Time & Location: June 17, 2011 at 10:00 AM in HEC 438
Title: Investigation of reactively sputtered Boron Carbon Nitrogen thin films

Research efforts have been focused in the development of hard and wear resistant coatings over the last few decades. These protective coatings find applications in the industry such as cutting tools, automobile and machine part etc. Various ceramic thin films like TiN, TiAIN, TiC, SiC and diamond-like carbon (DLC) are examples of the films used in above applications. However, increasing technological and industrial demands request thin films with more complicated and advanced properties. For this purpose, B-C-N ternary system which is based on carbon, boron and nitrogen which exhibit exceptional properties and attract much attention from mechanical, optical and electronic perspectives. Also, boron carbonitride (BCN) thin films contains interesting phases such as diamond, cubic BN (c-BN), hexagonal boron nitride (h-BN), B4C, \( \text{C}_3\text{N}_4 \). Attempts have been made to form a material with semiconducting properties between the semi metallic graphite and the insulating h-BN, or to combine the cubic phases of diamond and c-BN (BC2N heterodiamond) in order to merge the higher hardness of the diamond with the advantages of c-BN, in particular with its better chemical resistance to iron and oxygen at elevated temperatures.

New microprocessor CMOS technologies require interlayer dielectric materials with lower dielectric constant than those used in current technologies to meet RC delay goals and to minimize cross-talk. Silicon oxide or fluorinated silicon oxide (SiOF) materials having dielectric constant in the range of 3.6 to 4 have been used for many technology nodes. In order to meet the aggressive RC delay goals, new technologies require dielectric materials with \( K<3 \). BCN shows promise as a low dielectric constant material with good mechanical strength suitable to be used in newer CMOS technologies. For optical applications, the deposition of BCN coatings on polymers is a promising method for protecting the polymer surface against wear and scratching. BCN films have high optical transparency and thus can be used as mask substrates for X-ray lithography.

Most of the efforts from different researchers were focused to deposit cubic boron nitride and boron carbide films. Several methods of preparing boron carbon nitride films have been reported, such as chemical vapor deposition (CVD), plasma assisted CVD, pulsed laser ablation and ion beam deposition. Very limited studies could be found focusing on the effect of nitrogen incorporation into boron carbide structure by sputtering.

In this work, the deposition and characterization of amorphous thin films of boron carbon nitride (BCN) is reported. The BCN thin films were deposited by radio frequency (rf) magnetron sputtering system. The BCN films were deposited by sputtering from a high purity B4C target with the incorporation of nitrogen gas in the sputtering ambient. Films of different compositions were deposited by varying the ratios of argon and nitrogen gas in the sputtering ambient. Investigation of the oxidation kinetics of these materials was performed to study high temperature compatibility of the material. Surface characterization of the deposited films was performed using X-ray photoelectron spectroscopy and optical profilometry. Studies reveal that the chemical state of the films is highly sensitive to nitrogen flow ratios during sputtering. Surface analysis shows that smooth and uniform BCN films can be produced using this technique. Carbon and nitrogen content in the films seem to be sensitive to annealing temperatures. However depth profile studies reveal certain stoichiometric compositions to be stable after high temperature anneal up to 700ºC. Electrical and optical characteristics are also investigated with interesting results. The optical band gap of the films ranged from 2.0 eV - 3.1 eV and increased with N2/Ar gas flow ratio except at the highest ratio. The optical band gap showed an increasing trend when annealed at higher temperatures. BCN films with dielectric constant as low as 2.6 has been achieved. The band gaps in the range of 4-5eV has been achieved for samples deposited at various substrate heating temperatures. Lastly, the future research work on the BCN films that will be carried out as a part of the dissertation is proposed.

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Approved for distribution by K.B. Sundaram, Committee Chair, on January 1, 2011.

The public is welcome to attend.