From a sheet of ice to a hailstorm

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Diamond-like carbon films have a low coefficient of friction because they are extraordinarily smooth. This is why they are applied to almost all PC hard disks and many machine parts. A scientific paper explains conclusively for the first time why deposited layers do not grow rough.

class of materials based on plain old carbon has had a meteoric career in recent years. Its success can be attributed to various processes by which the sixth element of the periodic system can be laid down on solid surfaces in a highly controlled manner via carbon electrodes or from gaseous compounds in the plasma. 'Highly controlled' refers to the crystal structure. Depending on the process conditions, an amorphous – that is, atomically unstructured – film of crystalline graphite or diamond is deposited. Amorphous layers in particular are becoming ever more important because they permit the hardness of the film to be set deliberately to anything between graphite-like and diamond-like carbon (DLC). Another reason for the spectacular career of amorphous carbon is its ability to form ultra-smooth and hence low-friction, wear-resistant films. DLC has thus captured a broad spectrum of applications ranging from coatings for computer hard disks, scratch-resistant glasses and high-friction machine parts to hard-wearing drills, milling heads and other tools.

In order to optimize the structure of these and other films, researchers want to understand how the atoms are laid down on the surface. One aspect is: Why are DLC films so smooth? The mechanistic concept held until now assumes that the film is locally heated up: An atom lands on the surface and transfers its kinetic energy to the surrounding atoms.

This results in a short-lived 'thaw' that smoothens out any tiny elevations. "We demonstrated both empirically and in our calculations that the concept of a 'hot iron on a sheet of ice' is inaccurate," says Michael Moseler of the Fraunhofer Institute for Mechanics of Materials IWM, summarizing his findings. "The process is more like an 'erosive hailstorm'. We have discovered a universal smoothing mechanism that occurs not only with carbon but also with amorphous silicon and metal oxides. This finding is so significant that we have published our results in the September issue of Science."

A growing DLC film looks rather like a nanoscopic snowy landscape. The hailstorm of atoms triggers nano-avalanches on the slopes. This causes the mountains to be gradually eroded into the valleys, which ultimately smoothens the film. "This is a very important discovery that enables us to produce highly specific nanostructured surfaces," Moseler concludes.

Source: Fraunhofer-Gesellschaft

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