Fraunhofer CCD performs applied research and development contracts with industry and government organizations. Customers include companies from industry sectors such as manufacturing, semiconductor, biomedical and energy. CCD is a confident and reliable partner providing proprietary and competitive R&D services based on core competences in diamond and coating technologies. CCD's quality management system is certified according to the standard ISO 9001:2008.

Our customers know that maintaining a leadership position in today's competitive business environment requires ever more rapid innovation cycles and sustainable manufacturing solutions. Fraunhofer aims at accelerating innovation for its customers by driving technologies faster along the technology-readiness-level chain from basic research toward commercialization. CCD connects with world-class basic research through its close partnership with Michigan State University in East Lansing, Michigan, USA. The Center shares 20,000 square feet of laboratory and office space and is fully integrated with the College of Engineering with access to faculty, students and additional research facilities. CCD is also closely affiliated with and offers access to the Fraunhofer Institute for Materials and Beam Technology in Dresden, Germany.

**Engaging with CCD in Applied Research and Development Work**
We work closely with our customers to determine specific project objectives and requirements. Prior to commencing work, every project is structured with mutually agreed upon deliverables, schedules, milestones and costs. Our customers are provided with access to our extensive laboratory and engineering resources. Project results are treated with strict confidentiality. We recognize the need to protect intellectual property rights for our customers and work with them to negotiate mutually acceptable terms and conditions so that the developed solutions can be readily deployed.

**Core Competence: Coating Technologies at Fraunhofer CCD**
Surface coatings are an enabling technology across industrial sectors. Surfaces of parts, devices, components and tools need to be engineered so that they can perfectly function in the environment of a specific application. By providing engineered surface properties, coatings enable high performance applications that would otherwise only be possible with expensive bulk materials. Such functionalities include for example improved wear and corrosion resistance, reduced friction, biocompatibility or, in some cases, simply a specific appearance. CCD's coating technologies focus on applications of physical and chemical vapor deposition (PVD and CVD coatings) process and systems technologies and materials knowhow. The Center works with its customer to identify and develop the best coating solutions for their applications and supports them to deploy the developed processes and materials in manufacturing.

**Core Competence: Diamond Technologies at Fraunhofer CCD**
Diamond is a crystalline allotrope of carbon and the material with the highest atomic density found in nature. As such it is an extraordinary material with a unique combination of extreme properties such as highest hardness, highest thermal conductivity and highest dielectric breakdown strength, to name a few. The field of diamond synthesis and applications is undergoing a spectacular period of transformation as the ability to deposit high-quality monocrystalline diamond materials advances. CCD develops processes and systems to synthesize diamond and to make it accessible to customers for integrating it in applications in optics, electronics and electrochemistry. Diamond is not expensive. In fact, at CCD the material is synthesized by chemical vapor deposition using a process very like depositing coatings from other materials. It is used by our customers in the form of coatings such as poly- and nanocrystalline diamond films or a poly- or monocrystalline bulk material.
**Project Briefs**

**Boron-doped diamond electrochemistry:** Boron-doped diamond (BDD) is a new electrode material for electrochemical applications. Due to the fabrication from methane and hydrogen gases boron-doped diamond electrodes are less expensive than platinum electrodes. Yet BDD by far exceeds the electrochemical performance of metal-based electrodes. The wide electrochemical potential window, the low background current and the low adsorption make BDD electrodes particularly valuable for electrochemical trace analysis and neurochemistry. The material can be applied to a variety of substrates and shapes made from silicon, quartz, metals, and diamond. CCD researchers developed fabrication processes to reliably custom tailor BDD electrodes for applications ranging from heavy metal detection in tap water to building flexible diamond-polymer thin film electronics for electrical and chemical sensing of brain signals (NIH funded).

**Increased gas mileage and reduced emissions due to powertrain coatings:** CCD researchers developed a carbon-based coating to lastingly reduce friction and wear for powertrain components that experience highly loaded contact situations. By coating engine components, Fraunhofer engineers demonstrated a 3% horsepower increase across the usable speed range thus enabling the engine to achieve the same performance at lower revolutions per minute. These results demonstrate the tremendous potential to conserve fuel and reduce carbon dioxide emissions.

**Diamond for power and high temperature electronics:** Fraunhofer and Michigan State University researchers develop diamond-based power electronics. The exceptional semiconductor properties of diamond have enormous potential for high-power electronics technology with applications in transportation, manufacturing, and energy sectors. The team develops synthesis processes for doped and intrinsic electronic-grade wide bandgap diamond materials and works on manufacturing process flows to build power electronic devices such as vertical Schottky diodes.

**Manufacturing cost savings through 300% increase in tool life:** Meritor Inc., a global leader in providing advanced drivetrain, mobility, and braking and aftermarket solutions for commercial vehicle and industrial markets, collaborated with Fraunhofer engineers to test new high performance ceramic coatings for high temperature forming processes. Spindle punches were coated using a physical vapor deposition process developed in collaboration with the Fraunhofer Institute for Materials and Beam Technology (IWS) in Dresden, Germany. The punches are used for hot forging of steel parts at an operating temperature of 1950 °F (1065 °C). Compared to uncoated spindle punches, the best performing coated tools lasted three times as long while enabling tool changes once a day rather than every shift.

**Anti-reflective coatings for transit bus windshield:** CCD researchers work with The Mackinac Technology Company (MTC) and the University of Michigan Transportation Research Institute on developing an anti-reflective windshield coating for transit bus windows. Interior lighting reflects off the windshield and obscures the driver’s vision. The team demonstrated that an innovative ultra-low refractive index material made of amorphous carbon could be deposited in nanometer thin layers to the surfaces of windshield glass to significantly reduce reflection of visible light and improve driver vision.

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1 A brilliant cut single crystal diamond on top of a Diamond-like-Carbon coated end mill. © Fraunhofer USA

2 CCD Engineer prepares to diamond coat silicon wafers in a hot filament diamond system. © Fraunhofer USA