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Deposition of crystalline C–N film by arc evaporation process

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Abstract

Crystalline carbon nitride thin films were deposited by Arc evaporation process. The room temperature deposited films showed amorphous and polycrystalline phases whereas, the films were crystalline, when deposited at 300 °C. These films were nano-crystalline and had grain sizes varying from 5 to 30 nm depending on the deposition condition. The average C : N at.% ratio for films deposited at 300 °C substrate temperature was found as C : N :: 39.37 : 59.87. The microhardness of the deposited films were in the range of 2200Hv.015 to 1800Hv.015.

Keywords: Carbon nitride; Arc evaporation; Hard coatings

1. Introduction

In the last couple of decades, much emphasis has been made on the diamond and diamond like coatings for their applications in cutting tools and optical devices. Recently the research activity is geared up towards the fabrication of carbon nitride, β-C_3N_4, a material known to be harder than diamond [1,2]. In 1985, Cohen [3] had theoretically predicted that carbon nitride is harder than diamond. Several polymorphs of carbon nitride (C_3N_4) had also been predicted from the theoretical calculations and these polymorphs were, α, β, cubic, pseudo-cubic and graphitic. Since the prediction of theoretical properties made by Liu and Cohen [4], extensive research activity has been directed towards the fabrication of C_3N_4 films and only in the last few years that a significant progress has been made. Amongst the several polymorphs [5], β-C_3N_4 is metastable in energy and therefore, most of the experimentation is focused on β-C_3N_4 and less attention is paid to other polymorphs.

So far several methods are reported to yield C_3N_4 coatings, amongst them, laser ablation [6], RF sputtering [7], CVD [8], reactive DC/RF magnetron sputtering [9,10], and Arc plasma deposition [11] are noteworthy. Though many techniques have been used to fabricate C–N film, yet the crystalline carbon nitride film has been reported by few research group only. However, it has been found that even in an amorphous state a lot of potential lies in carbon nitride film and have enough hardness for tribological applications [12]. Most of the time nano-crystalline phases are embedded in an amorphous carbon nitride matrix [13].

In this report we discuss our results on the deposition of carbon nitride thin films by a simple Arc evaporation process.

2. Experimental

Carbon nitride thin films were deposited by Arc evaporation process using graphite as electrodes. Edward-E 306 UK, Arc evaporation system was used for this purpose. The deposition chamber was evacuated to 5×10^{-6} mbar by the combination of diffusion and rotary pump. Indian oxygen limited analytical reagent (IOLAR grade 1) nitrogen was used as a reactive gas during arc deposition. The amount of nitrogen gas introduced was such that the chamber pressure was at 4×10^{-5} mbar. During deposition, pressure of the chamber increased to 1×10^{-4} mbar. The

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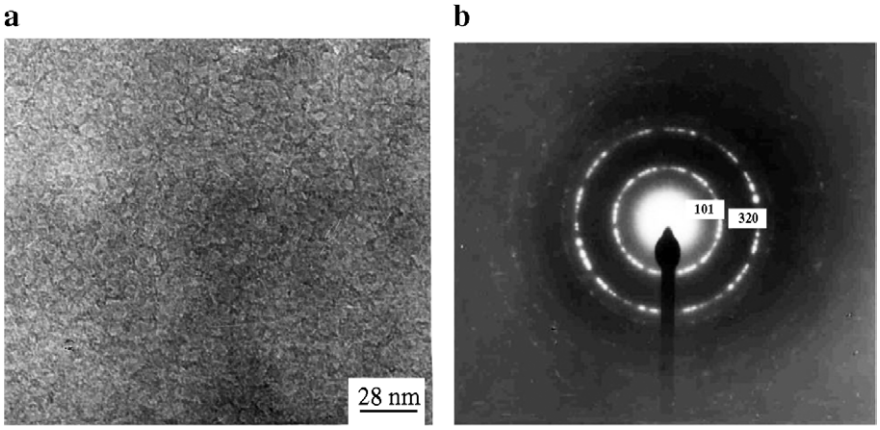

Fig.1. TEM micrograph of the CN film deposited at room temperature (a) and corresponding SAED (b).

films were deposited on Si and glass at room temperature and at 300 °C. For transmission electron microscopy (TEM) studies, carbon nitride films were simultaneously deposited on soap coated glass substrate, which were later floated in distilled water and taken on copper grid. The selected area diffraction pattern (SAED) pattern, structure and composition of the film were observed through transmission electron microscope (Phillips EM 200, Netherlands) attached with and KEVEX EDAX analyser. Atomic force microscope, AFM, (Seiko SPA 400, Japan) was used to investigate the topography of the deposited films. The hardness of the film was measured using Leica VMHT auto microhardness tester at 15 gf force. The composition of films deposited at 300 °C was only measured using Rutherford back scattering (RBS). Three films deposited simultaneously or under similar deposition condition was considered. RBS experiments

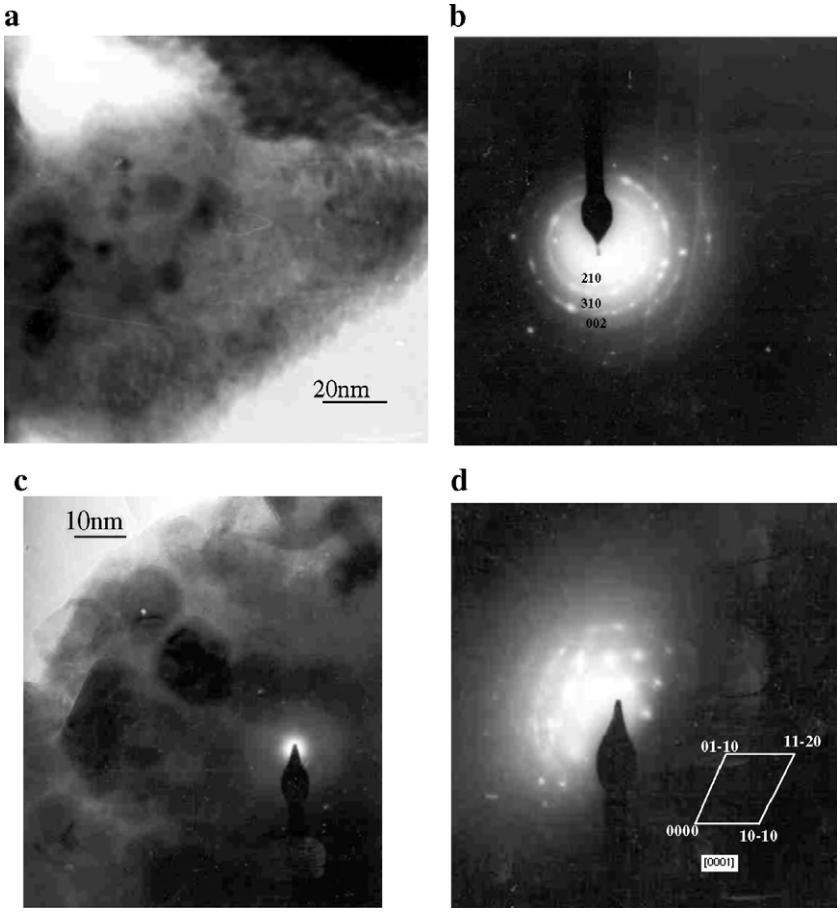

Fig. 2. TEM micrograph of the CN film deposited at 300 °C a) film having fine grain b) corresponding SAED, c) film having larger grains and d) corresponding SAED.