

DIAMOND

THE HARDEST MATERIAL
FOR
HARSHEST REQUIREMENTS



DiaCCon GmbH

Dr.-Mack-Straße 81
D - 90762 Fürth

Tel.: (+49) 911 / 950918 - 36

Fax: (+49) 911 / 950918 - 16

email: info@diaccon.de

Internet: www.diaccon.de

Schlauchfüllen um 60°

gedreht gezeichnet

THESE **DIAMONDS** IS VERY PRETIOUS TO THEE AND OF GREAT HARDNESSE,
FOR THEY WILL GRAVE IN IRON OR STEELE, TAKING NO HARME.
IF A MAN WERRE IT, IT STRENGTHEN HIM AND KEPITH HIM FROM DREMING IN HIS SLEEP,
FROM FAINTNES AND FROM POYSON, FROM WROTH AND CHIDING.
IT SENDETH AND HELPETH MEN TO GREAT WORTH. IT DEFENDETH A MAN FROM HIS ENEMIES,
AND KEEPETH A MAN IN GOOD ESTATE WHEN HE FINDETH HIM;
IT COMFORTE A MAN WITT, AND SUPPORT HIM OF RITCHES.

ANGLO-NORMAN DOCUMENT, THE "SLOANE LAPIDARY", 13TH CENTURY

EXPLORE DIAMONDS TODAY'S APPLICATIONS...



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UNIQUE PROPERTIES...

HARDNESS

THE MOST WIDELY KNOWN PROPERTY OF DIAMOND IS DOUBTLESS IT'S INCREDIBLE HARDNESS OF 10000 HV. THERE EXISTS NO HARDER MATERIAL ON EARTH THAN DIAMOND.

TRIBOLOGICAL PROPERTIES

DIAMOND EXCELS IN A LOW COEFFICIENT OF FRICTION AND EXTREMELY LOW WEAR, EVEN UNDER DRY RUNNING CONDITIONS.

THERMAL CONDUCTIVITY

DIAMOND SHOWS THE HIGHEST THERMAL CONDUCTIVITY (2000 W/KM AT RT), FOUR TIMES HIGHER THAN COPPER.

ELECTROCHEMISTRY

DIAMOND COATED ELECTRODES MADE ELECTRIC CONDUCTIVE BY BORON DOPING SHOW OUTSTANDING QUALITIES AND MAKE SOME ELECTROCHEMICAL PROCESSES POSSIBLE AT ALL .



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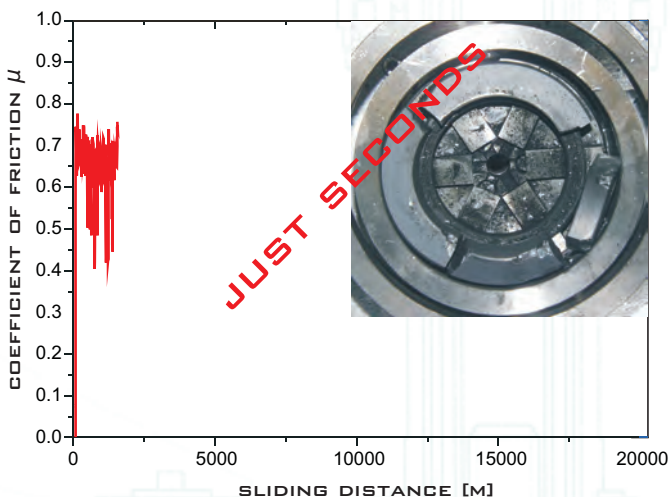
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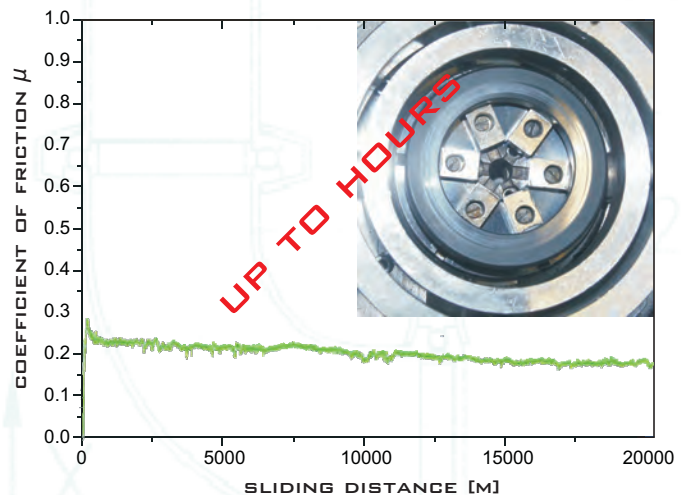
TRIBOLOGY

