

Development of a 2 kW Class Two-Stage Cascade Type Mixed Refrigerant Joule-Thomson Refrigerator for Semiconductor Etching Process with Cooling Temperature Below -100°C

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A mixed refrigerant (MR) Joule-Thomson (J-T) refrigerator has been developed for application in the semiconductor etching process. The designed refrigerator operates on a 2-stage cascade-type MR J-T refrigeration cycle. For pre-cooling, a vapor compression cycle utilizing R1234yf, a low global warming potential refrigerant, is employed. The main cooling cycle utilizes a mixture of argon (Ar), tetrafluoromethane (R14), trifluoromethane (R23), and octafluoropropane (R218). The target temperature of the MR J-T refrigerator is below -100°C . To facilitate its application in semiconductor etching, an indirect cooling method using coolant (HFE77200) is introduced. The paper provides a detailed description of the component selection process, including the compressor and heat exchanger, based on the design results. Additionally, numerical analysis of the coefficient of performance of the designed refrigeration cycle is presented, along with experimental results.

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