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Etching mechanisms during Plasma Jet Machining of silicon carbide

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Due to its excellent properties like high hardness, radiation resistance, very good thermal conductivity and large band gap, SiC is a semiconductor material with a high technological potential for mirrors in space applications.
It has been turned out that plasma jet dry etching is a very effective tool for processing of SiC. Investigations of the etching behaviour of the silicon and carbon oriented face of a 4H-SiC sample treated with a 13.56 MHz rf excited atmospheric plasma jet have been carried out. The jet source consists of a coaxial nozzle with a central tube carrying the feed gases helium and CF_4 and an outer ring-shaped nozzle for N_2 to shield the plasma jet from the surrounding atmosphere. Additionally an O_2 gas flow through the outer nozzle is provided and its effect on the volume removal rate and etching products on the sample surface is discussed. Etching rates with and without sample heating for different CF_4/O_2 mixtures have been measured. A minimum of the volume removal rate has been found for a sample temperature of around 150 °C for the silicon and the carbon oriented face, respectively.
Activation energies for the reaction of fluorine radicals with the SiC surface for varying gas mixtures have been determined from Arrhenius diagrams which indicate a layer forming process besides etching. Therefore X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM) investigations of the etched surfaces have been realized. Results show, that surface oxidation occurs on the surface during etching, where the silicon and carbon oriented face show a different behaviour. Furthermore the minimum in volume removal rate at 150° C sample temperature can be related to enhanced oxide formation and oxide thickness at this temperature.

Keywords
plasma jet machining
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silicon carbide
activation energy