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Low-temperature thermal conductivity of highly porous copper

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The development and characterization of new materials is of extreme importance in the design of cryogenic apparatus. Recently the Versarien company developed a technique capable of producing copper foam with controlled porosity and pore size. Such porous materials could be interesting for cryogenic heat exchangers as well as of special interest in some cryogenic devices for microgravity environments. For instance, in our Energy Storage Units [1, 2] for potential use in space applications, a porous ceramic is used to retain a cryogenic liquid (N_2, Ne, H_2, He) by capillarity. However, due to the ceramic's low thermal conductivity, a high thermal gradient builds up for low filling ratios. A high thermal conductivity material like copper with small pore size and high porosity (up to 80%) would combine the same capillary effect with a good thermal homogeneity in this type of devices with the possibility of easy soldering.
In the present work, a system was developed to measure the thermal conductivity of four Versarien samples of copper foam for a porosity between 50% and 80%, within the range of temperatures 20 –260 K, using a 2 W @ 20 K cryocooler. The coherence of our measurements is validated using a copper control sample and by electrical resistivity measurements at room temperature, by the estimation of the Lorenz number. With these measurements, the purity (Resistivity Residual Ratio) and the tortuosity were obtained for all samples.

[1] J. Afonso et al., Cryogenics 51 (2011) 621-629.
[2] P. Borges de Sousa et al. « 15 K LIQUID HYDROGEN THERMAL ENERGY STORAGE UNIT FOR FUTURE ESA SCIENCE MISSIONS », this conference.

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