Our goal is to empower our customers through access to the unique deposition capabilities of the DVD process.

Harry Burns, CEO & President

Coating technology for the future!

Our objective
Directed Vapor Technologies International, Inc. (DVTI) uses the unique properties of Directed Vapor Deposition to create customized coatings solutions, thus, enabling our customers to extend the potential of their core technologies.

Our vision
To realize the potential of directed vapor deposition to usher in a new generation of coatings and coating applications. The DVD technology has the capability to deposit thin and thick films having controlled compositions and architectures at high rate onto complex components. The results is a low cost processing approach for creating engineered surface coatings that are often difficult or impractical to produce with conventional techniques.
DVTI’s state of the art 3rd generation DVD coater

The DVD III is a production capable coater whose vacuum chamber measures 3ft x 3ft x 6ft, with the potential to easily coat complex objects up to 15in x 15in x 15in. Specialty objects such as pipes exceeding 15 in. can be accommodated with adjustments. DVD III is intended to evaluate production techniques and prove customer specific concepts. The source material is melted in three 1” diameter actively cooled copper crucibles by the continuous mode 60KW electron gun capable of multisource beam scanning, other melt pool designs are available with a minor reconfiguration. The high operating voltage of 75KV allows the beam to work at high chamber pressures, further increasing the available deposition parameter space. The fully computer controlled operation allows for repeatable deposition campaigns and a low cost per run.
Core Competencies

DVTI provides coating development services to its customers and transitions the developed coatings to a production environment through direct application, continued partnership or licensing.

DVTI’s core competency is in the development of next generation coating technologies based on the proprietary Directed Vapor Deposition (DVD) approach. This revolutionary technology originates in research conducted at the University of Virginia, and has the capability to deposit thin and thick films at high rate onto complex components (including those having non-line-of-sight regions). Through a licensing agreement with the University of Virginia Patent Foundation, DVTI holds an exclusive worldwide license to this technology.

DVTI is developing processes for several companies to improve coatings for their specific applications through the use of its new manufacturing facility at 4006 Hunterstand Court near the Charlottesville airport. Here DVTI operates its own production scale DVD coating system, in addition to the two additional DVD coaters.

EB-DVD is an advanced approach for vapor depositing high quality coatings. It provides the technical basis for a flexible, high quality coating process capable of atomistically depositing dense or porous, compositionally controlled coatings onto line-of-sight and non line-of-sight (NLOS) regions of complex components and parts. Unlike other Physical Vapor Deposition (PVD) approaches, DVD is specifically designed to enable the transport of vapor atoms from a source to a substrate during highly controlled conditions. To achieve this, DVD technology utilizes a trans-sonic gas jet to direct and transport a thermally evaporated vapor cloud onto a component. Typical operating pressures are in the 1 to 50 Pa range requiring fairly simple mechanical pumping to be used resulting in short (several minutes) chamber pump-down times. In this pressure processing regime, collisions between the vapor atoms and the gas jet creates an ideal mechanism for controlling the vapor transport. These transport conditions enables several unique capabilities:
1) **High rate deposition:** Vapor phase collisions between the gas jet and vapor atoms allow the flux to be “directed” onto a substrate. Since a high fraction of the evaporated flux impacts the substrate (i.e. the materials utilization efficiency is increased) instead of undesired locations (such as the walls of the vacuum chamber) a very high deposition rate (> 10 µm min⁻¹) can easily be obtained.

2) **Non Line-of-Sight Deposition:** The gas jet can be used to carry vapor atoms into internal regions of components and then scatter them onto the internal surfaces to result in NLOS deposition with similar properties as the line-of-sight areas. This effect is due to the relative high pressure of the inert carrier gas and the high number of collision as compared to other vacuum deposition technologies.

3) **Controlled intermixing during multiple source evaporation:** The use of high frequency e-beam scanning (100 kHz) allows multiple source rods to be simultaneously evaporated. By using binary collisions with the gas jet atoms, the vapor fluxes are intermixed allowing the composition of the vapor flux (and thus, the coating) to be uniquely controlled. This allows alloys with precise compositional control to be created even when large vapor pressure differences exist between the constituents. It also enables complex, multilayered coatings to be deposited in a single step.

DVTI has added further versatility to the DVD process by incorporating hollow cathode plasma activation. This capability can be used to improve the density of DVD layers as required. Plasma activation enables a large percentage of all gas and vapor species to be ionized and thus, accelerated towards the coating surface by an applied electrical potential, increasing their velocity (and thus the kinetic energy) allowing the coating density to be increased by an increased “atomic peening” process. These characteristics combine to make the DVD process a useful tool for the development of coating as diverse as novel thermal barrier coatings and as a next generation deposition approach for corrosion protection coatings.
Application Areas

DV
ti provides both development as well as coating services for the DVD technology.

Thermal barrier coatings
DVTI has extensive expertise in developing unique solutions to Thermal Barrier Coating (TBC) needs. Some of the DVD solutions include tailored top coats and bond coats with improved wear, erosion, molten sand and temperature resistance, and compatibility with new and future generations of superalloys. The improvements in TBCs can be immediately translated into either a reduction in fuel consumption or as a gain in engine thrust.

