched by organic radicals.

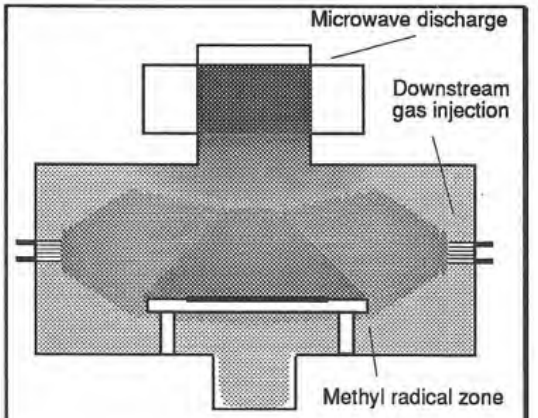
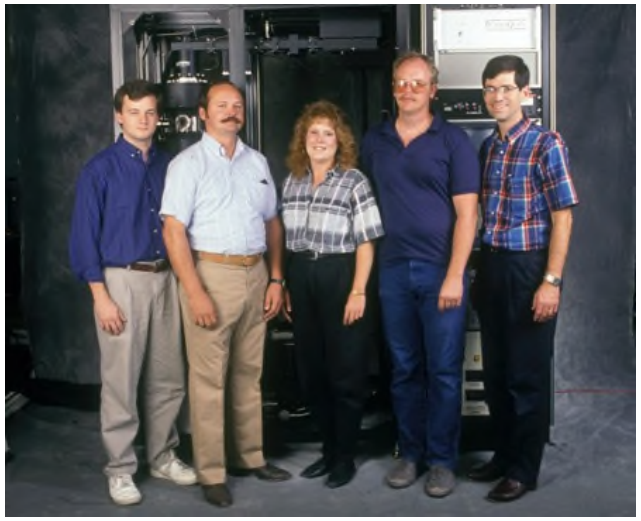


Fig. 2. Schematic of the PlasmaQuest Free Radical Reactor. A primary active species is formed in the discharge, then reacted downstream a secondary reactant, such as methane, to form a free radical etchant.

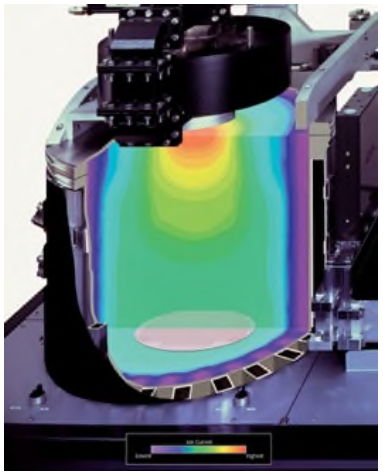
Asked Sematech

How do you scale the microwave plasma reactor?



The Original Crew on the TI reactor

John with Professor Thomas Mantei of the University of Cincinnati



Modeling the plasma in the PlasmaQuest magnetic bucket

The first PlasmaQuest ECR reactors were developed under a Sematech contract. Over the next decade, over 100 reactors were delivered worldwide.

At Photodigm, Professor Gary Evans of SMU asked…

Can we etch gratings for precision lasers?

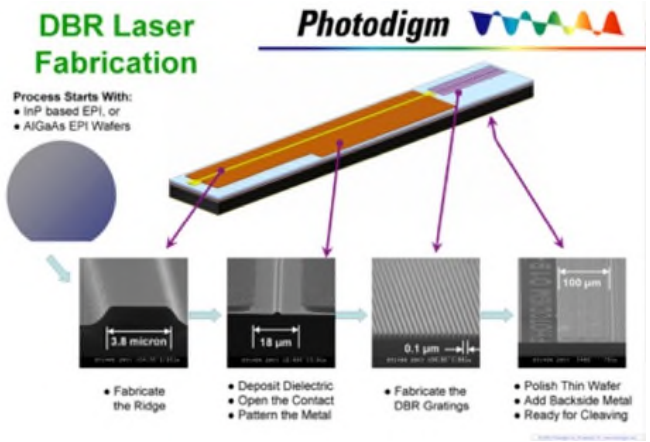
Photodigm founders, 2001

”Photodigm Building” 2001

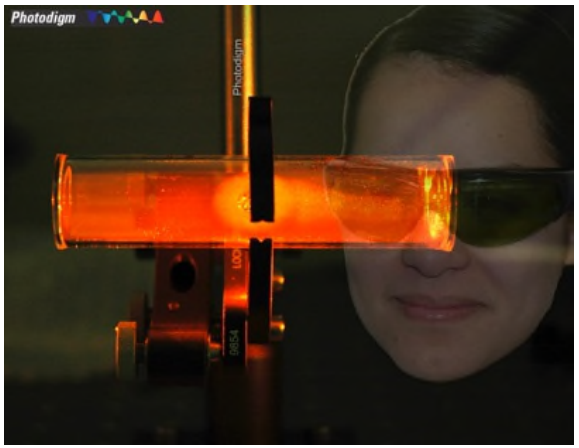
Prof. Gary Evans, Dallas Morning News

The Photodigm Wafer Fab and products

The original Photodigm wafer fab



Fabricating a Photodigm DBR laser requires over 150 steps, including subwavelength lithography



Illuminating a Rb vapor cell with a Photodigm DBR laser precisely tuned to the Rb D_2 line at 780.24 nm results in fluorescence from the D_1 line at 795 nm.

In Life and Business…

You don't do it alone…

Cathe (left) with
F.S. Rowland,
UCI 1977

With the team
at TI Japan
Miho *kojo* 1983

1997

Photodigm, 2012