Roughness and Superficial Structure of Crystals after Polishing with Compositions of Nano Detonation Diamonds

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The urgency of this work is due to increasing application of nano detonation diamonds (NDA) in technologies of processing of materials surfaces, and simultaneously wide application of chemical-mechanical polishing (CMP) technology with particles of amorphous nano oxide. Therefore the purpose consisted in consecutive consideration of comparative features of firm NDA particles and amorphous oxides production, structure, superficial properties, behavior in water environments, polished surfaces geometrical and structural properties studying, and interpretation on this basis of their interaction.

Polishing compositions on a silica basis (A-300, d = 4-10 nm, pH = 7-11) and on the NDA basis of various manufacturers were used: FERAN, Moscow: 130 nm, 60 nm, 25-30 nm, 1 % neutral suspensions; Sinta, Minsk of d = 5-7 nm, 1% suspension without additives; special compositions of GPI Moscow with various NDA concentration and ISC Kiev with SiO_2 additives of various pH. At identical nanometric sizes of two types firm particles their main difference consists in particles polycrystalline structure of NDA, and amorphous of SiO_2. They also differ in the ways of production, form, structure, chemistry of a surface and behavior in water. These features in different degree meet modern requirements to polishing compositions, and define distinctions in technology of polishing and properties of formed surfaces.

Following materials were used. (111) and (100) Si wafers as a most common material. Ge (111) and (100) monocrystals of different diameter.

Hydrothermal and gas phase ZnO, ±10` (0001), of 10×10×0.5 mm size and up to 30 mm diameter. $A^2B^5$ materials: CdSb (010) and $CdP_2$ (100). NiSb ellipsoid specimens ±10` (0001). Gas phase vacuum sublimation SiC:6H of 50 mm diameter ±30` (0001), and 10×10×0.5 mm Lely synthesized. Oxygen-free Cu (111), (110) and (100) monocrystals 10×10×2 mm. Invar alloy 10×10×0.5 mm samples. Nanoporous glass polymer composite with porous size 5-15 nanometers. Methods of AFM, RBS with He+ ions were used.

Results consist in the following.

Neutral 2% and 1% NDA polishing compositions form a Ge surface with linear nanoscratches (σ = 1.7–1.4 nm), and A-300 additives in increasing concentrations reduces σ. Increase pH to 10.2 reduces σ to 0.5 nm, which coincides with SiO_2 CMP at pH = 10.57.

All submicronic NDA compositions induce nano scratches on Si surface. CdSb roughness (σ) reduces from 2.5 to 0.4 nm with decrease of particle sizes from 130 to 25 nm, but it increased from 0.7 to 1,0 and then to 1.5 nm in compositions of 1% NDA 3-5 nm with A-300 of pH = 7, same of 0.3% NDA, sol SiO_2 + 25% NaOH with pH = 10.2 respectively. Minimum σ = 0.2 nm are obtained after CMP with SiO_2 in the presence of oxidant at pH = 10.5. Thus, the NDA concentration, chemistry and concentration of liquid phase ingredients affect the value of σ. Peaks heights and areas in the high-energy part of the measured ROR spectra characterize the depth and the number of scattering centers, lying outside the lattice nodes, decreasing with decreasing particle size of the diamond, bacoming minimal when SiO_2 polished (Si, NiSb, CdSb). In the case of Si NDA 3-5 nm with A-300 additives are almost equal to pure SiO_2 compositions with pH = 10.2.

NDA with SiO_2 inflicts more superficial imperfections, than pure 3-5 nm NDA polishing at the same pH = 7. Same results are obtained for NiSb and CdSb. α-SiC polishing with ASM 3/2, 1/0 and NDA 3-5 nm gives similar dependences. Diffusion layer correlates sequence of these processing. The minimum Nt values (4-12·1015 at/cm^2) belong to SiO_2 CMP, and identical to the polished surfaces of cubic (Si, Ga, As), hexagonal (ZnO, α - SiC), and rhombic and tetragonal (CdSb, CdP_2) crystals. In the case of CMP SiO_2 Nt also does not depend on microhardness (α - SiC, Si, GaAs, NiSb, ZnO). Crystallographic orientation at CMP of Cu also does not affect the form, the values of peaks and Nt value (10.8-15 ·1015 at/cm^2).

The found dependencies of roughness changing correlate to superficial layers of imperfections to depth of 2 nanometers. Dislocations may occur at polishing with NDA 130, 60 and 30 nm; smaller diamond particles with SiO_2 additives may form spot faults and lead to compositional changes in the surface of CdSb, GaAs, NiSb, ZnO.