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Fabrication and Engineering Applications of Ultra Smooth Nanocrystalline CVD-Diamond

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Abstract - Nanocrystalline diamond layers can be grown reliably on single-crystalline silicon-wafers as well as other appropriate substrates by hot-filament chemical vapour deposition. Such layers with varying and controlled thickness combine the remarkable properties of conventional diamond - such as extreme hardness and wear resistance - with the potential of creating particular shapes and geometries of microparts and microtools established in silicon-based microtechnology.

Here we report on nanocrystalline diamond layers with avg. grain size around 10 nm and thickness varied between 0.1 and 150 micrometers grown on single crystalline Si wafers with diameter up to six inches at about 750 C. The variation of O2 or N2 concentration in the H2/CH4 gas mixture shows a strong influence on the microscopic and macroscopic structures achieved. Under the best growth conditions/parameters the NCD films exhibit ultra small equiaxed grains and ultra smooth surfaces in the range of a few nanometers and transparent appearance. The chemical composition was investigated by XANES, RBS and ERD indicating a high phase and elemental purity of about 99%. The elastic properties have been investigated by LSAW, showing a declining Young's modulus from 1010 to 720 GPa, consistent with decreasing grain size and increasing sp^3/sp^2 ratio.

In the next step, by a sophisticated combination of photolithographic techniques and efficient reactive ion etching processes complex shaped microparts have been designed and fabricated. A number of different current applications have been developed and will be discussed, such as complex shaped microparts for high-precision mechanical devices, sensors and bio-applications.