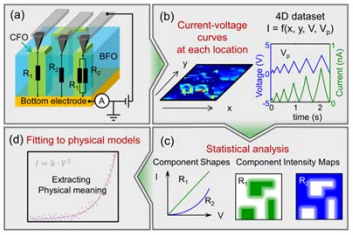
## Deep data analysis of conductive phenomena




a) Nanocomposite schematic (BFO – $BiFeO_3$, CFO – $Co_2Fe_2O_4$)
b) A 4D complex dataset is obtained during measurements
c) The dataset is deconvoluted using statistical analysis
d) The shapes of the deconvoluted current-voltage curves are fitted to physical models

Work was performed at the Center for Nanophase Materials Sciences; samples were obtained from National Chiao Tung University, Taiwan

### Scientific Achievement

**A new data mining approach for extracting physically-meaningful information from complex multidimensional scanning probe microscopy datasets is tested.**

### Significance and Impact

**Our statistics-based approach allowed separation of complex conductive behavior of a nanocomposite into four components with clear physical meaning.**

### Research Details

– $BiFeO_3/Co_2Fe_2O_4$ nanocomposite shows complex interfacial transport behavior.

– A 4D dataset containing information on its conductivity can be deconvoluted into four components and four intensity maps that show: 1. Ohmic behavior, 2. transport through a barrier, 3. low conductivity, 4. Memristive behavior in different parts of the nanocomposite.

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**Narrative Highlight Text**: Materials and phenomena in the world around us exist in an interweaved, entangled form. Decomposition of complex materials' behavior and processes are the key to understanding manifestations of Nature. However, tools for enabling such decomposition are not readily available, and therefore, complex systems often remain well-characterized experimentally, but still not well understood due to intricacy of the collected data. The spectroscopic modes of scanning probe microscopy (SPM) are an example of such data. Such high variability data on the nanoscale behavior of materials should be very useful for understanding and controlling materials functionality. Yet, to date there is no established method of analyzing such data or for understanding what they mean. In this paper we introduce a universal approach for treating multidimensional data sets and extracting physical meaning from them. Multivariate statistical analysis, which has proven be extremely useful in image recognition, electronic noses, etc., can be used for decomposing SPM spectra into few spatially-localized components to provide a straightforward physical meaning. We show that the conductive behavior of the BiFeO3-CoFe2O4 nanocomposite can optimally be represented by four components: a linear, non-linear, noisy low signal, and memristive. We demonstrate the power of the presented approach/method and discuss the limits of its applicability. This deep data analysis approach is very promising for aiding in the unraveling of nanoscale behavior in a wide range of systems and it can complement a large number of other types of experimental techniques (other imaging modalities, chemical spectroscopies, etc.).

**Reference**

"Deep Data Analysis of Conductive Phenomena on Complex Oxide Interfaces: Physics from Data Mining"
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