Abstract (PhD Thesis Martin Lonsky)

This thesis is concerned with systematic investigations of electronic noise in novel condensed matter systems. Although fluctuations are frequently considered a nuisance, that is, a disturbance limiting the accuracy of scientific measurements, in many cases they can reveal fundamental information about the inherent system dynamics. During the past decades, the study of electronic fluctuations has evolved into an indispensable tool in condensed matter physics.

The focus of the present work lies both in a further development of the fluctuation spectroscopy technique and in the study of materials of current interest. In particular, a comprehensive study of the charge carrier dynamics in the archetypal diluted magnetic semiconductors (Ga,Mn)As and (Ga,Mn)P was performed. In spite of extensive research work carried out during the last years, there still exists no theoretical consensus on the precise mechanism of ferromagnetic order and the electronic structure in these materials. Moreover, disorder and correlation effects complicate the understanding of these compounds.

Fluctuation spectroscopy experiments presented in this work provide strong evidence that a percolation transition is observed in samples with localized charge carriers, since the normalized resistance noise magnitude displays a significant enhancement around the Curie temperature. In addition, this quantity exhibits a power law scaling behavior as a function of the resistance, which is in good agreement with theoretical models of percolating systems. By contrast, it was found that the resistance noise in metallic samples is mainly dominated by the physics of defects such as manganese interstitials and arsenic antisites.

Furthermore, first noise studies were carried out on hafnia- and yttria-based resistive random access memories. In these memristor devices, the rupture and re-formation of oxygen deficient conducting filaments caused by the electric field and Joule heating driven motion of mobile anions lead to an unusual resistance switching behavior. For the first time, comparative noise measurements on oxygen deficient and stoichiometric hafnium oxide devices, as well as on novel yttrium oxide based devices were performed in this work.

Finally, new strategies for noise measurements of highly insulating and extremely low-resistive samples were developed and realized. In detail, an experimental setup for the measurements of dielectric polarization fluctuations in insulating systems was designed and successfully tested. Here, the polarization noise of a sample is measured as current or voltage fluctuations produced within a capacitance cell. The study of dielectric polarization noise allows for conclusions to be drawn regarding equilibrium structural dynamics in insulators such as relaxor ferroelectrics. On the other hand, as successfully demonstrated for a heavy-fermion compound, focused ion beam etching enables to introduce a meander-shaped geometry in single crystal platelets, in order to strongly enhance the sample resistance and thus make resistance noise measurements possible. First results indicate a connection of the noise properties with the Kondo effect in the investigated material.