Oxidation and Hot Corrosion Resistant Coatings
DVTI has developed coatings with significantly reduced thermally grown oxide growth rates, limited rumpling and good high temperature properties. These coatings show excellent hot corrosion resistance and a reduction in the Pt level required in the layer, when compared to conventional coatings.
Hard Chrome and Cadmium replacement
DVTI has developed new protective coatings for hard chrome and cadmium replacement. The unique capability of the DVD process enables DVTI to coat demanding applications such as landing gears where interior regions need to be selectively coated with either a corrosion protective coating or a wear resistant coating. Thus, the DVD technology not only improves the wear and corrosion resistance, but is doing so with a more environmentally friendly technology.

Superconductivity
DVTI is pushing the envelope to coat tapes with seed materials in order to enable the production of superconducting cables with lengths on the order of kilometers. Here the high deposition rate and unique quality of the DVD coating process has the possibility to make the difference needed to bring this rapidly maturing technology to fruition.

Solid oxide fuel cells and batteries
In fuel cell and battery applications DVTI has the unique capability to deposit coatings at rates that enable the creation of both structural components, such as the containment and electrodes, as well as the solid electrolytes.
DVTI is currently using all three generations of DVD coaters.

The original DVD I, where the initial concept was developed, is still in use and is ideally suited for projects where the coating to be applied benefits from not being in line with the material flux from the melt pool.

DVD II has multiple capabilities with up to four melt pools and nozzle axis in-line with the source. It is a high deposition efficiency tool capable of high deposition rates, utilizing high pressure deposition and plasma activation for morphology control with multisource evaporation for composition control (high speed (100kHz) beam scanning).

DVD III is the flag ship coater, a production capable unit that measures 3’ x 3’ x 6’, with the potential to easily coat complex objects up to 15in x 15in x 15in. DVD III is intended to evaluate production techniques and prove customer specific concepts prior to full production. The electron gun is a 60KW unit capable of multisource beam scanning. The high operating voltage of 75KV allows the beam to work at even high chamber pressures, further increasing the available deposition parameter space. The fully computer controlled operation allows for repeatable deposition campaigns and a low cost per run.
Facilities

DVTI has state of the art support facilities housed in the new production building in order to follow up with quality control and to continue to develop application-specific coatings.

The sample preparation laboratory.

Profilometry for surface quality assurance.

Large sample preparation area.

Heat pre-treatment oven.

Our latest addition is a cyclic oxidation furnace for life cycle testing.
DVTI has the in house capability to develop DVD hardware.

A wide range of core capability among the personnel has enabled us to develop, not only control systems based on the DeviceNet™ bus and LabView™ monitoring software for our latest deposition chamber, but also the complete control electronics system as well as all the mechanical solutions through the use of Solidworks™ CAD throughout the whole organization.

DVTI has the capability to adapt the DVD technology to fit new applications.

We modify hardware in our system to fit the needs of the applications.

The control software can be altered in house, over night, to fit changing production needs.

In short, we are capable to not only develop new process conditions to fit emerging needs, but also to tune the DVD systems to peak performance as the demands change with new projects.
Mr. Harry Burns, President & CEO
As President and Chief Executive Officer, Harry A. Burns, has over thirty years experience as a senior executive in industry. He has served as CEO of an international manufacturing company with revenues in excess of $500 million and is experienced with the start up of new technology spin-off companies and the commercialization of new technologies.

Dr. Derek D. Hass, Director Research and Development
Dr. Hass received a B.Sc. in Metallurgical Engineering from Michigan Technological University in 1993. A M.S. degree was received from the University of Virginia in 1996 and a Ph. D. degree in 2001. He is currently the Director of Research and Development at DVTI. His research interests include the application of the DVD technology to thermal barrier coatings onto turbine blades, coating for wear and corrosion, bonding layers for solid oxide fuel cells, thin film batteries, superconducting coatings and high temperature alignment layers of liquid crystal displays.

Dr. Erik Svedberg, Research Scientist
Dr. Svedberg was awarded a Ph.D. in materials science from Linköping University in Sweden during 1998 where after he was hired as a permanent research staff member with Seagate Research, working with advanced materials and coatings. During ~6 years at Seagate Erik developed combinatorial methodologies for thin film research as well as authoring more than 40 papers (for a total of 65 publications) and 2 patents related to research in the field of magnetic thin films and protective overcoats for disk drives. Recently Dr. Svedberg oversaw the development and installation of the first production scale DVD coater.
Our Customers

Come from both government user facilities and program offices and private industry:

**Private**

Major turbine engine OEMs and several other industry customers requiring coated parts.

**Government**

NAVAIR, AFOSR, ONR, ARL, NSF, DOE, DARPA, NAVSEA
Don’t forget to visit our web page!

www.directedvapor.com

Directed Vapor Technologies International, Inc.

Directed Vapor Technologies International (DVTI) develops physical vapor deposition technologies that enable advanced coating solutions. DVTI has exclusive, worldwide rights to use, license and manufacture a novel directed vapor deposition (DVD) coating approach. With this approach coatings can be applied significantly faster than with older methods, with a greater variety of materials, and with a much higher degree of control. DVD cuts the costs of the coating process, ensures high coating performance, and expands coating options dramatically.

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Contact information

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Front cover: The DVD I process
Photo, courtesy James Groves