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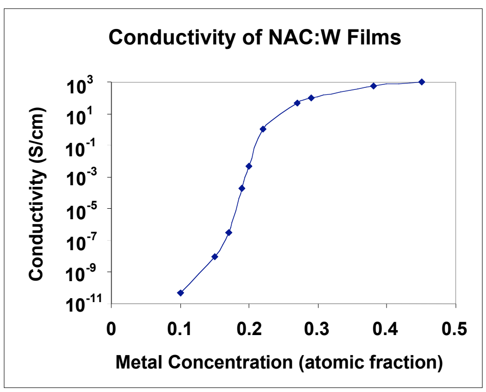
NANOAMORPHOUS CARBON COATINGS

Intex has developed a new class of multi-functional electronic materials, nanoamorphous carbon (NAC) coatings, with conductivity that can be varied from dielectric to metallic. The films are obtained by Plasma Enhanced Chemical Vapor Deposition (PECVD). The PECVD-produced film is an amorphous dielectric with a composition consisting of a substantially sp^3-bonded carbon network that also contains silicon and oxygen.

NAC films can be made electrically conducting by incorporating metals into the carbon matrix. The resistivity of the film is controlled by controlling the metal concentration. The conductivity reaches a maximum of ~10^3 S/cm. Dielectric films (without conducting additives) have conductivities in the 10^{-10} S/cm range. This is a larger range of conductivity than has been observed with any other known material.

The films can be deposited with good adhesion on metals, ceramics, semiconductors and some plastics. Concentrations of additives can be up to ~50 at.%. The figure below shows the conductivity as a function of the concentration of tungsten (W) incorporated into the film.



Conductivity of a NAC film incorporating tungsten (W). A threshold to high conductivity occurs at a doping level of ~20 at.%.

Many of the film properties are similar to those of diamond-like carbon (DLC) materials, but the properties significantly exceed those of DLC in important areas. The main characteristics of the films are the following:

- High hardness (6-20 GPa)
- High wear resistance
- High elastic modulus (100 – 400 GPa)
- Low friction coefficient (0.04 – 0.15)
- High chemical stability
- High temperature stability (750°C vs. 350°C for DLC)
- Wide range of conductivity (10^{-10} to 10^4 S/cm)
- Wide range of infrared transparency (1-14 μm)
- High dielectric strength ($3x10^6$ V/cm)
- Excellent hermetic sealing properties
- Low internal stress (<0.1 GPa vs. 1.0- 7.0 GPa for DLC)
- Biocompatibility

Films with thickness up to 10 μm can be made routinely, which is not possible for DLC. The deposition process is compatible with standard silicon processing and films can be patterned with ion-beam etching.

Metal-containing films used as thermoresistors can operate in air at temperatures up to 750°C. Normal DLC in contrast, oxidizes at ~350°C. This technology forms the basis for a MEMS-based pulsed infrared light source with high brightness developed by Intex, used as a light source in infrared gas sensors.

The NAC materials coat conformally and produce hermetic seals at very low thickness. Even 5-10 nm thick films have demonstrated effective corrosion protection on some substrates. NAC materials have high strength and are stable in corrosive environment.

The ability to tailor the electroactive properties of the NAC materials opens a wide range of applications, including:

- MEMS devices; active and passive elements
- Biocompatible protective coatings on surgical tools
- Dielectrics and electrical contacts in microelectronics
- Low friction protective coatings
- Implantable electrodes
- Electrodes for electrochemistry in corrosive media
- Ion-conducting membranes
- Coatings for OLEDs