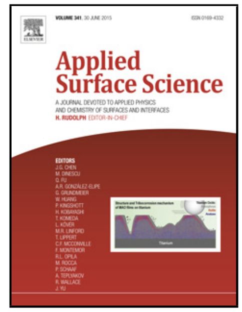

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Optimization of Black Diamond Films for Solar Energy Conversion

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Abstract

Black diamond, namely a surface textured diamond film able to absorb efficiently the sunlight, is developed by the use of ultrashort pulse laser treatments. With the aim of fabricating a 2D periodic surface structure, a double-step texturing process is implemented and compared to the single-step one, able to induce the formation of 1D periodic structures. Although the obtained sub-microstructure does not show a regular 2D periodicity, a solar absorptance of about 98% is achieved as well as a quantum efficiency enhanced of one order of magnitude with respect to the 1D periodic surface texturing.

Highlights

- Black diamond films were developed by fs-laser subwavelength surface texturing.
- Black diamond films can be used as photon-enhanced thermionic emission devices.
- A simple method for developing a 2D periodic surface texturing is proposed.
- Although not perfectly regular, the 2D texturing induced a 98% solar absorptance.
- The 2D texturing enhances the photoelectronic capability of black diamond films.

1. Introduction

Diamond is a wide bandgap semiconductor characterized by excellent electronic properties (e.g. high mobility of electrons and holes, high breakdown field, very high diffusion length of conduction electrons, low dielectric constant) combined to unique thermo-mechanical properties (e.g. the highest mechanical hardness and resistance to radiation damage, operating temperatures > 2000 °C under vacuum conditions) that enabled its successful application to devices for high-intensity high-energy radiation and neutrons [1-5]. Diamond has the other advantage of a negative electron affinity (NEA) condition if its surface is hydrogenated [6], meaning that electrons someway promoted into the conduction band have not an energy barrier for their escape into the vacuum. This allowed the application of diamond as an efficient coating for secondary [7, 8], thermionic [9], and field [10] electron emission.

An emerging application in the renewable energy field is the development of high-temperature solar cells based on photon-enhanced thermionic emission (PETE) devices [11], characterized by theoretical maximum