

YES's Surface Modification Solutions for the Medical Device Industry

Industry Application Drivers

There is a growing need to ensure uniform, consistent surface preparation and coating of implanted and inserted medical devices. Novel coating materials are being developed with desirable properties including improved adhesion and durability, enhanced osseointegration, low thrombogenic potential and better anti-microbial activity. Similarly, the choice of manufacturing technology to prepare these surfaces (clean, texture), and to apply and cure coatings is critical to ensure uniform thickness and performance within and between devices.

Typical Process and Application Needs

Process Schematic



Application Needs

- Device materials including metals (e.g. Ti, Co-Cr) and polymers (e.g. UHMWPE, PEEK) must be properly cleaned, prepared and textured (at micro and/or macro scale) to promote strong adhesion of a broad range of coatings
- Monolayer surface coatings are essential in many applications to achieve highly-controllable thin films with minimal use of coating materials. Such coatings may serve to modify surface hydrophobicity or may be used as the basis of attachment of additional coating layers to achieve more complex multi-layer coatings or for attachment of biomolecules such as bio-active peptides.
- Conformal monolayer coating applications e.g. for hydroxyapatite (HA) maintain optimal crystallinity through tight thermal control

Industry Parallels

YES (Yield Engineering Systems) has successfully deployed our VertaCure, EcoClean, and EcoCoat systems and associated technologies to provide highly efficient solutions for customers in the genomics and biotechnology sectors, leading research institutions, and industry's top technology incubators. Applications include manufacture of DNA and protein micro-arrays and microfluidic devices, which require modification of surface hydrophobicity and uniform and stable attachment of functional biomolecules. Next-generation sequencing instrumentation relies on precision-manufactured flow cells, containing millions of microscale locations which serve as the points of parallel sequencing of DNA. Such flow cells must be precision coated to enable stable localization of DNA primers or must enable precision positioning of nanopore structures

proximal to biosensors. YES's genomics industry customers have successfully applied our plasma-based surface cleaning and chemical vapor deposition (CVD)-driven surface coating technologies to high volume sequencing flow cell manufacture under rigorous quality standards. YES instruments and associated process profiles combine to enable high-quality device surface modification while minimizing the cost of coating chemistry to deliver outstanding device performance.

YES Products

YES engineers are expert in controlled surface modification, providing effective manufacturing solutions for several end markets including the fabrication of silicon microprocessors, genomic sequencing and microfluidic flow cell devices, medical devices and biosensors, and other advanced surface coating applications. YES's solutions provide unique capabilities to modify surfaces at micro- and nano-scale and offer low cost of ownership, low footprint and improved environmental impact compared to other coating technologies. Scalable solutions are available such that processes may be seamlessly transferred from benchtop devices to larger capacity units and automated loading-enabled units for high volume manufacturing (HVM) situations.

EcoCoat Systems: for Chemical Vapor Phase deposition with excellent repeatability and precision.

- Precise temperature control (< 1% variability) achieves thermal uniformity throughout the chamber, coating flask and vapor lines. This results in up to a 2x improvement in contact angle uniformity
- Coatings are deposited in vacuum under laminar flow resulting in milder operating conditions, lower generation of contaminating particles and improved surface properties (low stress, low warpage and low outgassing)
- Proprietary technology controls the amount and speed of liquid injection which together with temperature control and vacuum result in a high quality adhesion of the coated monolayer
- The YES process is approximately 3x faster than that of competitive products at a cost of ownership 2x lower than competition
- YES has experience depositing over 100 precursors including alkyl, amino, epoxy, and fluorinated-silane derivatives

EcoClean System: automated plasma strip / descum solution system through gentle molecular level cleaning.

- Patented ICP plasma source and distribution unit produces a high-density plasma closely coupled to the substrate. Proprietary water-cooling technology results in gentle cleaning and improved consistency delivering 2x the strip rate with no defects/damage (10 $\mu\text{m}/\text{min}$ with control down to 100 $\text{\AA}/\text{min}$)
- Proprietary design has only 3 moving parts resulting in high reliability (>95% uptime) and lower maintenance requirements. Footprint is ~50% of comparable products
- Very flexible system proven with controlled oxygen, hydrogen and fluorine species

VertaCure Curing System: vacuum-based low temperature polymer curing

- Proprietary pump and purge cycles along with double o-ring ensures low oxygen background held below 10 ppm. Proprietary design operates with active heating and cooling for variable ramp-up and ramp-down
- Up to 50% improvement in cycle time, 2x improvement in temperature uniformity, and low stress & outgassing compared to other methods

How Can YES Assist You?

YES is applying its clean, coat and cure technologies to medical device products including implants and elastomers, silicones and polyurethanes. Our EcoClean, EcoCoat and VertaCure solutions provide the following features to address key customer needs:

Cleaning and Nano Texturing

- Plasma etched nano-texturing is combined with the cleaning process for process efficiency and repeatable nano-patterning through the control of vacuum, laminar flow and temperature

Coating and Curing

- Improved adhesion of monolayer coatings
 - The vacuum bake/vapor prime system dramatically improves the application of surface priming coatings
 - Complete dehydration under vacuum followed by vapor deposition coating improves adhesion and results in superior films
 - The dry plasma process in an H₂-N₂ atmosphere can efficiently and rapidly remove TiO₂ layer and can be used to modify the Ti surface with a phosphorus treatment
- Conformal monolayer coating: nozzle design and laminar operation allow for consistent reproducible conformal coatings
- Improved monolayer coating quality and consistency with low particle contamination and surface imperfections
- VertaCure's proprietary temperature control affords exquisite control of HA crystallinity
- For PEEK, magnesium and chromium materials, the VertaCoat can easily be adapted to a vacuum plasma spray (VPS) process.

These attributes are achievable with lower cost of ownership, higher reproducibility and shorter cycle times than with traditional equipment.

About Yield Engineering

Yield Engineering Systems (YES) was founded over 30 years ago by seasoned Silicon Valley technologist and entrepreneur Bill Moffat. The company has had a "customer first" mindset from its founding days, engaging with customers via several models to provide tailored solutions for their unique requirements, from equipment sale to a service model for application development. The company's innovative products have provided solutions to customers ranging from Fortune 100 companies to seed-stage start-ups in North America, Europe and Asia.

Headquartered in Silicon Valley, YES is backed by KCK Group, one of the medical sector's leading investment firms. YES engineers are experts in controlled surface modification enabling several end markets: fabrication of silicon microprocessors, advanced packaging, (bio)MEMS, genomics, microfluidics, medical devices, and advanced technologies.

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