Impedance Spectroscopy of Thin Films

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Impedance spectroscopy measures the dielectric and conducting properties of a medium as a function of frequency, and fundamentally probes the interaction of a material or device with a time-varying electric field. By measuring the complex impedance as a function of frequency, one gains access to both the energy conserving and dissipative mechanisms of a sample's response to an electric field, whereas more traditional transport measurements probe either only the dissipative (e.g., resistance) or energy storage (e.g., capacitance) characteristics of the system's response. In this talk, we will introduce the basic principles of impedance spectroscopy, and illustrate the utility of the technique by way of several recent applications. First, we show how transport measurements can provide unique insight into the magnetic phase transitions in FeRh-based magnetic alloys possibly relevant for magnetic recording. Second, we illustrate a magneto-capacitive effect in MgO-based magnetic tunnel junctions, analogous to the well-known magnetoresistance effect. Third, we illustrate how temperature-and field-dependent impedance spectroscopy coupled with standard magnetic characterization can probe the interplay of magnetic and electric dipole ordering in magnetoelectric oxides. Finally, we will show our recent results in characterizing the metal-insulator transition in vanadium dioxide, providing some insight into the mechanism of this yet incompletely-understood material.