DRY RUNNING PRESENTS A MAJOR CHALLENGE FOR MODERN INDUSTRY. PUMPING, CONVEYOR AND MIXING EQUIPMENT IS PARTICULARLY AFFECTED. THE ISSUE IS FURTHER COMPLICATED SINCE THE EQUIPMENT SHOULD BE RESISTANT TO CHEMICAL ATTACK AS WELL. HARD COATINGS ARE WIDELY AVAILABLE FOR SUCH APPLICATIONS. HOWEVER, WEAR-FREE DRY RUNNING OVER A LONG PERIOD OF TIME HAS NOT BEEN REALISED YET. DIAMOND COATINGS MAKE DRY RUNNING POSSIBLE WITH EXCELLENT CHEMICAL INERTNESS, EXCELLENT EMERGENCY RUNNING QUALITIES AS WELL AS PREVENTION OF CONTAMINATION OF THE PRODUCT BY WEAR DEBRIS.

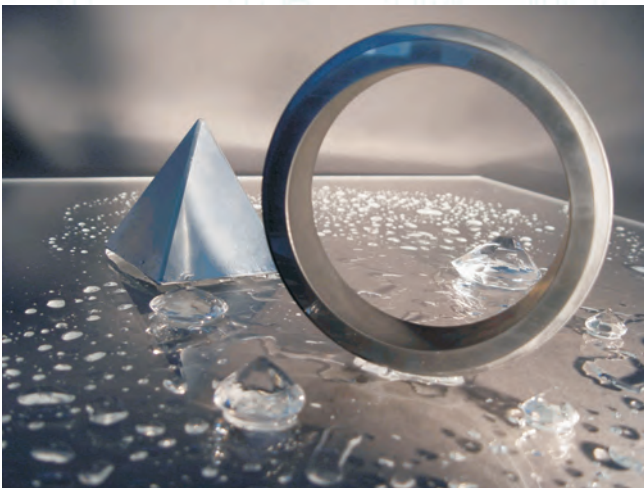
UNCOATED SIC IN DRY RUNNING FAST AND FATAL FAILURE



DIAMOND COATING IN DRY RUNNING JUST A POLISHED SURFACE



DIAMOND COATED SIC - SEALING FOR PUMPS



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TRIBOLOGY CONTINUED

FOR MOST PEOPLE DIAMOND HAS THE BIGGEST APPEAL AS A GEM ON A DÉCOLLETÉ OF A BEAUTIFUL WOMAN. BUT IF CRYSTALLINE DIAMOND IS COATED ONTO MECHANICAL SEALS OR BEARINGS AS A THIN COATING THE PERFORMANCE INCREASE IS A VERY AMAZING ISSUE AS WELL.

DIACCON OFFERS THE FULL POTENTIAL OF DIAMOND AS CVD COATING ONTO YOUR MECHANICAL SEALS AND BEARINGS. THE MAIN FOCUS IS THE COATING OF MECHANICAL SEALS MADE OF SILICONCARBIDE. UNFORTUNATELY CRYSTALLINE DIAMOND IS OFTEN CONFUSED WITH DLC. BUT THE PHYSICAL PROPERTIES ARE COMPLETELY DIFFERENT. DLC HAS A HARDNESS OF 3500 HV ONLY IN COMPARISON TO DIAMOND WITH 10000 HV. FURTHERMORE THE ADHESION OF DLC IS MUCH WEAKER THAN OF CRYSTALLINE DIAMOND BECAUSE OF THE LOWER COATING TEMPERATURE (250°C) WHICH PREVENTS STRONG BONDING. DIAMOND IS DEPOSITED AT TEMPERATURES OF 800°C WHICH RESULTS IN A STRONG CHEMICAL BONDING THAT IS NEEDED FOR HIGH TRIBOLOGICAL LOADS.

THE MOST EXTREME OPERATION CONDITION IS THE ABSOLUTE DRY RUNNING OF A MECHANICAL SEAL. IF A CONVENTIONAL UNCOATED MECHANICAL SEAL IS USED, THE WEAR AND FRICTION INCREASES VERY FAST, THE SEAL GETS HOT AND THE FACES AS WELL AS THE SECONDARY SEALING ELEMENTS ARE DESTROYED. THIS RESULTS IN LEAKAGE AND IN WORST CASE IN A COMPLETE BREAKDOWN OF THE SEALING SYSTEM. IF A DIAMOND COATED MECHANICAL SEAL IS USED IN SAME CONDITIONS THE FRICTION STAYS ON A LOW LEVEL WITH ALMOST NO WEAR. WITH SUCH DIAMOND COATED SEALS ONE CAN FACE ALSO CONDITIONS AS MIXED LUBRICATION AND ABRASION BY DEBRIS.

BECAUSE THESE ADVANTAGES ARE ACHIEVED BY A VERY THIN COATING ONLY NEITHER THE CONSTRUCTION NOR THE CONCEPTION MUST BE CHANGED.

