

## **BioTechnology**

### ***Allergan***

Developed a process to sterile filter Hyaluronic acid. Required extensive onsite lab. work and equipment redesign to solubilize and filter this extremely viscous material with its shear dependent non-Newtonian behavior.

### ***Bio-Synthetics***

Developed a novel low cost process for fuel alcohol production using a pressurized extruder cooker, enzyme solubilization and countercurrent solids removal to produce a low solids and high sugar content solution for fermentation in unstirred fermenters. The resulting high alcohol content ‘beer’ was then upgraded to fuel or industrial grade by distillation. The process design reused waste hot water from the distillation process to reduce energy costs and increase yield from unfermented starches. Yields in excess of 2.5 gallons per bushel of corn were obtained in testing. Studies were undertaken on use of the process for conversion of agricultural waste, on farm and large scale grass-roots corn to alcohol facilities. Hydrolysis of cellulosic waste, such as corn stalks, was integrated into the process

### ***Brunswick BioTechnetics***

Several projects were undertaken in support of a novel asymmetric membrane bioreactor capable of growing sensitive mammalian cells for antibody production.

Designed, fabricated and installed, in a clean room, an enclosed tubing way with built in manifolds to which several bioreactors could be attached to obtain growth media, power and waste disposal.

Designed an entire facility to FDA GMP standards for contract production of monoclonal antibodies for cancer treatment. The facility included a WFI production and distribution system, feedstock preparation, bioreactors, purification systems, glassware handling, product packaging and product quarantine facilities.

Designed and built a prototype modular production unit including refrigerated feedstock and product storage and a room temperature bioreactor and membrane concentrator. The unit was self-contained apart from input WFI and power and a waste outlet.

### ***PDQ Precision***

Developed and directed a testing program at a third party laboratory on a patented hot vapor cleaning device to show it was fast and effective, (3 log reduction in 30 sec), at removing blood soils from surfaces. Used the data to obtain registration of the device by the FDA as a Class II cleaning device usable for cleaning external surfaces in hospitals and pharmaceutical manufacturing facilities.

Developed a safe chemical formulation (8% hydrogen peroxide) for use as a sterilizing agent together with the device and demonstrated success in high-level disinfection and sterilization.

Formulated a testing program in conjunction with the FDA to improve the device listing to a Class I device suitable for endoscope cleaning without the need for a 510K submission.

Implemented the testing program by developing tools and protocols for cleaning the inside and outside of endoscopes and endoscope accessories.

The testing conducted at a third party laboratory also obtained a similar 3-log reduction.

### ***Purified Protein***

Designed, coated and supervised construction of modification to an existing facility for production of catalase from beef liver, including clean rooms and waste handling.

### ***River Medical***

Helped write the patent to broaden the claims and directed the choice of chemicals for testing of a chemically powered pressurization system for a home infusion pump. Supported laboratory and pilot plant efforts at manufacturing.

### ***Sorrento BioChemicals***

Designed preliminary facility layouts for a production and laboratory facility to extract biological products from natural sources and estimated tenant improvement costs for alternate sites

### ***Vical***

Designed and costed a pilot plant for production of liposomes.

## **Chemicals**

### ***Ashland Chemical***

Process and Project Engineer on a \$15 MM plastic resins facility.

Responsible for reactor and piping design, fabrication and installation.

Wrote and managed the insulation specification, bidding and installation contract

### ***Kelco***

Conducted a study on the efficiency of the IPA recovery still and costed various means of improving the efficiency.

### ***Polysar***

Process and Project engineer on a two-mile long umbilical pipeline connecting and existing and new synthetic rubber facility. Responsible for process calculations on the 36" dia. Steam line and other connecting pipelines such as styrene etc. Managed the detailed piping design and construction of piping supports. Provided onsite troubleshooting and resolution of errors in surveying, which caused mismatch between the two plants.

## **Cleaning, Decontamination & Passivation**

### ***BOC***

Identified water as the contaminant in HBr causing loss of etching selectivity between silicon and silicon oxide. Further identified the phase

separation mechanism in the cylinder that caused the sudden onset of this problem during etching.

