

# **Nanocomposites, Nanostructures and Heterostructures of Correlated Oxide Systems**

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# Nanocomposites, Nanostructures and Heterostructures of Correlated Oxide Systems

Symposium held April 9–13, 2012, San Francisco, California, U.S.A.

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\*Invited Paper



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## PREFACE

This volume contains papers presented at the Symposium-HH “Nanocomposites, Nanostructures and Heterostructures of Correlated Oxide Systems” held in San Francisco, California, April 9–13, 2012, during the JSAP-MRS Joint Spring Meeting (JSAP: Japan Society of Applied Physics). This was one of the eleven special symposia celebrating the 80th anniversary of JSAP. A high level of interest was demonstrated by the large number of papers presented (180), as well as the large attendance and vigorous discussions during the four days of talks and poster presentations. Furthermore, the stage was set prior to the Symposium by a comprehensive tutorial on “Oxide Heterostructures and Nanostructures – Fabrication, Properties, Magnetic Coupling, and Applications.” The friendly atmosphere encouraged a keen Q/A between the speakers and the audience, and was effective in attracting a wide range of scientists and engineers from academic, government, and industrial institutions.

**Scope and Focus of the Symposium:** Future electronics will increasingly rely on oxide materials because of their unique functionalities. Advances in the synthesis and characterization of oxide thin films and nanostructures have brought about the observation of exciting new materials phenomena. The parallel fields of oxide heteroepitaxy and nanomaterials both exploit surfaces, interfaces, and boundaries in materials to achieve better performance and new properties. Core to both fields is the ability to control these structures at unprecedented atomic levels. Because of these common themes in this Symposium, we aimed to bring together researchers from both communities to identify and illuminate new areas of interaction and collaboration. The combined expertise of the two fields were explored and connected to major challenges across the disciplines. At their core, the ability to control multi-layered oxide thin film heterostructures to possess well defined surfaces and interfaces makes them a novel extension and an ideal form of nanocomposite systems. This symposium, in particular, focused on correlated electron phenomena in such nano- and heterostructures.

### Topics addressed in the Symposium:

- Synthesis and characterization of oxide nanocomposites/nanomaterials, heteroepitaxial thin films, and multi-layered systems
- Characterization and control of defects in oxide nanocomposites and heterostructures
- Studies of functional oxide materials arising from electron correlations (magnetic, dielectric/ferroelectric, superconducting, etc.)
- Studies of interfacial properties in such materials (ferromagnetic/superconductor, novel p-n junctions, exchange bias)
- Novel ferromagnetic/ferroelectric/multiferroic properties arising from hetero-interfaces

The Symposium was composed of Invited, Oral and Poster presentations. Subjects were discussed in the following categories:

- Nanostructures
- Strongly correlated systems and metal-insulator transition
- Multiferroics and magnetoelectric effects
- Manganites and magnetism
- ZnO and transparent conducting oxides
- Superconductivity
- Nanocarbon
- Heterostructures and interfaces
- Thin film growth processes
- Two dimensional electron gases

From the beginning to the end, the session room was full of participants, it was quite impressive.

While there were many exciting contributions, a few are highlighted here. S. Gemming discussed how local changes due to point and planar defects can be correlated to changes of the elastic, polarization and magnetic properties. K. Tanaka investigated the strain and structural dependence of magnetic properties in the exciting multiferroic  $\text{EuTiO}_3$ . J. MacManus-Driscoll discussed exciting developments in the search for room temperature magnetoelectric effects. M. Fitzsimmons reported on the use of polarized neutron reflectometry to probe the magnetic response in  $\text{LaAlO}_3/\text{SrTiO}_3$  heterointerfaces and thus provided strong insight into the nature of magnetism found in this system. S. te Velthuis reported on studies of magnetic structure at oxide interfaces using polarized neutron reflectometry. A. Ohtomo succeeded to grow ordered  $\text{La}_2\text{CrFeO}_6$  and  $\text{La}_2\text{VMnO}_6$  double-perovskite thin films with ferrimagnetic ordering, which may prove useful for future applications.

In this Symposium, we tried a unique approach of identifying a special theme, i.e., clarification of the relationships among Nanocomposites, Nanostructures and Heterostructures to gain a deeper understanding of Nanocomposites. Then, an international team of collaborators was proposed around this common research theme: a clear and systematic understanding of Nanocomposites is challenging due to the irregular structure and complex interfaces. However, by introducing ion implantation damage to a Heterostructure, it is possible to transform it into a Nanocomposite. We can therefore trace the evolution of the structures during this processing, leading to a better understanding of Nanocomposites. According to this idea, three papers were presented at the Symposium representing the international research group. This work will pave the path forward to even more magnificent results, which we hope will be presented at the second series of JSAP-MRS-13F in Kyoto in 2013. The preparation for this second joint Symposium has already begun, and the Organizers look forward to an even more enthusiastic attendance with great contributions.

Tamio Endo  
Hiroaki Nishikawa  
Nobuyuki Iwata  
Anand Bhattacharya  
Lane W. Martin

September 2012

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The Symposium organizers greatly appreciate all of the contributing authors who have made the Symposium a productive forum for research interaction. We thank the invited speakers who profitably lead discussions. The invited speakers were: Kai Liu (U. California-Davis), Sibylle Gemming (HZDR), Akira Ohtomo (Tokyo Inst. Tech.), Jacobo Santamaria (U. Complutense), Josep Nogues (U. Autònoma de Barcelona), Suzanne te Velthuis (Argonne Nat. Lab.), Judith M-Driscoll (U. Cambridge), Katsuhisa Tanaka (Kyoto U.), Reji Philip (Raman Res. Inst.), Peter Badica (INCDFM), Hitoshi Tabata (U. Tokyo), Shigetoshi Ohshima (Yamagata U.), Tetsuya Yamamoto (Kochi Univ. Tech.), Toshio Kamiya (Tokyo Inst. Tech.), Hideomi Koinuma (U. Tokyo), and Ulrich Habermeier (Max-Planck).

We also thank the four tutorial instructors. Their marvelous lectures given at the beginning of the Symposium set the stage for the presentations which contributed substantially to the Symposium. The tutorial instructors were: Hidekazu Tanaka (Osaka U.), Ulrich Habermeier (Max-Planck), Manfred Fiebig (ETH Zurich), and Guus Rijnders (U. Twente).

We would like to express sincere thanks to the session chairs who made the sessions and discussions run smoothly, to the reviewers of proceeding manuscripts for their prompt and careful reviews, to the international collaborative research group (J. Fassbender, K. Liu, S. Gemming, J. Osten), to the Symposium committees (S. Arisawa, T. Tsuchiya, A. Hoffmann, A. Suzuki) for their help of organizing and widely promoting the Symposium. We especially thank Kazuhiro Endo for his great assistance in initiating the Symposium and valuable suggestions.

We wish to thank the organizations for their financial support, to whom we owe the achievement of a successful Symposium: Japan Society of Applied Physics, Materials Research Society, and Sigma-Aldrich.

Finally we gratefully acknowledge the Materials Research Society and 2012 Spring Meeting Chairs for beautifully organizing this Meeting, and the MRS publications staff for assembling these proceedings. We express special thanks to Kazumi Wada and Osamu Ueda for their great work to lead and manage the JSAP-MRS Joint Symposium Groups.

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