TYPICAL MECHANICAL SEALS AND BEARINGS COATED WITH CRYSTALLINE DIAMOND



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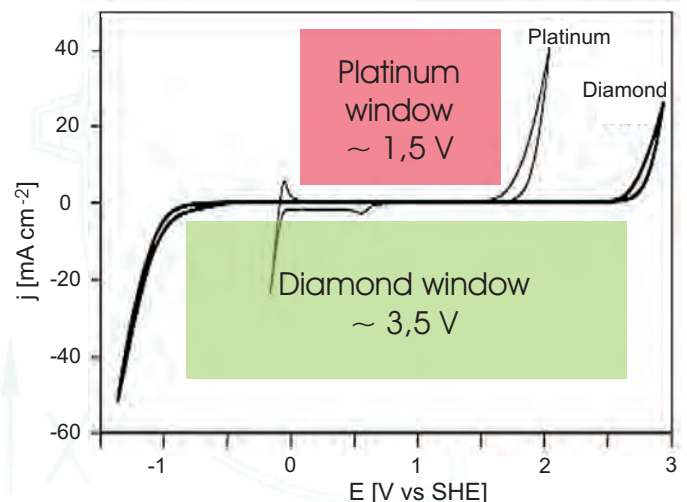
ELECTROCHEMISTRY

IN ELECTROCHEMISTRY ELECTRODES ARE WIDELY USED FOR SYNTHESIS AND DECOMPOSITION OF VARIOUS SUBSTANCES. THE BROADER THE ELECTROCHEMICAL WINDOW IS, THE MORE EFFICIENT IS THE ELECTRODE MATERIAL. A LARGE ELECTROCHEMICAL WINDOW SHOWS PLATINUM FOR EXAMPLE, BUT IT IS EXORBITANT EXPENSIVE. IN COMPARISON SHOW ELECTRODES WITH CRYSTALLINE DIAMOND A MUCH BROADER ELECTROCHEMICAL WINDOW. DIACCON OFFERS YOU THE EXCELLENT ELECTRODE MATERIAL DIAMOND ON DIFFERENT SUBSTRATES (NIOBIUM, TITANIUM, SILICON) AND WITH APPLICATION ADAPTED PROPERTIES. BECAUSE OF OUR DIFFERENT COATING SETUPS (HORIZONTAL AND VERTICAL COATING SETUP) WE ARE ABLE TO COAT VERY DIFFERENT GEOMETRIES (SHEETS, EXPANDED METALL, 3D STRUCTURES). FURTHERMORE A SPECIAL TECHNOLOGY ALLOWS US TO PRODUCE ELECTRODES IN ALMOST EVERY SIZE.

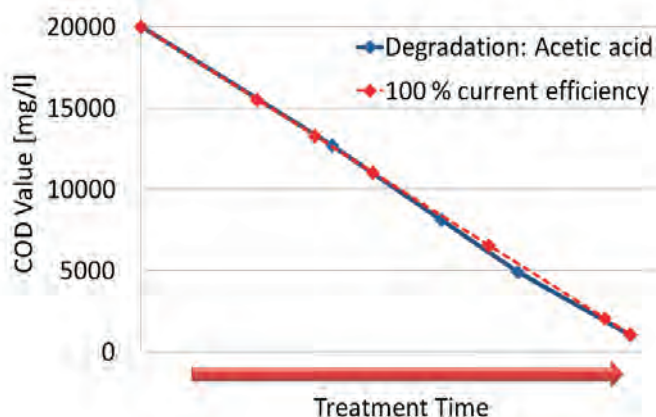
STANDARD DIAMOND COATED ELECTRODE (500MM X 150MM)



ELECTROCHEMICAL WINDOW OF PLATINUM AND DIAMOND



COD REMOVAL AT DIAMOND ELECTRODES NEAR 100% EFFICIENCY



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ELECTROCHEMISTRY CONTINUED

DIAMOND ELECTRODES FOR WASTE WATER TREATMENT

DUE TO THEIR HIGH OXYGEN EVOLUTION OVERPOTENTIAL IN AQUEOUS SOLUTIONS THE PRODUCTION OF STRONG OXIDANTS IS POSSIBLE WITHOUT THE ADDITION OF ANY CHEMICALS LIKE IN THE FENTON PROCESS. DUE TO THIS, THE WASTE WATER TREATMENT IS ENVIRONMENTALLY FRIENDLY AND EASILY SCALABLE BY ADJUSTING THE REQUIRED ELECTRIC POWER ONLY. DIAMOND ELECTRODES HAVE VERY GOOD CORROSION STABILITY IN AGGRESSIVE MEDIAS.

