# STUDY OF EROSION OF CERAMIC MATERIALS UNDER TRANSIENT THERMAL LOAD

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## 1. INTRODUCTION

The interaction of the plasma with the surface of the facing components will have a significant impact on the fusion plasma parameters and will also determine the lifetime of the first wall and diverters/limiters. The recent replacement of beryllium by tungsten for the ITER first wall raises anew a number of issues related to plasma-surface interactions, in particular, plasma contamination by high-Z impurities.

One possible solution to this problem is to coat the tungsten with a layer of a low-Z refractory material, such as boron carbide. In addition, in other machines for plasma confinement it is possible to use ceramic protective components [1]. Experimental studies of ceramic materials promising for coating plasma-facing components (PFC) should first of all include the study of hydrogen isotope retention, as well as erosion processes under transient heat loads.

Several experimental setups have been developed at the Budker Institute of Nuclear Physics to study materials for fusion PFC. To study the effects of fusion-relevant thermal exposure on materials, powerful electron beam (up to 1000 J, 100 – 600 µs, 3 cm$^2$) [2], continuous infrared fiber laser for pulsed-periodic material impact experiments (4 kW) and pulsed laser on neodymium glass (up to 200 J, 500 – 800 µs) [3] are used.

## 2. STUDIES CERAMICS FOR PFC

These setups allow simulating transient heat loads (fluxes up to 10 GW/m$^2$, with durations of ~ 0.1 – 1 ms). The heat sources used enable the integration of in situ diagnostic systems to monitor the samples condition. Therefore, the setups are equipped with optical diagnostics that allow studying erosion processes directly during impact. This approach enables a detailed investigation of erosion processes caused by transients, as well as the characterization of threshold thermal loads.

This work presents the capabilities of the experimental complex created at the Budker Institute, as well as the first results of studying the durability of boron carbide coatings deposited by various methods [3]. Other ceramics are also being studied in order to find a suitable alternative armor material for plasma-facing components.

Currently, the erosion of several high-temperature carbides and diborides under single-pulse heating has been investigated. These studies have characterized the threshold thermal load at which the erosion process begins, leading to material loss. The results of this work are shown in Fig. 1.

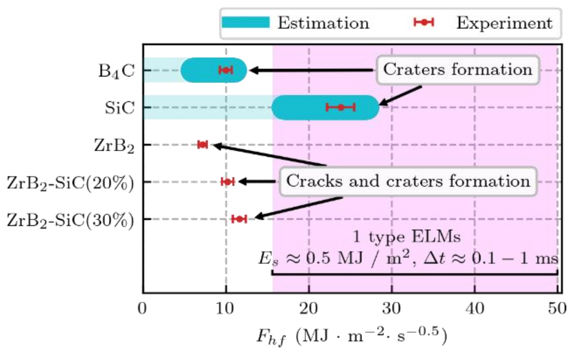


*Fig. 1. The heat flux factors corresponding to the erosion beginning on the surfaces of boron carbide ($B_4C$), silicon carbide (SiC) and zirconium diboride-based ceramics ($ZrB_2$, $ZrB_2$-SiC(20%), $ZrB_2$-SiC(30%)).*

## 3. PROSPECT

Plans for a further experimental campaign include exploring new ceramic materials, specifically diborides such as titanium diboride, as potential replacements for carbides. Carbon-free materials appear more promising due to their expected lower hydrogen retention rate. In addition, the nearest plans include testing samples using a stationary plasma source based on helicon discharge in magnetic field (25 kW, external magnetic field 200 – 600 G, plasma density up to $2 \cdot 10^{13}$ $cm^{-3}$) [4] and periodic pulse electron beam (average power 5 kW, peak power 200 kW, from 100 μs to stationary, up to $10^6$ pulses) [5]. New sources of exposure will make it possible to study the hydrogen retention problem and phenomena associated with thermal fatigue of materials.

## REFERENCES

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