Diamond coated boron nitride

Boron nitride has a wealth of desirable properties such as, high thermal conductivity, chemical inertness, high dielectric constant and high ac dielectric strength (95 kV/mm) and significantly the ability to be machined into complex shapes but several grades will absorb moisture from its environment and this limits their use above around 100^{o}C and also significantly effects the dielectric properties. It is also a relatively soft material and pure forms in particular will wear and abrade away.

Work done by Ultra Biotecs Ltd aimed at producing a material suitable for use as a very high voltage insulators resulted in the filing of an International Patent No. WO 2018/142138 A1 (now published) developed a process that solves the shortcomings of BN, whilst maintaining and improving many important areas.

The results of this work showed that if the boron nitride was coated with a suitably high dielectric strength material such as Diamond or synthetic diamond then many shortcomings preventing the use of this material were solved or at least greatly improved.

Only two suitable coating materials were identified; Diamond or synthetic diamond and high purity silica, with diamond being the preferred material due to its very high abrasion resistance and its very high ac dielectric strength. Both materials produce an impermeable continuous waterproof coating therefore eliminating any water absorption.

Subsequent work done in conjunction with Cardiff University has resulted in the June 2019 publication of a paper in the journal of The Royal Society of Chemistry. (We'll attach a link)

In this process the diamond is keyed into the surface by seeding the BN, so the Diamond is not just laid on to the surface but keyed into the substrate

It addresses the problems associated with diamond coating on boron nitride and how to overcome them to produce an excellent pinhole free and well adhered diamond coating (confirmed by Raman spectroscopy).

This technique of growing diamond on ceramics can be useful in areas where machinable dielectrics can form large scale devices which can then be coated with thin layer of diamond. If the diamond is doped with boron it can be made semiconducting or fully conducting.

One of the key advantages of this process is the Dielectric constant of the BN is increased from around 4 to 46 (a tenfold increase) The ac dielectric strength of parallel pressed boron nitride is 95 kV/mm and the ac dielectric strength of diamond is approximately 300 kV/mm and they are in series with each other (additive)

Whilst the other important properties are maintained or improved:

-High thermal conductivity

-High wear

-Machines into complex shapes

-The operating range of this material is 700°C to 800°C in air but very much higher in an inert atmosphere.

Further experimentation using a boron doped diamond coating on boron nitride ceramic has shown that the combination becomes superconducting at approximately 3.4K.

Work continues with Cardiff University on other properties of this unique material combination.