THE PRINCIPLE OF ELECTROCHEMICAL WASTE WATER TREATMENT

IF STANDARD WASTE WATER CLEANING TECHNIQUES ARE INSUFFICIENT THEN OXIDIZING TECHNOLOGIES ARE USED. SUCH OXIDATION MINERALIZES THE ORGANIC WASTE BY AGENTS LIKE OZON AND HYDROGEN PEROXIDE WHICH MUST BE ADDED TO THE WASTE WATER.

DIAMOND FEATURES IN COMPARISON TO OTHER ELECTRODE MATERIALS A VERY HIGH OVERPOTENTIAL FOR THE ELECTROLYSES OF WATER. AS A RESULT, DIAMOND CAN PRODUCE VERY STRONG OXIDIZING HYDROXYL RADICALS DIRECTLY IN WATER AT HIGH CURRENT EFFICIENCY. THE CURRENT DENSITY-POTENTIAL GRAPH OF DIAMOND IN COMPARISON TO PLATINUM IS SHOWN ON THE PREVIOUS PAGE. THESE RADICALS MINERALIZE DUE TO THEIR HIGH OXIDATION POTENTIAL OF 2,8 V ORGANIC WASTE TO CARBON DIOXIDE.

SO WASTE WATER CAN BE EFFECTIVELY CLEANED FROM GERMS, DYES, CYANIDES, OILS, HORMONE AND OTHER ORGANIC WASTE (SEE PICTURE BELOW). FURTHERMORE STRONG OXIDIZING AGENTS LIKE PEROXO COMPOUNDS CAN BE SYNTHESIZED ON DIAMOND ELECTRODES.



CLEANING OF HEAVILY POLLUTED WASTE WATER BY DIAMOND ELECTRODES AFTER DIFFERENT TREATMENT TIMES.



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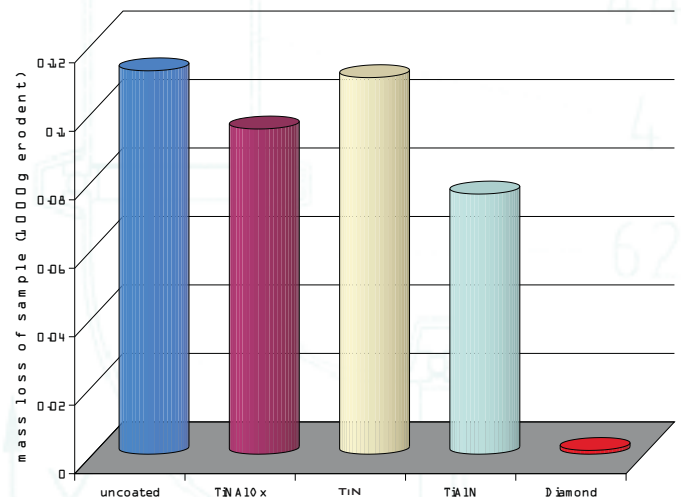
ABRASION

BESIDES THE WEAR BY TRIBOLOGICAL LOAD IS WEAR CAUSED BY ABRASION ANOTHER URGENT PROBLEM. EVERY APPLICATION DEALING WITH MIXING, PRESSING AND PUMPING OF SOLIDS OR SUSPENSIONS FIGHTS WITH THIS PROBLEM. EVEN IN A LUBRICATED TRIBOSYSTEM A THIRD PART, REPRESENTED BY SAND GRAINS OR SIMILAR, CAN CAUSE FATAL DAMAGE TO THE SLIDING SURFACES. LONG TIME STABILITY AND ALMOST NO LOSS OF SURFACE MATERIAL ARE THE DEMANDS THAT ARE MADE. CRYSTALLINE DIAMOND AS THE HARDEST KNOWN MATERIAL IS HIGH ABRASION RESISTANT AND CHEMICAL INERT IN ALMOST ALL ENVIRONMENTS.

GRIT BLASTING TEST WITH HIGH ABRASIVE SIC-POWDER



ABRASION RESISTANCE OF SEVERAL COATINGS ON TITANIUM



DIAMOND COATED INJECTION MOULDING NOZZLE



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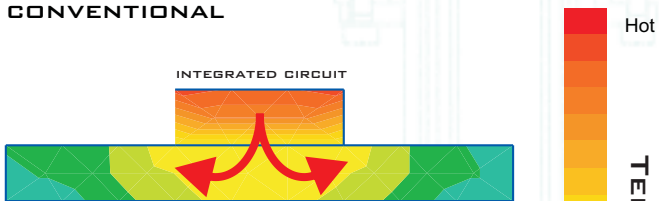
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THERMAL CONDUCTIVITY

