§12. Ceramics for Railgun Bore Components

Katsuki, S., Akiyama, H. (Kumamoto Univ. Eng.)
Sato, K. N.

Small-bore railguns have been developed to demonstrate the acceleration of frozen hydrogen pellets that are used to refuel magnetically confined fusion reactors. Erosion of bore surface, which is caused by the energy flux from the plasma armature, is the most serious problem for repetitive operation in plasma armature railguns. Both polycarbonate (PC) and ceramic (alumina) rail spacers were tested to investigate how the heat resistant materials work on the railgun performance. Also heat load at bore was estimated by using 0-D time-dependent railgun plasma simulation including the thermal conduction into the bore materials.

Experiments result that the use of ceramic insulators has made the plasma armature reduced by 30% and the velocity slightly increased. This indicates that the total amount of particles ablated from the bore has been reduced by using ceramics rail spacers.

Figures 1 and 2 show photographs of post-shot rail surface around initial position of projectile in cases of PC and ceramic rail spacers, respectively. Rail material is copper. Plasma current with the density of 20 kA/cm^2 causes the erosion on the bore and forms a special shape like ripples on the rail surface in both cases. States of the surfaces are quite different form each other. Ripple size is much larger and lots of holes are observed everywhere in case of ceramic rail spacer. These holes are caused by vaporization inside the rail. They strongly suggest that the heat from the plasma penetrates deeply into the bore materials. Therefore, heat load on the bore is more severe while heat resistant materials are used.

Figure 3 shows the time evolution of mass and radiation power from the railgun plasma. Upper graph shows that the use of ceramic rail spacers reduces the total amount of ablated materials since the most part of the materials coming from the surface is taken in the plasma. The less ablation leads the increase in plasma temperature, and makes the heat load on the bore enlarged.

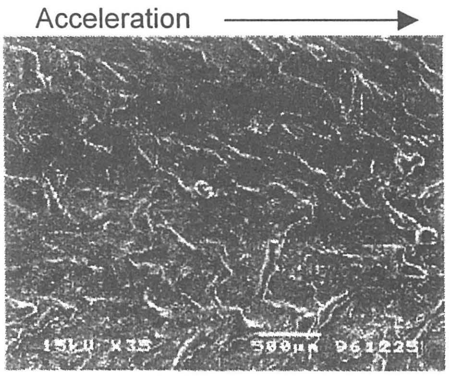

Fig. 1. Photograph of rail surface in the case of polycarbonate insulators.

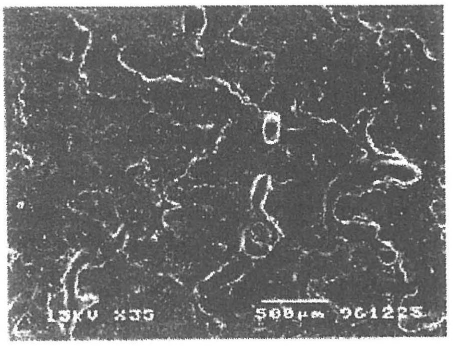

Fig. 2. Photograph of rail surface in the case of ceramic (alumina) insulators.

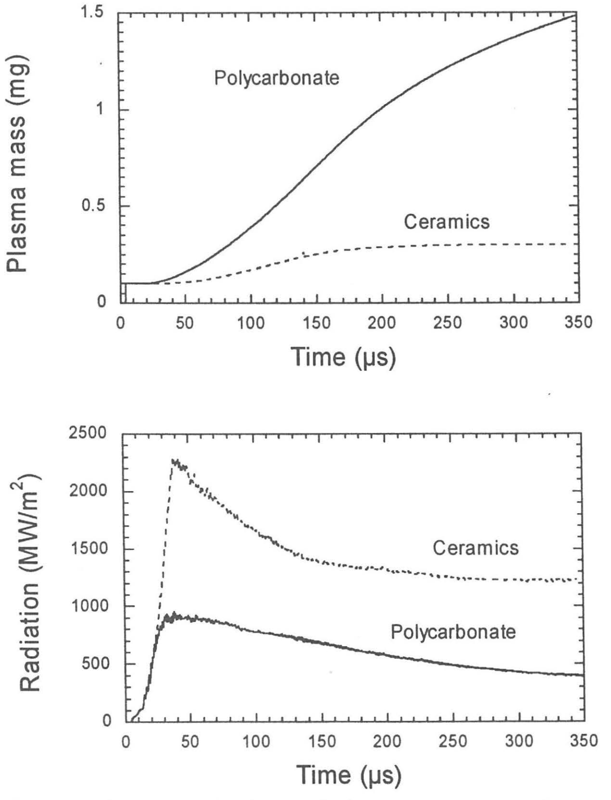

Fig. 3. Time evolution of plasma mass and radiation power from the railgun plasma.