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Invention Title: Bridge Enhanced Nanoscale Impedance Microscopy

Inventor(s): Mark Hersam, Liam Pingree

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Patent or Application Serial No.: 11/490,592

Grant/Contract Number(s): DMR-0134706 , CMS-0304472

Foreign Applications filed/intended in (countries):

The invention identified above is a Subject Invention under **35 U.S.C. 200, et seq.**, and the Standard Patent Rights clause at **37 CFR 401.14, FAR 52.227-11** or **FAR 52.227-12** (if applicable) which are included among the terms of the above identified grant or contract award from the United State Government. This document is confirmatory of:

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Signed this 23rd day of August, 2006

By Indrani Mukharji, PhD (Name of Grantee/Contractor Official) Indrani Mukharji (Signature)

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Bridge-Enhanced Nanoscale Impedance Microscopy

This application claims priority benefit from application serial no. 60/701,286, filed on July 21, 2005, the entirety of which is incorporated herein by reference.

The United States Government has certain rights to this invention pursuant to Grant No. NCC 2-1363 from the National Aeronautics and Space Administration, and Grant Nos. DMR-0134706 and CMS-0304472 from the National Science Foundation, to Northwestern University.

Background of the Invention.

For decades, macroscopic impedance spectroscopy techniques have characterized alternating current (AC) charge transport for a variety of materials systems and devices. Subsequent modeling of this frequency dependent behavior has revealed underlying electrolytic surface reactions, doping levels of semiconductors, the properties of interfaces in organic and inorganic multilayer devices, and charge transport in percolation network systems. However, these macroscopic methods only reveal an ensemble average of the underlying contributions of individual pathways, defects, film thickness variations, electrochemical reactions, and failure mechanisms. To probe these effects with higher spatial resolution, a series of noncontact scanning probe impedance measurement techniques have been developed, such as scanning capacitance microscopy, scanning capacitance spectroscopy, and scanning impedance microscopy. These strategies sense relatively long-range electrostatic interactions between the probe and the sample with spatial resolution on the order of 50 nm.

However, such techniques can be limited. For instance, in scanning capacitance microscopy, a non-contact mode technique, long-range tip-sample interactions contribute to the overall signal, and the topography and capacitance signals are completely convolved and cannot be separated. Scanning capacitance spectroscopy, another non-contact mode approach, is likewise hindered and can require a data collect period approaching 24 hours. Scanning impedance microscopy is another non-contact technique, also providing convolved topography and capacitance signals. To deconvolved such modulations, a two-paths method is employed: in the first scan, the