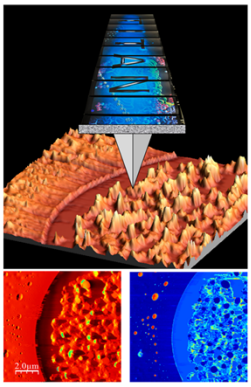
"Googling" the Wealth of Information Available from Microscopy



Atomic Force Microscopy (AFM) imaging of mixed polymer plastics (polystyrene and polycaprolactone). The response of the cantilever excitation is analyzed using supercomputing power (Titan) to extract many material parameters from a single experiment, for example material stiffness (bottom left) and electrostatic response (bottom right).

Work was performed at the Center for Nanophase Materials Sciences.

Scientific Achievement

Measurements of local properties over a large dynamic range, by capturing all relevant information of tip-surface interactions in large data sets, and analyzing them using a supercomputer.

Significance and Impact

Previous techniques often capture only the information that is deemed valuable. The current method provides a way to collect complete sets of data, without imposed operator bias. Big data algorithms then provide maximal understanding of materials. Supercomputers make this fast enough for real-time feedback to the microscopists.

Research Details

- Full acquisition of the motion of a scanning probe microscope's cantilever during an experiment, with subsequent analyses of the data yields all relevant information about the response.
- Data analytics enable exploration of physics in an objective and unbiased manner.

A. Belianinov, S. Kalinin, S. Jesse, *Nature Communications (2015)* DOI:10.1038/ncomms7550.

U.S. DEPARTMENT OF ENERGY | Office of Science

OAK RIDGE National Laboratory

Narrative Highlight Text: This work highlights the development of the G-mode which is a new approach which allows full exploration of multidimensional tip-surface interaction in dynamic Atomic Force imaging at the information channel capacity limit. The use of multivariate statistical methods such as Principal Component Analysis, allows one to guide a data sampling strategy and attain insight into data structured in space, frequency, and informational domains. This method is much more advantageous compared to current lock-in based microscopy techniques, since it provides a way to explore data without information loss or imposed bias, along with the statistical feedback for a complete understanding of a system, as well as effective compression of the produced information. Having access to the entire data set increases operator's confidence in the observed phenomena since the resulting signal can be analyzed from different perspectives providing an answer to a myriad of question relating to data veracity and experimental conditions. With this new, in depth knowledge, dynamic Atomic Force Microscopy can begin to transition to models that are dictated by physics of tip surface interaction as imprinted in the recorded full cantilever response.

Reference

"Complete information acquisition in dynamic force microscopy"
Alexei Belianinov, Sergei V. Kalinin, Stephen Jesse
The Institute for Functional Imaging of Materials and Center for Nanophase Materials Sciences, Oak Ridge National Laboratory,
Oak Ridge, TN 37831
Nature Communications Accepted

Acknowledgement of Support

Research for (AB, SVK and SJ) was conducted at the Center for Nanophase Materials

Sciences, which is sponsored at Oak Ridge National Laboratory by the Scientific User Facilities Division, Office of Basic Energy Sciences, U. S. Department of Energy. Polystyrene - polycaprolactone polymer blend test sample courtesy of Oxford Instruments Asylum Research.