# Thermal Analysis with High Accuracy of Multi-beam Aperture

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**Abstract**

The electron beam lithography machine can write the data pattern by bombarding the photoresist with high energy electron beam, which plays an irreplaceable role in the preparation of high resolution and high precision mask. However, with the decreasing of chip feature size, the production rate of the mask prepared by single electron beam lithography is too low, which limits its application in industry. The multi-electron beam lithography machine developed in recent years can greatly improve the processing efficiency of mask plate by using a large number of electron beam arrays for exposure. However, as a key component for generating array electron beams, the aperture intercepts most of the electrons from the electron gun during operation. These high-energy electrons collide with the splitter module, causing serious thermal effects and distortion of the aperture hole under thermal stress. It will affect the beam shape formed by the electron beam passing through the aperture hole on the mask, and lead to a decrease in pattern accuracy. That will seriously affect the performance of multi electron beam lithography machines. Due to the fact that the aperture operates in a vacuum environment, the existing heat dissipation methods for the beam splitter module mainly rely on surface radiation and heat conduction through surrounding components to dissipate heat, resulting in unsatisfactory heat dissipation effects. Therefore, it is particularly important to find a new and effective heat dissipation technology to reduce the thermal effect of the aperture during working process, so as to improve its stability, accuracy and consistency.

In this study, the thermal effect of the electron beams on aperture was simulated with a finite element numerical method. The variation of temperature field under different cooling methods is compared and analyzed. In addition, a thermal-mechanical coupling model was used to analyze the stress field of the aperture, and the influence of different cooling methods on

the distribution of the stress field was discussed. Finally, the aperture deformation caused by thermal field and stress field under different cooling methods is compared.

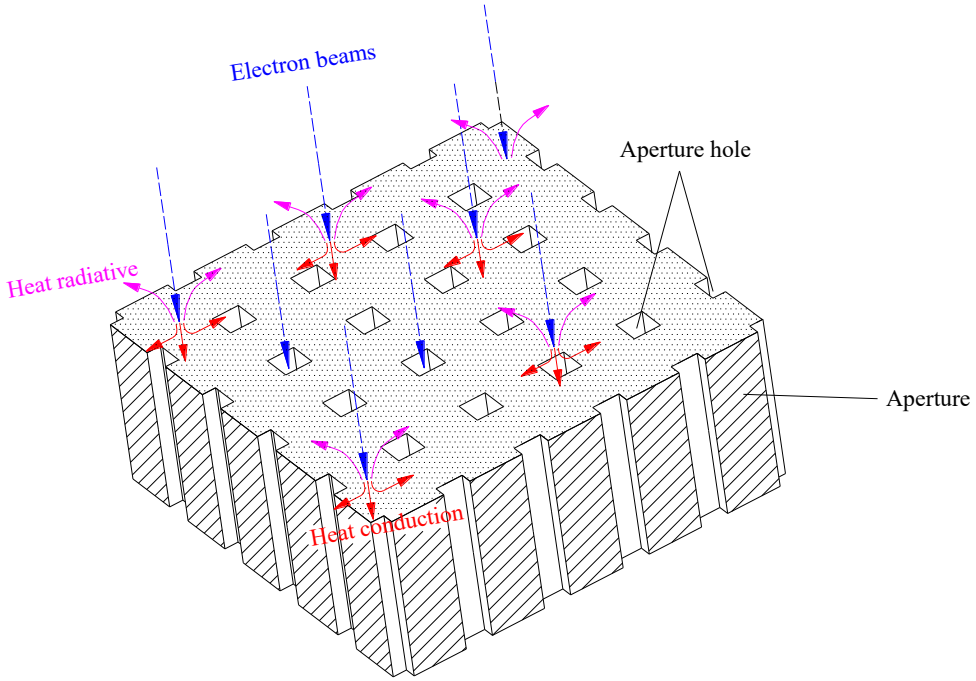


*Figure 1:* Heat exchange diagram of the interaction between multi electron beams and aperture.