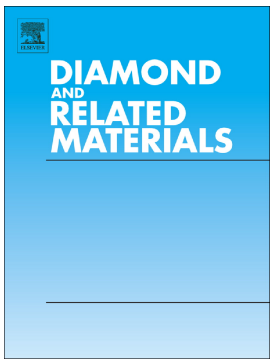


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# Implementation of smooth nanocrystalline diamond microstructures by combining Reactive Ion Etching and Ion Beam Etching

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**Abstract**

Due to its extraordinary properties diamond can be used as mold in a hot embossing process which allows the replication of micro-optical structures. For this application a low surface roughness is indispensable. We investigated the ability of ion beam etching (IBE) to smooth defined rough areas after reactive ion etching (RIE). Simulations based on the influence of the angle dependence of the ion beam etch rate showed the suitability of this approach.
Different surface qualities were achieved for nanocrystalline diamond films by RIE with three different oxygen-argon gas mixtures and etch depth, respectively. SEM images displayed the expected increase of surface roughness with the oxygen share of the gas mixture and the achieved etch depth.
No masking layers were employed during ion beam post-processing. The comparison of different AFM images confirm that this process enlarged the etch depths corresponding to the initial surface roughness until the rough areas are smoothed completely. With increasing surface roughness the expenditure of time necessary to reach saturation rose. Etch rates measured for reactive ion etching were 5 to 6 times higher than the etch rate measured for IBE. Simply comparing the etch time the combination of RIE and IBE is up to four times faster than only employing IBE for the fabrication of structures despite using low RIE plasma powers.

*Keywords:* Reactive Ion Etching, Ion Beam Etching, nanocrystalline diamond, surface roughness

## 1 Introduction

Diamond is a material with extraordinary properties like exceeding hardness, high thermal conductivity, a low coefficient of thermal expansion and chemical inertness. Therefore, it has numerous applications and is interesting for the fabrication of microstructures. These can be used as mold in a hot embossing process, for example, for the replication of micro-optical structures like diffractive optical elements (DOE). Low surface roughness is an important quality factor for microstructures especially in the field of optical applications. The achieved roughness depends on both the fabrication process and the quality of the chosen material. Micropatterning of diamond surfaces is typically performed by lithography and etching techniques. The employed etching process thereby determines the dimensional accuracy of the patterns, the sidewall angle and the surface roughness, whereas ion beam etching (IBE) [1 - 6] and reactive ion etching with capacitive (RIE) [7 – 14] or inductively coupled plasma (ICP) [15 – 21] can be employed. Ar, $SF_6$, $Cl_2$ or $CF_4$ can be added to the oxygen plasma to