Effect of water adsorption on electrical conductivity and permittivity of diamond nanopowders

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Nanodiamond (ND) powders in vacuum are good insulators with conductivity (G) of the order of 10^{-12} Ohm^{-1} cm^{-1} or less and the magnitude of the dielectric constant ε of a few units. Due to the large specific surface area of powders and high conductivity of water comparing to the diamond it should be expected increase of G and ε in the system ND-adsorbed water.

Frequency dependence of the conductance G (f) and capacitance C (f) for dry and wet powders in the frequency range 1 Hz<f<1.6 MHz were measured. The data were obtained using two-electrode cell placed in vacuum set.

The water's isotherms were determined by weighing the samples after exposing them at various pressures of water vapor in region 0.5<P <15 Torr.

The detonation diamond powder with specific surface area 300 m^2/g UDD-SP (SPA "Sinta", Minsk) were studied. Dependence of G (f, p) and ε (f, p) were obtained for the initial hydrophilic powders with oxygen containing groups on the diamond surface and the hydrophobic surface with chlorine groups.

Dependences of G(f, p) are interpreted in the basis of percolation theory. In this theory percolation threshold is determined, when the non-conductive matrix becomes conductive. Our experiments show G increase starting from $p/p_s=0.2$ for hydrophilic and 0.40 for hydrophobic (p_s-saturated water vapor pressure). It can be explained by merging of water clusters [1]. Near the percolation threshold G(f) shows power-law dependence of frequency ($G \sim f^s$; *s*-is a function of pressure).

The theory [2] predicts the existence of non-trivial polarization processes leading to the effect of giant dielectric polarization for water bearing porous dielectrics at $1Hz<f<10^5$ Hz. This theory takes into account the surface contribution to the polarization. It was shown in our experiments, that indeed in the low-frequency ε increases to 10^4-10^6. Significant polarization becomes possible after formation of polylayer of water. The various physical and chemical processes under the action of electric fields, explaining the phenomenon of giant polarization at interfaces, are discussed (the restructuring of electric double layers, surface migration and diffusion of charges).

The obtained information can be useful both for estimation of the properties and possible practical application of ND powders.

[1] P.S. Vartepetian, A.M. Voloshuk, *Uspehi Khimii* **64**(11), 1055 (1995) (In Russian).
[2] T.L. Chelidze, Y. Guergen, Geophys., *J. Int.* **137**, 1 (1999).