

Diamond Coatings

Still the hardest substance known to man, diamond is resistant to wear, the best thermal conductor, an excellent electric insulator, immune to attack from most chemicals, relatively friction-free, and transparent not only to visible light but also to infrared and ultraviolet. These characteristics would make diamond the ideal material for a wide range of industrial applications were it not for its extremely high cost.

However, advances in materials technology have demonstrated that it is possible to get the advantages of diamond in a number of applications without the cost penalty—by coating and chemically bonding an inexpensive substrate (supporting material) with a thin film of diamond-like carbon (DLC). Diamond films offer tremendous technical and economic potential in such advances as chemically inert protective coatings; machine tools and parts capable of resisting wear 10 times longer; ball bearings and metal cutting tools; a broad variety of optical instruments and systems; and consumer products ranging from wristwatch crystals to eyeglasses. In the U.S., Japan and Europe, there are growing diamond-coating industries competing to bring forth the first of a stream of commercial applications and get a foothold in a new market that is predicted to reach \$500 million–\$1 billion in this decade and expand far beyond that in the 21st century.

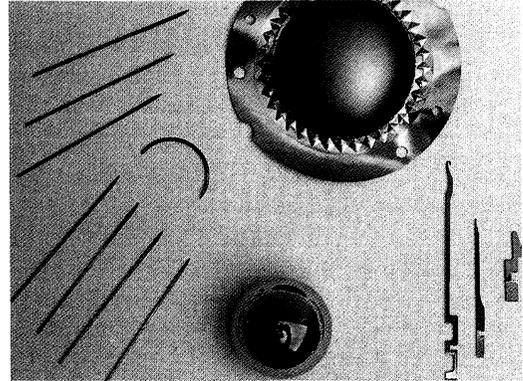
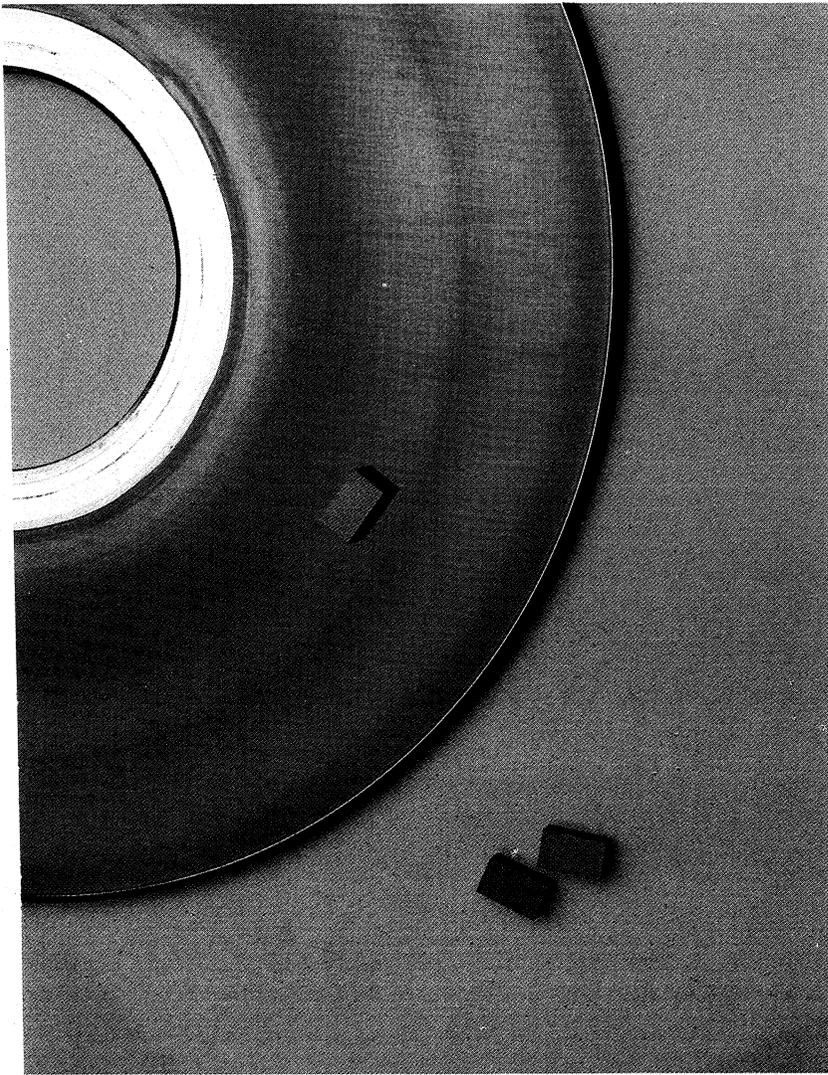
Among the American companies engaged in DLC commercialization is Diamonex, Inc., a diamond coating spinoff of Air Products and Chemicals, Inc., Allentown, Pennsylvania. Along with its own proprietary technology for both polycrystalline diamond and DLC coatings, Diamonex is using, under an exclusive license, NASA technology for depositing DLC on a substrate.