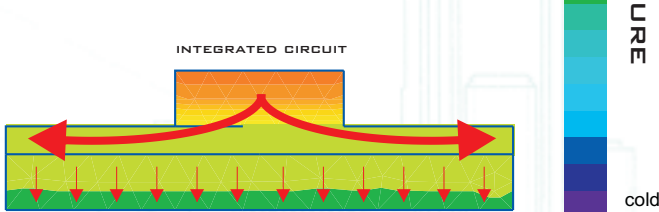
BESIDES THE HIGHEST HARDNESS OF ALL MATERIALS DIAMOND EXCELS ALSO IN THE HIGHEST THERMAL CONDUCTIVITY (AT RT). DIAMOND COATINGS SHOW ALREADY AT A SMALL LAYER THICKNESS A MUCH HIGHER THERMAL CONDUCTIVITY THAN COPPER AND ARE AT 150 μm AS GOOD AS NATURAL DIAMOND. THAT MAKES DIAMOND TO THE MOST PREFERRED MATERIAL IN APPLICATIONS WHICH ASK FOR HIGHEST HEAT TRANSFER. IN MODERN ELECTRICAL ENGINEERING, FOR EXAMPLE, DIAMOND COATED HEAT SPREADERS CAN MULTIPLY THE LIVE TIME OF HIGH INTEGRATED CIRCUITS BECAUSE OF BETTER COOLING.

HEAT SPREADING EFFECT ON ELECTRICAL DEVICES

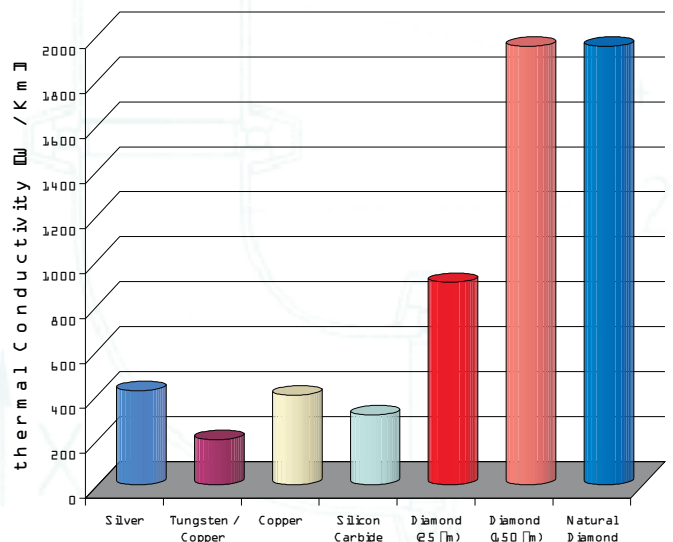
CONVENTIONAL



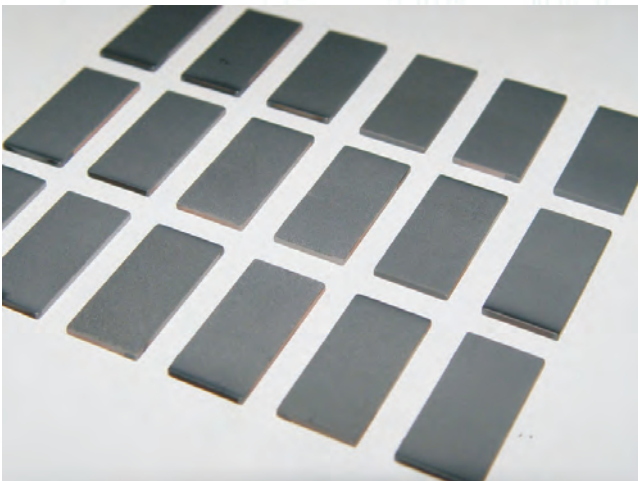
WITH DIAMOND COATING



THERMAL CONDUCTIVITY OF DIFFERENT MATERIALS



DIAMOND COATED HEAT SINK



DiaCCon GmbH

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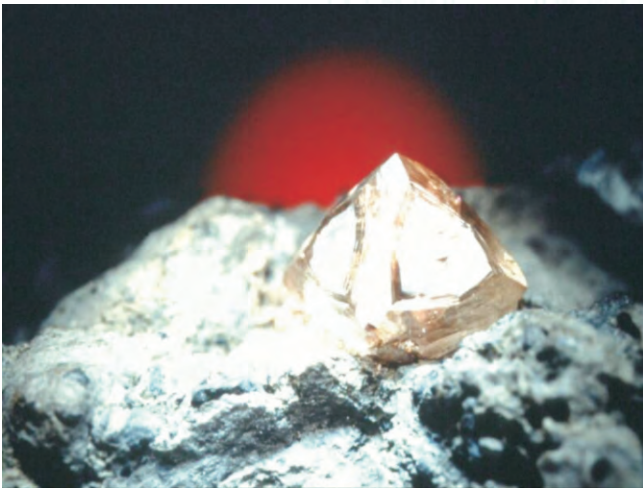
THE DIAMOND COATING

1.) NATURE CREATED DIAMOND WITH ITS UNIQUE PHYSICAL PROPERTIES, LIKE THE HIGHEST HARDNESS.

