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Carbon Thin Films for Biomedical Applications

Functionalization of Material Surfaces

In recent years, a lot of work has been focused on the synthesis of novel carbon thin films materials, especially crystalline diamond, diamond like carbon (DLC) and carbon nitride (CN) which offers excellent tribological, optical, electrical and other properties with the additional advantage that carbon is a biocompatible material. The diversity of methods used for the deposition of diamond-like carbon films provides the flexibility to tailor their properties according to specific needs and potential applications.
The first deliberate attempt to make carbon nitride films was probably by Cuomo et al. in 1979 [1]. However, no great interest in this material was evident until Liu and Cohen's theoretical work of 1989 [2] indicated that the properties of β-C_3N_4 (Fig.1) might be similar or superior to those of diamond. The now fairly well-known result of this theoretical work has been the stimulation of much research to find an adequate method to reproducibly synthesize crystalline C_3N_4. Initially, the theoretical work was motivated by an empirical model developed to estimate the bulk modulus of tetrahedrally bonded materials. This model indicated that solids with high bulk modulus should be found in crystals with short, low-ionicity bonds between the constituents. The C-N bond, and tetrahedral crystals based on this bond, are obvious candidates for such high-compressibility solids.
CN_x films consist of mainly carbon and nitrogen, and some may be doped with hydrogen. As these elements widely spread in living body, it is conceivable that CN_x may possess excellent biocompatability. The assumption was soon confirmed by Du et al. In 2000, Cui and Li summarized previous investigation and studies on biocompatibilities of DLC and CN_x coatings. Lately, DLC and CN_x coatings have raised more attraction for their excellent chemical inertness, wear resistance, bio- and hemocompatible nature.

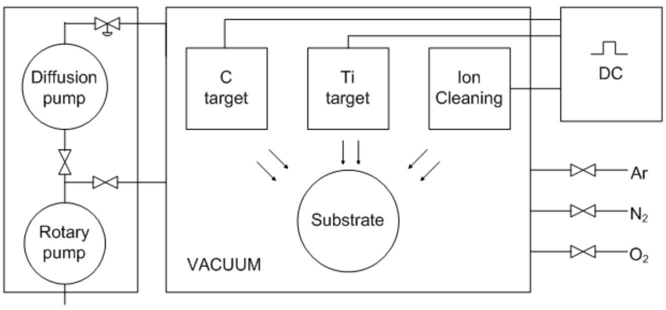

Fig.1 – Pulsed arc discharge sputtering system UVNIPA-1-001

In our department was accomplished a vacuum installation type UVNIPA-1-001 (Fig.1) for deposition of DLC, CN, Ti, TiN, TiC, Ti(CN) and multilayer thin films, outfitted with three sources: an arc source with a magnetic separator for sputtering of nonmagnetic metals, a source for bombardment with gas ions having an energy up to 6 keV, and a pulsed arc source for sputtering of graphite. All the three sources were installed in the same plane. The working vacuum chamber housed a planetary-type holder for substrates. The installation provided, within a single vacuum cycle, cleaning of the substrate surface with an ion beam (argon), deposition of metal (titanium) layer from a magnetically separated beam and deposition of C film by pulse (1-30 Hz) arc sputtering of graphite. The fact that there is accelerating potential at the holder at all the stages of the process and use of low frequency (not over 10 Hz) of the discharge pulses at the graphite target contributed most to the achievement of the low temperatures of the process [3].

This paper will focus on development in mechanical properties research on carbon nitride and DLC films (Fig.2) for biomedical applications. Mirror polished Si, CoCrMo and Ti6Al4Vmedical alloys were used as substrates for the coatings. The effect of nitrogen and argon gas flow and other deposition conditions on the film properties were investigated. Films were analyzed by SEM and Raman spectroscopy and tribology testing methods.

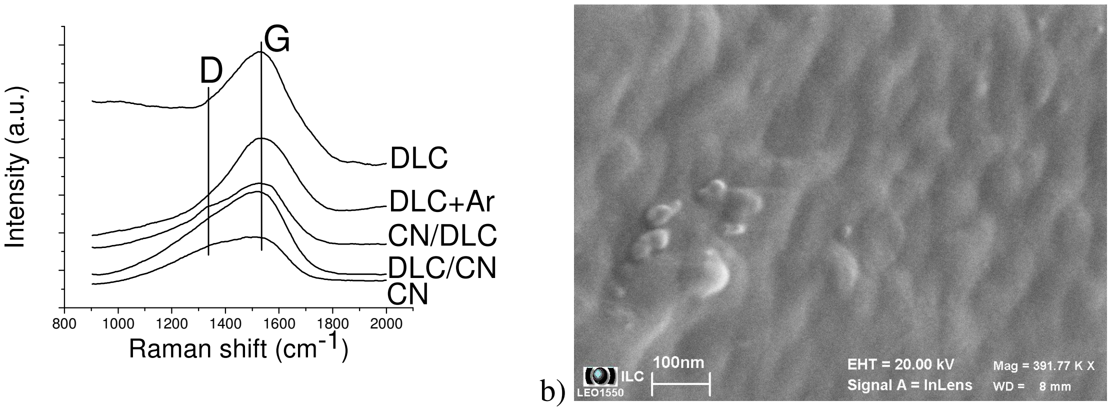

Fig. 2 – a) Raman spectra of the films, b) SEM image of DLC / CN thin films

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