Member Profile: Plasma Technology Systems

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The Bay Area is renowned for the semi-conductor industry and biotechnology. The history of biotech and genetic engineering in the Bay Area dates back 30 years. According to BayBio's 2005 report, more than one-third of all domestic public biotech companies are located in Northern California investing close to $4 billion/year in research. Some say the life sciences were born in the Bay Area. The area is rich in innovation with support from R&D and incubator companies as well as top life science companies and renowned universities.

Our history begins in 1983 in the founding, by Stephen Kaplan, of Plasma Science, Inc. With experience developing primary plasma systems and background in polymer chemistry, Mr. Kaplan saw a niche in exploring the use of plasma for surface modification of plastics in the life science, aerospace and non-semiconductor electronic devices industries. The mission was to provide tools to allow the engineer or scientist to choose a material based on the bulk properties to satisfy the mechanical or optical requirements, and then plasma modify the surface for the surface chemistry requirements. Plasma Science was the first and possibly the only manufacturer of plasma equipment to focus exclusively on the plastics and allied industries.

Marketing to the life science industry started on "Day 1," according to Mr. Kaplan. "Dr. Om Kolluri devoted fifty percent of marketing efforts to that industry." With the growing adaptations of polymers (versus glass) for bioscience laboratory glassware much of the early Bay Area work consisted of modification of plastic roller culture bottles (to ensure that the cultures attached to the walls of the bottles), plastic Petri dishes, titer plates and centrifuge tubes. Plastics such as polypropylene and polycarbonates were modified to mimic the wetting properties of the glass counterparts. Soon thereafter the applications became more sophisticated–such as altering polymers for use in gel permeation chromatography tools and for DNA replication.

In addition to the life sciences industry, plasma is used for aerospace applications. The first Plasma Science purchase order was written by Dupont for the manufacture of small batch (PS0500) and continuous fiber modification (PS1010) plasma systems for use in the development of advanced composite systems. At Plasma Science these systems were used for projects to include the modification of military connectors and Spectra™ (UHMWPE) for Allied Signal. The modification of the connectors involved an activation process to enhance adhesive bonding of molded silicone rubber gaskets. It was one of the first commercial uses of plasma outside the semi-conductor industry.

The PS0500 plasma treatment system

Fiber treatment continues to the present day for the life sciences industry with modification of UHMWPE for dental applications, polypropylene for suture materials, and various polymer tubing for adhesion enhancement prior to bonding, overmolding and printing.

Another early application (1985) that is still in use today is the activation of Delrin™ for adhesion to polyurethane RIM (Reaction Injection Molding) foams for prosthetics by TruLife formerly known as Seattle Foot. Delrin is used as the mechanical reactive element to thrust the foot forward when weight is shifted. The RIM is a dense foam molded in-place to provide the flesh an aesthetically pleasing, lifelike appearance. Without plasma treatment the RIM would not adhere.

Photo of prosthetic with plasma modified materials courtesy of TruLife

Processes became more sophisticated with applications for plasma enhanced chemical vapor deposition (PECVD) of thin film coatings onto intraocular and contact lenses, to reduce protein adsorption, and development of coatings for blood oxygenation tools. Continuous profile hollow polypropylene tubes were coated via PECVD providing an ultra thin sheath to decrease porosity for controlled oxygen permeation as well as aid in hemophilicity.

With the purchase of Plasma Science by Himont in 1989, focus shifted to the manufacture of large volume reaction chambers for the automotive industries. There was a growing concern in finding environmentally-friendly technologies for primerless adhesion for polyolefins. In addition to the automotive applications, these large systems are used today for treatment of device tubing, large sheets of sintered porous polyethylene media and panels for medi-

Plasmatech Continued on Page 16

Plasmatech Continued From Page 15

cal device equipment. Materials processed for the aerospace community include inflexible Kapton™ assemblies, fluoropolymers and composite honeycombs to enhance adhesion.

The "60 inch web treater" was developed for modification of rolled goods to include wovens, non-wovens, films, foils and membranes. This system allows for extremely cost effective functionalization of films (such as cyclic olefin copolymers and polystyrene) for immunoassay/microfluidic devices and customized modification of membranes and wovens for filtration/separation chemistries. Work continues today for activating Spectra™, Zylon™ and Kevlar™ for the aerospace and defense industries.

Airco/BOC Coating Technology (BOCCT) purchased Plasma Science from Himont in 1994 to create a separate technology center to complement BOCCT's involvement in QLF® (silicon oxide barrier) coatings. PECVD coatings were developed for scratch resistance on ophthalmologic products (as well as automotive glass).

The TC04 system loaded with a tray of pipette tips

BOCCT's focus, however, was on equipment manufacturing and the customer's interest in process development was not being met. Therefore Mr. Kaplan opened 4th State, Inc. in 1996 to offer Plasma Science equipment owners consulting resources and a lab for research and development projects. The lab has grown to offer customers R&D and contract services in equipment ranging from small batch to 60 inch rolled goods. One of the primary applications at 4th State is activation of fluoropolymer films for adhesion to acrylate and silicone pressure sensitive adhesives (PSAs) for civil engineering projects locally and throughout the U.S.

The story continues with the purchase of Plasma Science's service and support business by Plasma Technology Systems, LLC (PTS). PTS's initial focus was supporting existing equipment owners and renters with spare parts, routine maintenance and calibration services. Since 1999 the services have grown considerably–now offering R&D, training classes and workshops, system upgrades, custom equipment design and development of tools for high temperature monomer delivery. PTS also has alliances with companies offering atmospheric and corona processing services, allowing the team to suggest the most appropriate technology for the application.

Recent Bay Area applications at the PTS lab include modification of silicones, nylons and Pebax® to change surface properties either for adhesion or lubricity and activation of metal stents for subsequent drug loading. Considerable work in the area is conducted for modification of microfluidic tools. Application examples include PECVD polystyrene coatings or creating specific amine functional sites. Additional work of interest is in activation of and even removal of Parylene™ and the deposition of hydrogel-like films.

PTS and 4th State have strong relationships with Stanford and Berkeley (and affiliated research labs) as well as many other academic institutions throughout the U.S. and the world. Students are welcome to work in the labs at a discounted fee.

Continuing work with UCSF/Berkeley bioengineering group includes PEGylation of UHMWPE implants for reducing wear and as presented at the 2005 BioInterface meeting, successful introduction of mercaptosilanes for functionalizing devices for the Stanford Genome Technology Center.

With the strong R&D and incubator environment in the Bay Area, we find continual excitement in being privy to developments in the life science industry. And thanks to involvement in the Surfaces for Biomaterials Foundation, PTS is able to generate contacts with other technologists who share with us their successes and challenges in the industry. This networking greatly aids us in understanding different surface modification requirements, which allows us resources to solve complex customer issues often involving multiple surface modification methods. In addition, understanding other companies' surface modification technologies is critical in ensuring our customers' success using our technology.

To conclude, over the past 25 years and through a few different sets of company eyes, we see that plasma's use has grown from a lab curiosity or simply a wetting tool to a sophisticated method for complete surface re-engineering. Many medical device companies have the equipment in house or are using resources through vendors such as PTS and 4th State.

Plasma processing in the Bay Area has become a critical tool for providing functionality for attaching a myriad of biological coatings; providing tailored nano-scale coatings for chemical resistance and lubricity; continued importance in modification of materials for genomics research; and growing modification of point-of-care diagnostic devices. We anticipate that plasma surface modification will become as important a tool to the biosciences as it has become synonymous to the manufacture of semiconductor devices.