Interested in the aerospace potential of synthetic diamond coatings, Lewis Research Center has, for more than a decade, conducted extensive research on the properties of DLCs, including investigations of a variety of different ways to deposit them on many different types of substrates. Among the coating methods researched is a technique known as direct ion beam deposi-

tion, in which an ion generator creates a stream of ions from a hydrocarbon gas source; the carbon ions impinge directly on the target substrate and “grow” into a thin DLC film. Lewis' research has generated patents related to a dual ion approach. This low pressure, low temperature approach—as opposed to high-temperature, high-pressure processes normally used in making synthetic diamond—allows coating substrates that cannot tolerate high temperatures—plastics, for instance.

Lewis is providing technical assistance to Diamonex on a major step that would significantly expand the DLC market: scratch-resistant coatings for plastic prescription eyeglasses. The critical technical problem is making the hard DLC coating thick enough to provide scratch resistance yet maintain optical clarity for clear vision; that is not a problem with sunglasses, where color and light attenuation are desirable. Diamonex plans to form a joint venture with a lens manufacturer to commercialize this technology.

The photos illustrate some of the applications of diamond coating. At near right are a magnetic data storage disc and several read/write head sliders; disc and sliders are coated to reduce friction and increase disc life. At upper far right are some typical applications for non-optically-transparent DLC coatings: at top center is a speaker diaphragm which is coated to provide a higher frequency response from the speaker; moving clockwise in the photo are needles used in weaving cotton cloth, coated to reduce friction and snagging; at bottom photo is a diamond-coated ball for an artificial hip joint, whose wear resistance and durability is increased by coating; and at left photo are surgical needles, coated to promote reduced patient recovery time by minimizing needle puncture damage. At lower right are several optical applications; at top, prescription eyeglasses; at the three o'clock position, a polycarbonate blank for sunwear; at four o'clock, two coated polycarbonate lenses; at bottom photo, a lens with iridescent diamond coating for fashion; and at upper left photo, sunglasses.



Diamonex is developing, and offering commercially—under the trade name Diamond Aegis™—a line of polycrystalline diamond-coated products that can be custom tailored for optical, electronic and engineering applications.

Additionally, Diamonex is engaged in a collaboration with Seiko Instruments, Inc. of Japan involving development and commercialization of diamond coating technologies. Diamonex brings to the partnership its own proprietary technologies, plus the Lewis ion beam technology. Seiko will contribute its own microwave coating technology and has access to coating technologies developed by Japan's National Institute for Research in Inorganic Materials and licensed from the Research Development Corporation of Japan.

Diamonex' initial focus is on optical products and the first commercial product is expected in late 1990. Other target applications include electronic heat sink substrates, x-ray lithography masks, metal cutting tools and bearings.

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