耦合器热窗的极限真空方案模拟分析*

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摘　　要：深圳中能高重复频率X射线自由电子激光装置（简称S³FEL）注入器1.3 GHz低温超导加速模组的高功率耦合器热窗的真空泵端口通过角阀连接到真空总管，从而便于安装、检漏和故障诊断。为了保证超导加速模组降温前耦合器热窗的极限压力达标，通过理论计算与软件模拟，对比验证了在不同方案下耦合器所能维持的极限真空度。结果表明：未经处理的耦合器A管采用单台离子泵方案，其极限真空度未能达到实际工程指标；而高温烘烤耦合器A管后，其极限真空度达到10^{-7} Pa量级，优于实际工程指标；耦合器A管设置两台离子泵后极限压力下降50%，可通过继续增加离子泵数量的方法使其满足工程指标。

关 键 词：低温模组；耦合器；热窗；真空

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Simulation Analysis of Ultimate Vacuum Scheme for Coupler Warm Windows

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Abstract: The vacuum pump port of the high-power coupler warm window of the injector 1.3 GHz cryomodule of Shenzhen superconducting soft-X-ray free electron laser (S³FEL) is connected to the vacuum main via an angle valve for easy installation, leak detection and troubleshooting. In order to ensure that the ultimate pressure of the coupler warm window meets the standard before the cryomodule cools down, through theoretical calculation and software simulation, the ultimate vacuum degree that the coupler can maintain under different schemes were compared and verified. The results show that the ultimate vacuum degree of the untreated coupler tube A using a single ion pump does not meet the actual engineering indicator. After high-temperature baking of coupler tube A, its ultimate vacuum degree reaches the level of 10^{-7} Pa, and is better than the actual engineering indicator. After setting up two ion pumps in coupler tube A, the ultimate vacuum pressure decreases by 50%, which can meet the engineering standards by further increasing the number of ion pumps.

Key words: cryomodule; coupler; warm window; vacuum

深圳中能高重复频率X射线自由电子激光装置（以下简称S³FEL）采用先进的超导加速器技术，具有高重复频率、高亮度、飞秒级超短时间脉冲、高相干性、多用户的软X射线光源，同时具有超高时间分辨、空间分辨、能量分辨的特性，作为研究材料以及物质科学前沿的重要工具，在重要的科学领域满足国家重大需求。S³FEL共需要25台1.3 GHz超导加速模组，通过连通段串联形成超导加速器，将电子能量提升至2.5 GeV。S³FEL装置布局如图1所示。

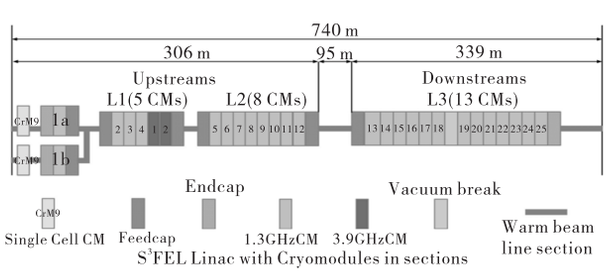

图1　S³FEL装置布局图

Fig. 1　The S³FEL device layout drawing

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