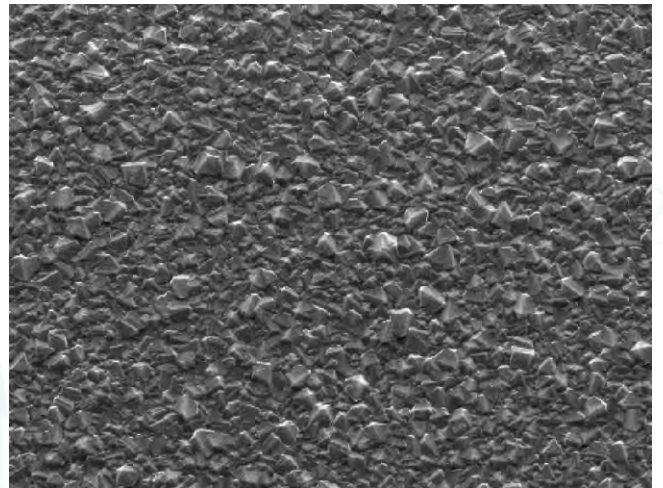
2.) DIAMOND SINGLE CRYSTALS CREATED BY DIACCON SHOW THE SAME OUTSTANDING PHYSICAL PROPERTIES LIKE NATURAL DIAMOND.

3.) A CRYSTALLINE DIAMOND COATING CREATED BY DIACCON CONSISTS OF COUNTLESS SMALL SINGLE CRYSTALS WHICH FORM A HOMOGENIOUS COATING ONTO THE SURFACE OF THE COMPONENT. ALL THESE SMALL DIAMOND CRYSTALS OFFER IN THEIR COLLECTIVITY AS A WELL ADHERENT COATING THE FULL POTENTIAL OF DIAMOND.

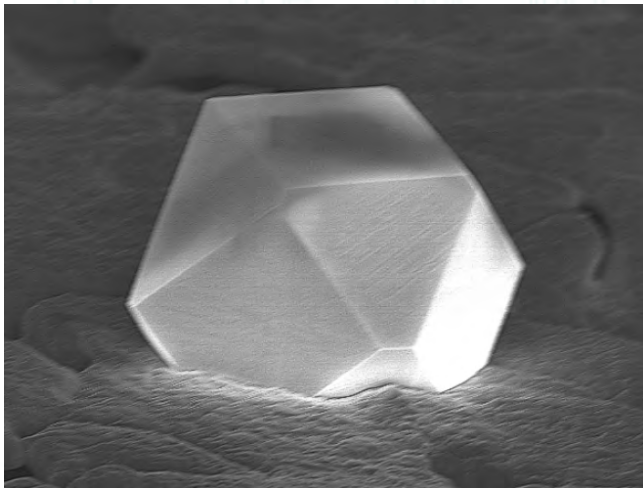
1.) A SINGLE DIAMOND CRYSTAL CREATED BY NATURE



3.) THE DIAMOND COATING CONSISTS OF COUNTLESS DIAMONDS



2.) A SINGLE CVD - DIAMOND CRYSTAL CREATED BY DIACCON



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Schlauchfüllen um 80°

gedreht gezeichnet

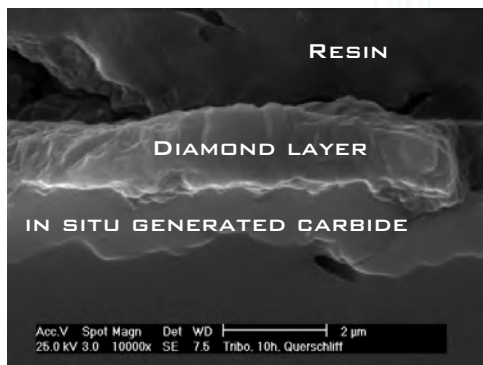
COATABLE MATERIALS

CRYSTALLINE DIAMOND CAN BE APPLIED ON MANY MATERIALS. FOR THIS, TWO MAIN GROUPS, METALS AND CERAMICS, ARE DISTINGUISHED.

METALS MUST HAVE A MELTING POINT ABOVE 700°C AND ARE BEST COATABLE IF THEY GENERATE IN SITU STABLE CARBIDES AT DEPOSITION TEMPERATURES. CARBIDES LEAD TO STRONG ADHESION OF THE DIAMOND LAYER CAUSED BY COVALENT BONDING. FOR YOUR APPLICATION LOOK AT OUR PERIODIC TABLE OF DIAMOND COATING.

