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M2Po3B-05: Design and development of near field emissivity measuring device for superconducting materials

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With the advancement of micro- and nano-machining technologies, the distance between components in devices has continually decreased, leading to heat fluxes that exceed the radiation limits predicted by Planck's law. These rapidly increasing heat fluxes can have detrimental effects on near-field devices in cryogenic temperatures, such as difficulties in heat dissipation and reduced operational lifespans. However, studies have shown that the near-field radiation intensity of superconducting materials decreases in their superconducting state, providing a novel approach for thermal management in near-field devices. Therefore, this paper presents a device designed to measure the near-field radiative heat transfer (NFRHT) of superconducting materials. The device consists of a temperature-controlled calorimetric module, a distance adjustment module, and a parallel ranging module, among others. The temperature-controlled calorimetric module uses a steady-state calorimetric method to measure heat flux by determining the temperature difference between the two ends of a heat flow meter, with a minimum detectable value of 1 microwatt. The distance adjustment module features a mechanical piezoelectric driver and spring-connected moving rods, enabling movement with a precision of 0.1 microns. The parallel ranging module incorporates a planar parallel maintainer with a plane-relative deviation spacing of up to 0.1 microns and a measuring range of less than 100 microns, using a capacitive sensor. This device can drive and measure micrometer-scale step lengths at near-field distances, with a total measurement uncertainty of less than 5%.

Authors: LI, Bixi (Technical Institute of Physics and Chemistry); Mr HUANG, Zichun (Technical Institute of Physics and Chemistry); Mr XIE, Liancheng (Technical Institute of Physics and Chemistry); Mr ZHANG, Hengcheng (Technical Institute of Physics and Chemistry); Ms SHEN, Fuzhi (Technical Institute of Physics and Chemistry); Mr ZHANG, Hao (Technical Institute of Physics and Chemistry)

Presenter: LI, Bixi (Technical Institute of Physics and Chemistry)

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