

The Classification of Skin Effect Regions of Pure Metals I: A Diagram of the Incident Frequency vs. the Relaxation Time of Metal

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This is the first part of a series of two papers. In this work, the classification of skin effect regions has been re-investigated under the conditions of various frequencies of incident electromagnetic waves and relaxation times of pure metals for the case of an electromagnetic wave at normal incidence upon the plane surface of a semi-infinite metal. There are four characteristic times (or corresponding characteristic lengths) in this phenomenon, which are: the collision time related to the de Broglie wavelength, the relaxation time for conduction electrons' collisions, the period of the applied field, and the hydrodynamic time related to the skin depth, which represent the variation of the applied field in the metal. Based on relative magnitudes of these four characteristic times, the skin effect is divided into four regions: the classical skin effect region C, the relaxation effect region R, the anomalous skin effect region A, and the quantum effect region Q. Three main discrepancies between this classification and related results in literature are discussed. As examples, the skin effect regions of the monovalent metals copper, gold, and chromium are shown in frequency vs. relaxation time diagrams.