Researched sources of contamination from piping systems with different metallurgies and surface passivation treatments when in WF6 and HBr service. See paper.

Used computer modeling of surface species to show the reason electropolishing increased emissions of sulfur containing gases when in WF6 service

Identified the formation of iron hydrohalide complexes as the cause of corrosion during HBr purification and implemented successful solution.

Evaluated various papers by Ohmi on fluorine passivation of stainless steel and showed that his own data did not support his analysis and claims and that the stainless steel passivation layer was inherently unstable over the cylinder filling and refilling cycle.

### ***PDQ Precision***

Developed means for the device to be used for decontaminating sensitive equipment from chemical and biological weapons without corroding.

Performed successful cleaning tests with selected process on mild steel coupons without corrosion. Wrote patent to cover this and other applications of the technology.

### ***Praxair***

Conducted study on selection of material and passivation techniques for germane cylinders. Performed detailed literature analysis to understand the chemistry behind the passivation techniques. Evaluated various reactions with the surface species using thermodynamic analysis. Made confidential recommendations for both aluminum and steel cylinders to improve their performance. Also reviewed Japanese patent, which claimed copper in aluminum was a catalyst for germane decomposition. Showed that the data in the patent was better explained as reactions with residual water in the cylinder.

## **Defense**

### ***Navy***

Subcontractor on Navy project to develop a heat absorbing protective suit. Responsible for testing to determine temperature penetration with time of various designs. Developed ways to reduce the weight, increase the flexibility and meet washability, breathability and flammability requirements. Conducted testing and fabricated test material for suit fabrication.

### ***Lockheed Martin***

Conducted literature and feasibility studies on the use of glass microbubbles as emitters of light of various wavelengths. Designed and built a high temperature reactor to purge out the original blowing gas and refill with the desired gas. Developed accurate sampling techniques to determine gas concentration within the bubbles. Produced samples filled with argon and nitrogen for testing.

## **Expert Witness & Legal Consulting**

### ***Brown, Haller & Mclain/River Medical***

Reviewed draft patent application for home infusion pump pressurized by a chemically generated gas and broaden the claims to include all the possible ways in which the pressuring gas could be generated and identify the different Markush groups involved

### ***Kleinfelder/Motorola***

Hired through the legal department of Motorola to provide a confidential assessment of the emissions from various Motorola facilities. Also developed training materials and gave seminars to Motorola and Kleinfelder personnel to help them understand what processes generated pollution and under what circumstances.

### ***Maurer/Poolmizer***

Hired to evaluate the technical performance of a level control device, which was accused of failing to cut off at high level and had thus caused flooding. Showed it was very difficult for this to occur without obvious prior damage to the device.

### ***Eimer-Stahl/Praxair***

Hired by the law firm of Eimer Stahl as an expert witness for Praxair in a case brought by ARC with regard to a development contract for production of electronic grade WF6. Analyzed the thousands of pages of memos, depositions and analyses and wrote detailed confidential report.

## **Oil, Gas & SynFuels**

### ***Black, Sivals & Bryson***

Process and Project engineer in design, fabrication, installation and startup of modular gas plants and sulfur removal plants. Designed innovative 300 ft flare stack using TV tower for support. Modeled sulfur dioxide dispersal plumes to establish stack height. Upgraded company computer system and implemented computer simulation of distillation columns for gas plants

### ***D.O.E***

Study to look at on-farm crude alcohol production with a central distillation plant for fuel alcohol production using the farm milk production/central creamery as a model. Used combination of Biosynthetics Technology for corn conversion to alcohol and Stake Technologies steam hydrolysis of corn stalks to produce the carbohydrate portion of cattle feed. The wet protein from the process was mixed back in to produce a balanced cattle feed. This provided an indirect way to convert a waste product, corn stalks, into alcohol.

### ***Potomac Alcohol***

Full scale engineering study to convert the existing Schaefer brewery in Baltimore to a fuel alcohol facility. Used Biosynthetics technology for corn conversion, the existing brewery fermenters for alcohol production and a modular distillation facility from APV. Study included finding a cheap source of low grade (# 10) corn from nearby corn shipping silos and a market for byproducts in the Delaware/Purdue chicken facilities.

