G-Mode KPFM: Bringing Kelvin Probe Force Microscopy into the Information Age

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Atomic force microscopy has advanced well beyond simply topographic imaging to simultaneously allow advanced functional imaging of materials magnetic, electrostatic, electrochemical properties among many other material properties. In particular, Kelvin probe force microscopy (KPFM) has provided deep insights into the local electronic, ionic and electrochemical functionalities in a broad range of energy storage and conversion materials and devices. Practically, the detection methodologies adopted in classical KPFM limit the measurement in terms of channels of information available and the time resolution of the measurement (e.g. ~1-10 MHz photodetector stream is down sampled to a single readout of surface potential per pixel). Despite the popularity of KPFM, the level of information available is not sufficient for some systems such as electroactive materials, devices, involved in energy conversion and storage which typically involve time and bias dependent electrochemical phenomena. In this presentation, the foundations are laid for a new era in functional imaging utilizing big data collection and analytics. General Acquisition mode (G-Mode) KPFM will be introduced, and combined with big data analytics, will be shown to be possible to extract dynamic information on the local electrochemical processes taking place with nanometer resolution. G-Mode KPFM is immediately implementable on all atomic force microscopy platforms, is shown to allow simultaneous capture of numerous channels of information simultaneously, as well as increased flexibility in terms of data exploration across frequency, time, space, and noise domains. Furthermore, because electrostatic between the scanning probe tip and the sample can be mistaken for piezo-electric behavior in piezoresponse force microscopy, it is highly valuable to have a reliable, fast, and information rich method to help differentiate these two phenomena.