Laser ablation of thin tungsten layers deposited on carbon substrate


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Purpose

The main purpose of the present study was the development of LIBS-based method, which allows the determination of composition and thickness of thin coatings deposited on the main wall of a fusion reactor. For that aims:
- The optical design of the recording system, which is principal is applicable in situ measurements in fusion reactors was elaborated
- The removal rate of tungsten coating on the graphite substrate by excimer laser ablation was estimated

Experimental

Two different types of samples on carbon substrate, graphite IG11, prepared by DIARC Technology Inc using the DIARC plasma method were under the test.

The first type of samples, W-C, had tungsten coating of 0.2 - 5 μm thickness on the graphite substrate.

The second type of samples, DLC-W-C, have sandwich-like coating: tungsten 1 – 5 μm layer on the carbon substrate covered by diamond-like carbon (DLC) 2 – 7.5 μm layer

Samples

LIBS spectra

Tungsten covered samples

Spectra recorded for subsequent laser shots.
Sample: 2 μm tungsten layer on graphite substrate, fluence 6 J/cm²

In the spectrum of the first shot H₂ line is detectable
Continuum decreases with laser shots
There are bands of C in the spectrum
Removal rate of W is ca 0.5 μm per shot

Intensity of characteristic spectral lines as a function of laser shot

LIBS spectra

Tungsten+DLC covered samples

Induced spectra of DLC-W-C samples: 2 μm
DCL on 5 μm tungsten layer, fluence 6 J/cm²

No tungsten lines were observed.
Probable reason: delamination of layers due to the laser action

Photo of a graphite sample with 7.5 μm DLC layer on the top of 5 μm W marker coating, after about 20 laser shots.

Due to the laser action cracks appear and coatings delaminate

Results

The equipment used had sufficient sensitivity for recording of the spectrum during a single laser shot and at low pressures. Without extra problems, LIBS signal should recover 1 m distance.
The diagnostic lines suitable for characterization of tungsten and carbon layers were determined.
Using laser ablation alone, it is not possible to determine DLC layer thickness on W marker coating. At the same time, the current pulses belonging to DLC-W-C and W-C samples differ considerably

Further steps

Time-resolved measurements of LIBS spectrum arising during one laser shot. It allows to diminish the contribution of continuous spectrum and get free from the blocking filter.
Use spectrometer, which is able to resolve hydrogen and tritium lines.

Results obtained by LIBS will be compared with those found by other sample characterization methods.
Find out the similarities and differences of LIBS spectra produced by excimer and Nd:YAG lasers.

Conclusions

Details of testing chamber

Experimental

Samples

Current pulses recorded in circuits of different samples

Current pulse corresponding to DLC differs considerably from the pulse of C substrate When the deposited layers are removed, the current pulses have the same amplitude