## ***Provincial Refining Corp***

Provided on-site engineering services and troubleshooting in startup of brand new refinery in Newfoundland. Projects included; removing sludge from large oil tanks and recovering oil from it; repair and modification of a liquid sulfur pipeline; modification of the sulfur plant to directly load liquid sulfur into special liquid sulfur trucks; analysis and repair sulfur plant incinerator problems; solving problem of high ammonia in waste water treatment plant; engineering modifications to sour water stripper and flare system; design and fabrication supervision of modular sulfur dioxide monitoring stations; sulfur dioxide plume simulation; upgrading engineering computing capability.

## ***Shell***

Process engineer for the Utilities on a \$15 billion tar sands to synthetic crude facility in Fort McMurray, Alberta. Designed crude and processed bitumen storage facilities and responsible for integration of the mining and processing facilities. Responsible for byproduct recovery and marketing, Designed unique liquid sulfur truck shuttle system to railhead in order to market sulfur for export in Vancouver. Evaluated INCO technology for sulfur dioxide recovery and use in production of ammonium sulfate fertilizer. Responsible for Environmental Impact Study portion of presentation to Alberta Energy Resource Conservation Board.

## **Semiconductor Chemicals**

### ***Advanced Silicon Materials Inc.***

Provided technology and on-site and off-site consulting services for a five-year R&D fluidized bed silicon deposition program at the Moses Lake facility. Provided the design for the fluidized bed and developed ancillary systems to resolve heat transfer, silicon granule removal and operating issues. Wrote two patents, US 5,798,137 and US 5,810,934 to protect this technology. Over the five years was responsible for a number of innovations and research programs:

A large-scale cold fluidization study using a 30 ft tall reactor and a carefully selected mixes of helium argon and nitrogen to provide simulation of the reactor at operating conditions. This study demonstrated in bed segregation of particles by particle diameter and produced polished granules from the original dusty granules supplied by Ethyl Corp

Small-scale hot fluidization using a 2" diameter reactor and silane. This demonstrated the feasibility and safety of using a quartz reactor for silane deposition

Automated Silicon removal systems were developed and tested, including online weighing and automated sealing of the containers.

A bead polishing system was set up and operated to produce shiny beads from Ethyl material for evaluation by Komatsu. The shiny beads were shown to drastically reduce the conditioning time needed prior to the start of crystal pulling when using the unpolished material.

A study was done to compare the use of lasers and arc lamp heaters for reactor heating. After considerable testing the laser option was selected and implemented using a second hand YAG laser.

Responsible for the overall process design of a \$5mm pilot plant.  
Responsible for the design and procurement of the major equipment for the pilot plant including the 30 ft long 4" diameter quartz reactors  
Designed and built a highly efficient prototype modular reactor heater  
Designed and implemented chlorine injection for heating and etching.  
Designed an online weigh scale to provide accurate measurement of the weight of the reactor and contents.  
Started up and operated the new reactor systems.  
Ran the first laser heated fluidized bed system.  
Produced low hydrogen beads directly from the reactor.  
Developed analytical techniques for hydrogen content in silicon.  
Supervised the operation of multiple runs  
Continually upgraded the reactor design to resolve issues and improve performance  
Successfully removed wall deposits prior to shutdown to provide multiple reuse of the reactor.  
Over the five years successfully managed the consulting and equipment budget to within 1% of the annual and project estimates.

### **BOC**

Designed, built and started up the worlds first ultra high purity hydrogen bromide gas purification facility for BOC. Developed new selective adsorption technology to remove water but not hydrogen bromide. The modular design of this facility was later duplicated to purify other gases. Used computer simulation of competing species to show that selective deposition of tungsten from tungstenhexafluoride, WF<sub>6</sub>, was not feasible. Developed solvent exchange to manufacture sensitive high boiling point low K materials by reduction of precursors.  
Studied alternate cylinder materials and evaluated competing passivation technologies for them.

