§45. Establishment of Surface Erosion Evaluation Method and the Application to Inner Surface Monitor for Large Fusion Chambers

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The first result of our threshold evaluation method was demonstrated with tungsten irradiated by electron beams[1]. This new method to estimate the erosion threshold of various material surfaces with high power pulsed electron beam was extended to the surface erosions with various pulsed laser lights. The most interested here were the erosions of plasma facing surface materials useful for fusion reactor chambers.

When something happens there is the threshold value for the variable to induce the quality change of interest. When we evaluate the threshold value we normally increase the variable from the lower side with the small increment one by one. The total number of increments is large to reach the threshold. On the contrary the total number of decrements is much smaller than the above normal case, when we decrease the variable from the upper side, which is more cost effective to evaluate threshold value. This is a universal explanation for the method proposed in this article.

An example of the universal method is shown for optical inspection of material surface quality change and examples of the applications are described here. The followings are some examples of our methods, and we can extend the method to a variety of derivatives, not only for the crater formations but also for various optical quality of the optical components including reflection and/or transmission coefficients under various environmental conditions accompanied.

The highlight of the candidate material at this time is the CVD polycrystalline diamond, especially the commercial optical grade one. The pulse duration of the laser was 10ns, and the wavelength was 190nm. The repetition rates of the laser was 5Hz. The sample surfaces were irradiated up to 10,000 shots per spot, and the surface erosion profiles were measured with various surface profilers with red laser displacement sensors.

The threshold shot accumulation numbers to start erosions were estimated with the plots of maximum erosion depth vs accumulation numbers in Fig 1. We compared the endurance strength of the above diamond with the tungsten strength. There was not much difference of both strengths, which was very attractive for such diamond to be used as parts of various structure materials especially for the plasma facing surface materials of nuclear fusion reactors.

Different grades of polycrystalline diamonds (thermal management grade and electrochemical grade) were also irradiated with Nd:YAG laser lights (10ns, 1.06 micron and 10 Hz). In this case, we also changed the initial temperature before irradiations from room temperature to 373K and 473K. There were not much differences of the results with the temperature change within this range.

The applications of the above threshold estimation method with the laser displacement sensors and the CVD polycrystalline diamond of optical grade are proposed for the future developments of advanced diagnostic tools in additional paper.

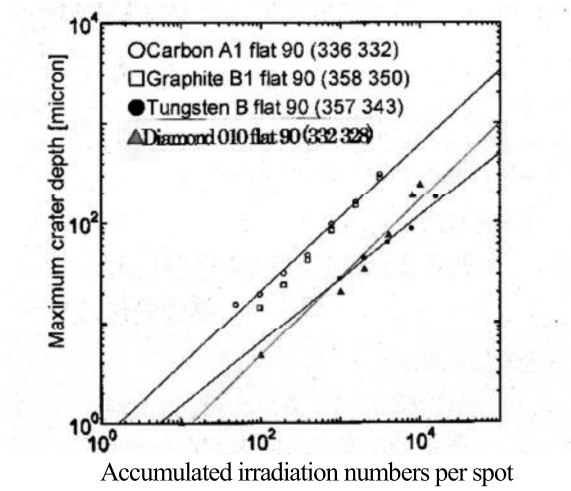

Fig. 1. Maximum crater depth in micron as a function of accumulated irradiation numbers per spot with short pulse ArF laser lights.

After the assurance of the result shown in Fig.1 in the near future with our additional experiments and evaluations, we will be able to demonstrate that the polycrystalline CVD diamond will be able to replace the conventional plasma facing surface materials, for example, CFC and tungsten. It is recommended to prepare more advanced version of displacement sensors with higher algorisms, and more favorable diamond if obtainable.

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1) Kasuya, K. *et al.*, 18th Symposium on Gas Flow and Chemical Lasers, and High Power Lasers, Aug.30- Sept.3, Sofia, Bulgaria, SPIE Proceedings, 7751, Paper No.12, CD-ROM Distribution (2011).