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CW mode test and electromagnetic-thermal simulation of conduction-cooled SRF cavities at PKU

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A liquid helium-free cryostat for RF testing of superconducting cavities has been designed and constructed. G-M cryocoolers are used to provide cooling capacity, with heat leakage less than 0.02 W at 4 K. The vertical test of the Nb3Sn cavity and the horizontal test of the Nb cavity were carried out with the cryostat using different connection structures between the 4 K stage of the cryocooler and the cavities. Both cavities are cooled down to 4 K and stable CW operation was achieved at low Eacc The Q0 of Nb3Sn cavity tested was very close to that in 4.2 K LHe when the EACC was less than 1.2 MV/m. The maximumEacc of Nb3Sn cavity and Nb cavity reached 1.75 MV/m and 0.43 MV/m, respectively. The test results showed that the thermal uniformity of the cavity can be effectively improved by cold spraying a ˜2 mm thick Cu layer on the outer surface of the cavity. An electromagnetic-thermal coupling simulation model for superconducting cavities was established and a novel connection is designed based on the cold spraying process and high thermal conductivity Cu and Al. Under worst-case conditions, the simulation results indicated that the cavity temperature can be controlled at about 5 K when the RF loss is 2.7 W using this connection. For a Nb3Sn cavity prepared by the authors (Q0=2×109 @ Eacc=10 MV/m), the Eacc is expected to reach at least 7 MV/m. A Nb3Sn cavity cold-sprayed with a 2 mm thick Cu shell and flanges is currently being processed to validate this connection design.

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