### **Diamond Cubic**

Engineering support of a tribromosilane to silicon fluidized bed PDU facility These included; ongoing support of the commercial facility design by Stearns-Catalytic, simulation of the impurity formation in the TBS formation reactor; studies on impurity absorbent systems; distillation design for small scale quantities of TBS; particulate control for dopants, TEOS, TCA and STB; sales of products to other industries; alternatives to TEOS and writing the operating manual for the PDU

### **J.C. Schumacher( now a division of Air Products)**

In charge of the research into the fluidized bed production of silicon from tribromosilane. Responsible for lab and pilot plant operation, reactor design, PDU design and the process aspects of the commercial plant design. Succeeded in producing high quality shiny and round silicon granules in long (multi day) reactor runs. Developed novel and low cost, robust quartz reactor designs. Evaluated and tested silicon carbide and metal reactors. Developed bromine recovery technology and demonstrated high purity bromine on a lab scale. Developed several technologies to

remove impurities. Designed distillation system for high purity. Tripled TBS yield by correct application of catalytic technology. Researched more efficient crystal pullers and continuous crystal pulling technology.

### **Voltaix**

Consulted on germane cryogenic distillation and resolved issue by redesign of condenser and liquid redistributor. Responsible for on site research program into manufacture of disilane. Resolved disilane ammonia separation issues, modified the pilot plant and successfully produced disilane. Wrote patent application for new production technique.

## **Technology Development in House (For Licensing)**

### ***Improved Silicon Yield from Silicon Deposition Reactors***

This technology is fully described in US patent US 6,368,568 and provides a method for recovering the silicon feedstock, TCS/DCS or TBS/DBS, from the effluent of a silicon deposition reactor. This can be used to increase the output of an existing silicon plant significantly or reduce the cost of a new one. The technology also provides ways to avoid the formation of dangerous polymeric silicon halides in the effluent system. It is particularly valuable for conversion of an existing TCS facility using Siemens reactors to one using fluidized beds.

### ***Improved Heat transfer in Silicon Fluidized Beds***

This technology is fully described in US patent US 6,451,277 and provides several different ways to improve the heating of silicon fluidized bed deposition reactors. The key claims are the separate heating and injection of the silicon feedstock and the diluent and the removal and reheating of silicon granules. Both techniques can be used in a single reactor and provide a means to raise the temperature of the reactor and increase the scale of the reactor.

### ***Advanced Fluidized Bed Silicon Deposition System***

This technology is fully described in US patent US 6,827,786 and describes ways in which the technologies of the previous two patents can be combined with other technologies to form an efficient deposition system. Examples are given for the application to different feedstocks. One key innovation is the use of multiple feedstock and diluent injection stages using a water-cooled injector. A quartz model of this reactor has been tested both cold and hot for a couple of years using a variety of simulants to realistically test the problems of agglomeration and wall deposits seen in the actual operation of a fluidized bed deposition reactor. Several modifications have been made to improve operations that are currently confidential.

### ***Safer handling of Germane & other hydride gas US application, # 10/633462,***

The benefits of the technology are in safely handling 100% concentrations of germane and other unstable hydrides both in purification and shipping. The technology relies on using a solid diluent, which prevents runaway decomposition by removing the heat from any initial decomposition zone.

The solid diluent occupies much less volume than a gaseous diluent and thus permits a drastic increase in capacity. Currently germane is restricted to a 20% concentration in hydrogen, thus a 100% cylinder would have 5 times the capacity. Other benefits ensue in the purification systems. Several methods are provided for appropriate design of the system for any given hydride. Successful testing has been carried out using a propane air mix as a simulant. Without the solid diluent the mixture exploded when ignited with a spark, with the diluent it did not.

### ***A Set of Processes for Removing Impurities from A Silicon Production Facility US Application 11/193734***

The benefits of these processes are in lowering the cost and increasing the production and purity of solar or electronic grade silicon. The processes can be used independently or in combination and in new plants or retrofits. A set of three low cost processes for removing boron, phosphorus, carbon and metal impurities from metallurgical grade silicon during the process of making electronic grade silicon. One process removes boron by using one or more high temperature solids removal devices to remove solid titanium diboride from a halosilane reactor effluent stream where the high temperature is preferably greater than 150 C, more preferably greater than 200 C and most preferably greater than 300 C. A second process removes carbon as methane and phosphorus as phosphine by means of a membrane separator which processes all or part of a hydrogen recycle stream to recover hydrogen while rejecting methane and phosphine. A third process concentrates then oxidizes a high boiling halosilane stream containing a high fraction of metal halides to silicon, carbon and metal oxides with recovery of all or part of the elemental halogen produced in the reaction. Implementations specific to chlorosilanes and bromsilanes are provided where needed.