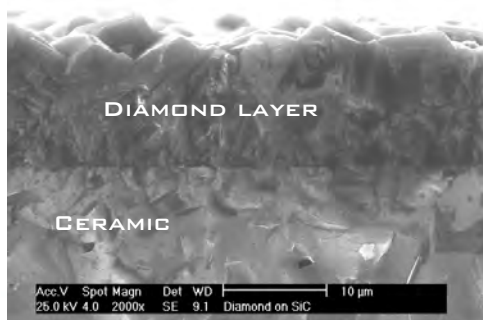
BEYOND **CERAMICS**, ESPECIALLY CARBIDES ARE VERY BEST COATABLE. SIMILAR TO THE CARBIDE GENERATING METALS THEY SHOW OUTSTANDING ADHESION OF THE DIAMOND COATING. DIAMOND COATED CERAMICS ARE THEREFORE THE FIRST CHOICE FOR HEAVY DUTY APPLICATIONS.

CROSSECTION OF A DIAMOND COATED METAL



	II											III	IV
Li	Be											B	C
Na	Mg											Al	Si
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb
	Ra	Ac											

CROSSECTION OF A DIAMOND COATED CERAMIC



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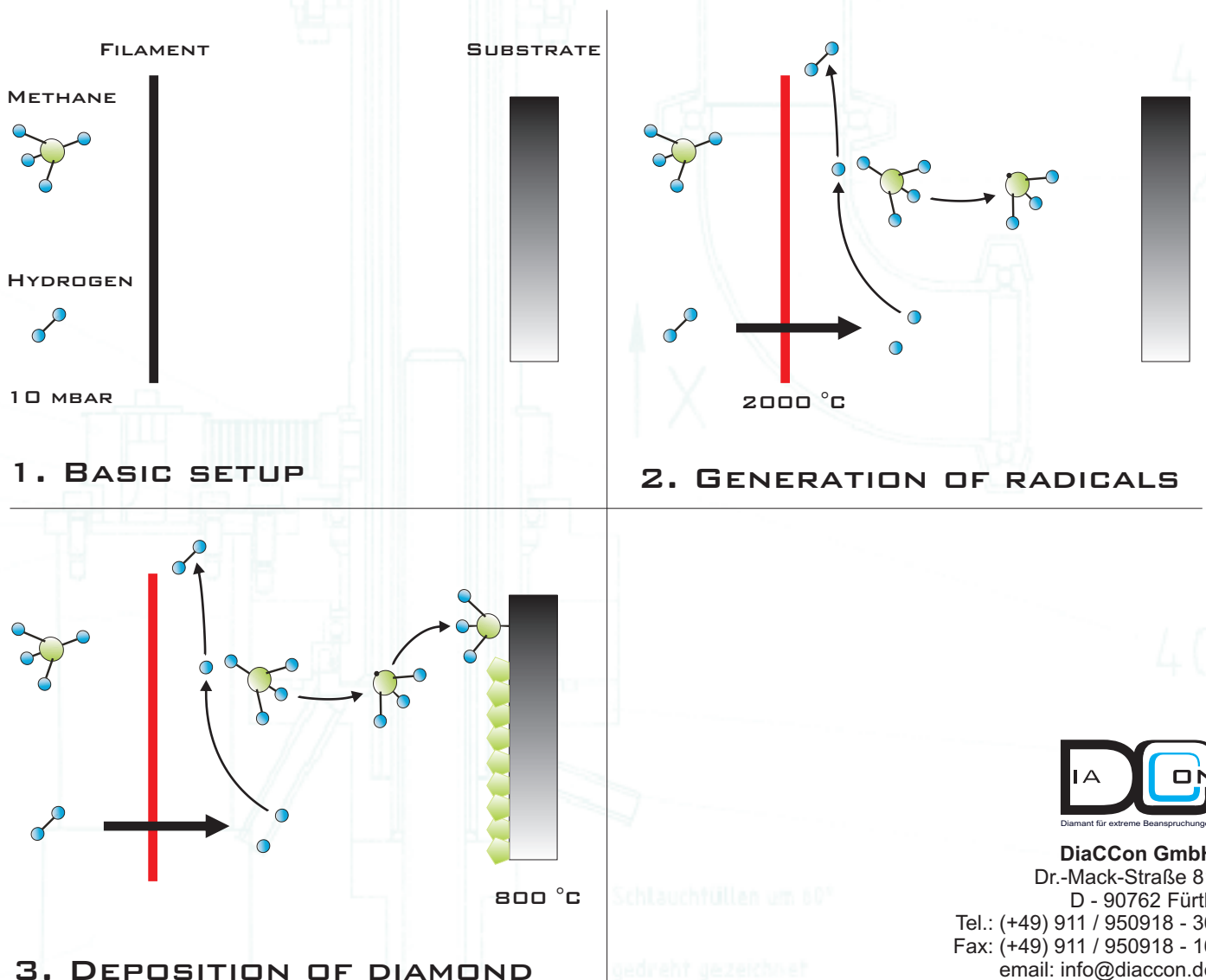
THE DEPOSITION PROCESS

DIACCON USE THE HOT FILAMENT - CVD - PROCESS. "CVD" STANDS FOR "CHEMICAL VAPOUR DEPOSITION". THE PROCESS CAN BE SPLIT INTO THREE STEPS:

STEP 1: THE BASIC SETUP CONSISTS OF THE REACTION CHAMBER, A FILAMENT AND THE PRETREATED SUBSTRATE. IN THE REACTION CHAMBER THE TWO GASES METHANE AND HYDROGEN ARE FEEDED RETAINING A PROCESS PRESSURE OF 10 MBAR.

