Measurement of the Intrinsic Conductivity of Copper at Near-Terahertz Frequencies

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Terahertz (THz) radiation could be employed in a variety of applications, such as molecular spectroscopy, medical imaging, and high speed communications. However, devices that realize this promise are rare, largely due to a lack of powerful, efficient, and compact radiation sources (P. H. Siegel, *IEEE Trans. on microwave theory and techniques*, vol. 50, no. 3, pp. 910–928, 2002).

One reason for the slow development of THz devices is that the theoretical understanding of the conductivity of metals is incomplete beyond 100 gigahertz (GHz). Confirming such a theory is difficult because experimental measurements in this regime are unavailable, unrepeated or even contradictory (S. Lucyszyn, *IEE Proc.-Microwaves, Antennas and Propagation*, vol. 151, no. 4, pp. 321–9, 2004). Electromagnetic simulation tools, used in THz device design, would be enhanced by employing improved models for metal conductivity as a function of frequency and surface characteristics. Better computational tools would then enable superior device design.

We will present measurements of the intrinsic conductivity of bulk copper at 400, 650 and 850 GHz. These data will help fill part of the existing gap in the published literature, and will be of interest to designers of THz devices and makers of electromagnetic simulation software. We will also compare our measurements with several models for surface impedance in order to determine whether our experimental results agree with classical predictions, i.e. the Drude model.

We performed these measurements using a high quality factor quasi-optical hemispherical resonator. Previous measurements performed by others using similar systems have been demonstrated up to 370 GHz (M. Y. Tretyakov, et. al. J. of Mol. Spectr., vol. 238, no. 1, pp. 91–97, Jul. 2006). Our group has already presented measurements at 400 and 650 GHz, exceeding this frontier. We are now able to make measurements at 850 GHz as well. This method of measurement proved to be highly sensitive to variations in ambient temperature, so a temperature stabilization system was employed to reduce uncertainty in the data.