SE/TF-03-1-I-TU

Nano-structured and architecturally engineered thin films and optical surfaces

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Tailoring of the structure of thin films and optical surfaces in micro- or nano- scale aroused much research interests in recent years. Objectives of this research are the fabrication and characterization of thin films and optical surfaces with nano structures or architectures for photonic and optical applications. Silicon oxide and silicon nitride thin films and their multilayered thin films were deposited on ZnS, sapphire and silicon substrates using PECVD method. Single or multilayer polycrystalline thin films with thickness up to 3 nm and with stress as low as 200MPa were prepared. Low energy ion beam erosion with glancing angles was applied to induce nano structures in both thin films and bare optical surfaces. Pyramid-like structures were found in the thin films after the ion beam erosion. Dot and ripple structures were formed in the bare crystalline optical surfaces of the substrates. White light interferometer and AFM methods were used to characterize the structures. The structures had a dimension from several nanometers to several tens of nanometers in the normal direction, and a dimension up to 400nm in the lateral direction. Fourier analyses proved that the nano structures showed self-organized characteristics, depending strongly on the ion beam erosion parameters. Mechanical properties of the thin films were also investigated with nano indenter. It was approved that the compliance of both SiO_x and SiN_x were greatly improved when in the form of thin film. Based on this conclusion, Single Point Diamond Tuning (SPDT) method was applied to fabricate 3D architectures in the thin films. Pyramid and grating structures with dimension down to sub-micron were fabricated. Finite Difference Time Domain (FDTD) analyses showed that near field wave front can be strongly manipulated by the nano- structured or architecturally engineered thin films and optical surfaces. It was demonstrated that, when micro- or nano- structures were formed in the thin films, there would be an additional interference effect from the thin films contributing to the manipulating of the wave front other than the effects of diffraction and deflection in the bare optical surfaces with micro- or nano- structures. Combining the ion beam erosion and the SPDT methods, a 'moth's eye' structure can be realized, both in the thin films and on the optical surfaces of the substrates.