STEP 2: THE FILAMENT IS ELECTRICALLY HEATED UP TO 2000 °C. THUS THE HYDROGEN IS SPLIT IN TWO HYDROGEN ATOMS. THE ATOMIC HYDROGEN REACTS WITH METHANE TO A HYDROGEN MOLECULE BY SPLITTING OFF A HYDROGEN ATOM FROM THE METHANE. A METHYL RADICAL IS GENERATED. THE CARBON OF THE RADICAL IS sp^3 CONFIGURED, AS DIAMOND ITSELF.

STEP 3: THE RADICAL ATTACHES TO THE SUBSTRATE'S SURFACE AND DIAMOND GROWS. THE SUBSTRATE'S TEMPERATURE IS ABOUT 800 °C. BUT NOT ALL THE RADICALS ARE BONDED AS DIAMOND, UNWANTED sp^2 CONFIGURED CARBON IS GENERATED IN SMALL AMOUNTS AS WELL. HOWEVER, THIS CARBON IS ETCHED AWAY BY THE ATOMIC HYDROGEN AND PURE DIAMOND GROWTH RESULTS.



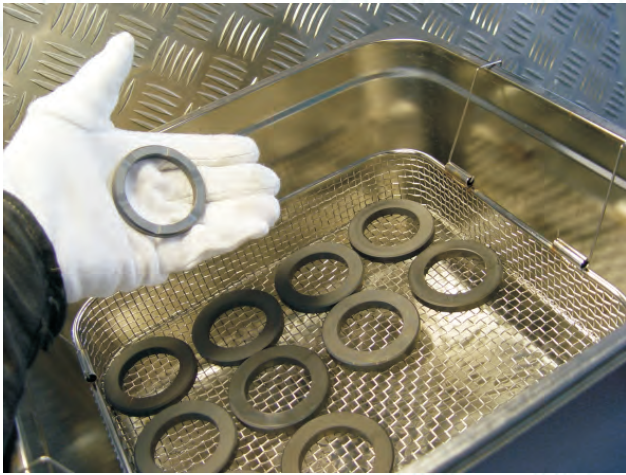
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DIACCON

WE MAKE CRYSTALLINE DIAMOND

FOR EIGHT YEARS THE TEAM OF DIACCON IS INVOLVED IN RESEARCH AND DEVELOPMENT OF DIAMOND COATINGS ON DIFFERENT INDUSTRIAL COMPONENTS. THEREBY DIACCON IS ABLE TO USE HIGH-TECH EQUIPMENT (SEM, FTIR, XRD, RAMAN-SPECTROSCOPY, ETC.) AS WELL IN PRODUCT DEVELOPMENT AS IN QUALITY CONTROL OF BATCH PRODUCTION. BESIDES PURE COATING SERVICES, OUR MAIN FOCUS IS THE PROCESS DEVELOPMENT IN CLOSE COOPERATION WITH OUR CUSTOMERS.



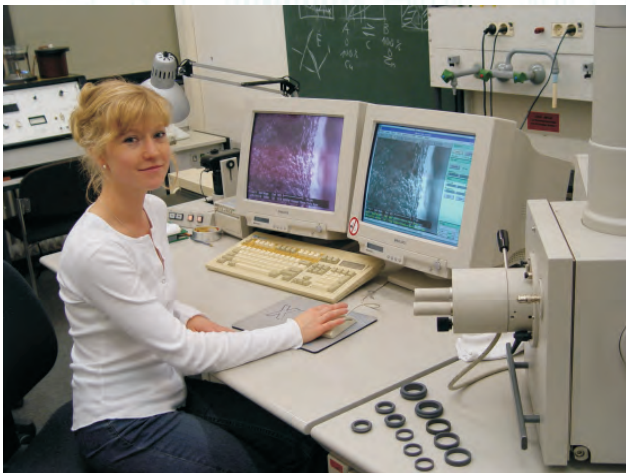
CLEANING & PRETREATMENT

Cleaning and pretreatment in particular are very important steps for well adherent diamond coatings



DEPOSITION PROCESS

Many years of experience in diamond coating lead to stable and reproducible processes



QUALITY CONTROL

Quality control is an essential chain link in product development and batch production



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