COMPARITIVE STUDY OF POLYMERS AND CERAMICS ABLATION IN ELECTROTHERMAL PLASMA SOURCES*

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Electrothermal plasma sources have various applications in electric launcher technology due to their ability to drive projectiles at hypersonic velocities in hypervelocity launchers. These plasmas have also applications in assisted ballistics, including electrothermal chemical (ETC) launchers, in which the performance of ET sources depends on maximization of pressure, density and velocity. Since the plasma materials are mainly provided from wall ablation inside the capillary tube, electrical properties can be changed with different liner materials depending on the ablation property.

This study provides a comparison between six different ceramics (aluminum oxide, aluminum nitride and boron nitride) and polymers (Teflon, Lexan and polyethylene). The 1-D, time dependent ETFLOW code, a new modified capillary discharge code with modified nodes for materials selection, has been used to calculate the plasma parameters at the exit of the capillary[1]. The code incorporates a nonideal model for the calculation of plasma conductivity[2]. Results show that the plasma temperature is 2.2-2.6eV for all tested materials. The lower dissociation energy and the higher molecular mass per number of atoms in the molecules lead to increased total ablated mass, density, exit pressure, and result in reduction of the bulk velocity. Aluminum nitride has the highest value of total ablated mass, erosion depth, and erosion rate, while polyethylene has the lowest values. The total ablated mass for Lexan is about 30.9 mg, which is in a good agreement with experimental results. It has been found that the dissociation energy is the most affecting property; the higher the dissociation energy the lower the total ablated mass and hence lower ablation depth and ablation rate. Choosing a capillary material with a large number of bonds will lead to a decrease in the total ablated mass. In general, reducing the total ablated material leads to a decrease of the plasma pressure and an increase of the bulk velocity.

1. J. D. Hurley, M. A. Bourham and J. G. Gilligan, “Numerical Simulation and Experiment of Plasma Flow in the Electrothermal Launcher SIRENS”, IEEE Trans. on Magnetics, Vol.31, No.1, 1995, pp. 616-621.
2. M. R. Zaghloul, M. S. Al Na'imi and M. A. Bourham, “Measurement of Electrical Conductivity of Weakly Nonideal Multicomponent Plasma Mixtures Generated From Dielectric Materials”, IEEE Trans. Plasma Sc., Vol. 37, No.8, 2009, pp.1626-1631.

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