### ***Experimental Study of Fluidized Beds with Sticky Beads***

Technology has been developed to safely experiment with both hot and cold fluidization of simulants of sticky materials. Such materials include silicon granules, low-grade coal, biomass and polymers such as polyethylene. Use of these techniques provides a cost effective way to evaluate problems and test solutions in a low cost safe and expeditious manner.

### ***Thermal Energy Storage Panels***

The storage of low-grade heat for diurnal temperature stabilization has been simulated and design has been completed on various panel designs. A system of temperature tunable waxes has been identified and tested which change phase at or near room temperature. 90% energy reductions can be accomplished relative to air conditioning for most areas with 20-30 deg F day night temperature shifts. A typical office can be completely independent of air conditioning and heating in conditions typical of Sacramento because the system can utilize the waste heat from office equipment in the winter. Experiments to reduce the panel cost and evaluate other storage materials are ongoing.

### ***Improved Solar Collectors***

An improved thermal solar collector for hot water is under development. The goal is a low cost collector with advanced dual glazing to provide heat retention capability without losing collection efficiency. Markets include solar heating of hot tubs, domestic hot water and home heating.

## **Waste Treatment/Reduction**

### ***Alcoa***

Process analysis of a production line for ceramic chip packages to reduce per package solvent emissions so production could be increased. Safely reduced the effluent flow rates from the greenline spray booths thus reducing the capital and operating cost of a catalytic fume incinerator. Designed, obtained bids, APCD permits and supervised installation and startup of incinerators. Modeled problems with pressure oscillations in a tape caster and provided innovative solutions. Evaluated problems with a regenerative incinerator on site and discovered emissions were due to incomplete combustion during bed cycling. Evaluated ways to improve throughput and reduce solvent loss. Reduced solvent use by factor of 3 by reusing solvent from previous washes of the ball mill grinder. Studied options for further solvent recovery.

### ***Agnew Lake***

Designed process to recover and reuse aqueous ammonia from the tailings of uranium yellowcake production facility by using the lime neutralization and ammonia stripping. Designed and supervised startup of process.

### ***Atomic Energy of Canada***

Designed system for recovery of heavy water from spent ion exchange resin.

### ***Brunswick BioTechnetics***

Designed waste treatment for the wastewater from the biological reactors

### ***Cameron-Yakima***

Designed and supervised construction of new fume incinerator for multiple hearth furnace, which reused the old burners and controls but had higher efficiency. Improved the throughput of the rotary kiln and removed a safety hazard from the leaking fumes by modifying the afterburner and installing a draft inducer. Developed plans for site development of the whole activated carbon facility including a steam recovery system, carbon dust recovery cyclones and an acid gas scrubber. Designed and built an automated wastewater transfers system using a small PLC.

### ***Commonwealth Edison of Chicago***

Responsible for process design of retention ponds and wastewater treatment to remove oil and coal dust for 5 sites of the Power company. Involved on site visit to evaluate site topography and locate retention ponds and to collect samples of run-off.

### ***Diamond Cubic***

Responsible for design of bromine and HBr scrubbing systems.

### ***Custom Engineered Materials Inc***

Designed prototype carbon adsorption system to remove photo resist vapors and use of the heat value of the solvents to regenerate the carbon beds. Design included detailed design of fume incinerator to meet APCD requirements.

### ***Landry Service Co***

Studied means of drying the sludge from the centrifuges in use at a the Chevron refinery for crude oil tank cleanup. The existing screw dryer was evaluated and found to be undersized. A testing program was established to determine the actual design capacity when producing 50% sludge and then expansion plans were implemented to meet the desired throughput.

### ***Schumacher Technology***

Researched literature and developed predictive techniques for unique co current jet system used to educt reactive vapors into scrubbing systems. Developed and tested similar device for educting reactive vapors into a cyclone and removing the solids formed.