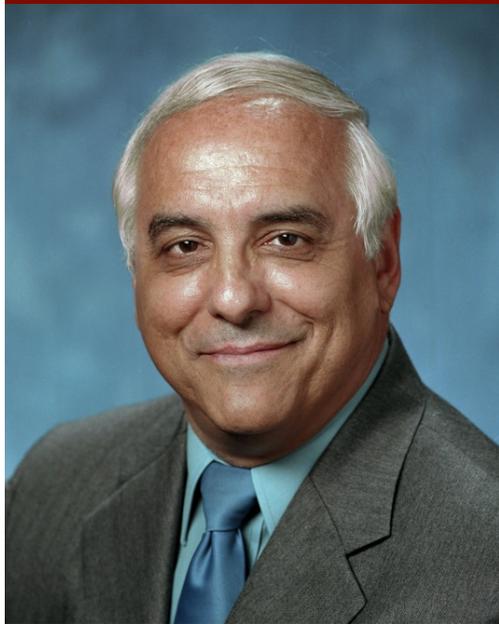


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# Science and Technology of Multifunctional Oxide and Ultrananocrystalline Diamond (UNCD) Films



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**Abstract:** New paradigms in the research and development of novel multifunctional oxide and nanocarbon thin films are providing the bases for new physics, new materials science and chemistry, and their impact in a new generation of multifunctional devices for micro/nano-electronics and biomedical devices and biosystems. This talk will focus on discussing the science, technology, and engineering of multifunctional oxide and nanocarbon thin films and applications to a new generation of multifunctional micro and nanodevices and systems, as described below:

**1. Science and technology of complex oxide thin films and application to key technologies:** Novel  $\text{TiO}_2/\text{Al}_2\text{O}_3$  superlattices, exhibiting giant dielectric constant (up to  $k=1000$ ), low leakage current ( $10^{-7}$ - $10^{-9}$  A/cm<sup>2</sup>) and low losses ( $\leq \tan \delta=0.04$ ), based on new physics underlined by the Maxwell-Wagner relaxation mechanism, which enables a new generation of microchip embedded capacitors for microchips implantable in the human body, the next generation of gates for nanoscale CMOS devices, and super-capacitors for energy storage systems;

**2. Science and technology of novel ultrananocrystalline diamond (UNCD) films and integration for fabrication of a new generation of industrial components and multifunctional and biomedical devices:** UNCD films developed and patented at by Prof. Auciello when working at Argonne National Laboratory (1996-2012) are synthesized by a novel microwave plasma chemical vapor deposition technique using an Ar-rich/ $\text{CH}_4$  chemistry that produces films with 2-5 nm grains, thus the name UNCD to distinguish them from nanocrystalline diamond films with 30-100 nm grains. The UNCD films exhibit a unique combination of outstanding mechanical, tribological, electrical, thermal, and biological properties, which already resulted in industrial components and devices currently commercialized by Advanced Diamond Technologies (a company co-founded by O. Auciello and J.A. Carlisle and spun-off from ANL in 2003). Devices and systems reviewed include: a) UNCD-coated mechanical pump seals for the petrochemical, pharmaceutical and car industries (**shipping to market**); b) UNCD-coated bearings for mixers for the pharmaceutical industry (**shipping to Merck-Millipore market**); c) new UNCD electrodes for water purification, which outperform all other electrodes in the market today (**shipping to market**); d) UNCD-AFM tips for science and nanofabrication (**shipping to market**); e) RF-MEMS switches monolithically integrated with CMOS driving devices for next generation of radars and mobile communication devices; f) UNCD-based MEMS biosensors and energy harvesting devices g) NEMS switch-based logic; h) bioinert UNCD coating for encapsulation of a microchip implantable in the retina to restore sight to people blinded by retina photoreceptors degeneration (**31 blind people received microchip implants in 5 countries and are reading letters and recognizing objects and walking through doors without aid**); i) UNCD bioinert coating for heart valves; j) UNCD coating for devices to drain eye liquid for treatment of glaucoma; k) UNCD coating for magnets located outside the eye to produce magnetic fields to attract superparamagnetic nanoparticles injected in the eye to reattach detached retina; l) UNCD coating for stents; m) UNCD coating for artificial joints (hips and knees); n) UNCD surface used as a unique platform for growing stem cells and induce differentiation into various cells of the human body.

**Biography:** Orlando Auciello is currently an Endowed Chair Professor at UTD, sharing his duties between the Materials Science and Engineering and Bio-Engineering Departments. Auciello graduated with M.S. (1973) and Ph.D (1976) degrees in Physics from the Physics Institute "Dr. Balseiro" (Universidad Nacional de Cuyo, Argentina). He also studied Electronic Engineering at the University of Cordoba-Argentina (1964-1970). Auciello was a Researcher at the University of Toronto-Canada (1979-1984), Associate Professor at North Carolina State University (1985-1988), and Senior Research Scientist at the Microelectronics Center of North Carolina (1988-1996), Senior Scientist at Argonne National Laboratory (1996-2010), and then Distinguished Fellow at Argonne National Laboratory (2010-2012). He is an Adjunct Professor at University of Colorado-Colorado Springs and Michigan State University. Auciello is the President of the MRS for 2013.