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Nanomaterials: Applications and Properties**

NAN materials:
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Properties-2018

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NAP-2018



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Alexander Pogrebnyak (Ukraine) Valentyn Novosad (USA)

Topics

1. Synthesis and Properties of Nanomaterials
2. Carbon-based and other 2D materials
3. Photonics & Nanomaterials
4. Trends in Spintronics and Spin-related Phenomena at Nanoscale
5. Thin Films, Nanostructured Materials and Coatings
6. Nanomaterials for Clean Energy and Environment
7. Nanotechnology and Nanomaterials for Life Sciences
8. Miscellaneous and Interdisciplinary Topics



Reforming R@D Policy and innovation in Ukraine



Raising money for research in USA

2D materials



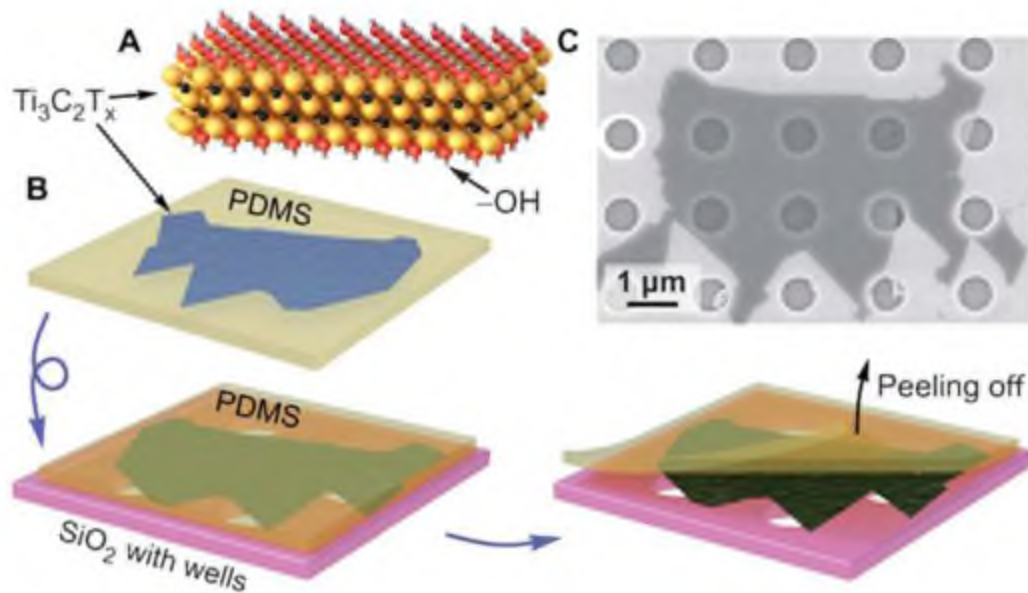
Yury Gogotsi is the director of the A.J. Drexel Nanomaterials Institute and leads research in the Nanomaterials Research Group in the College of Engineering.

Drexel is a comprehensive global research university ranked among the top 100 in the nation. With over 24,000 students, Drexel is one of America's 15 largest private universities. Founded in 1891 in Philadelphia

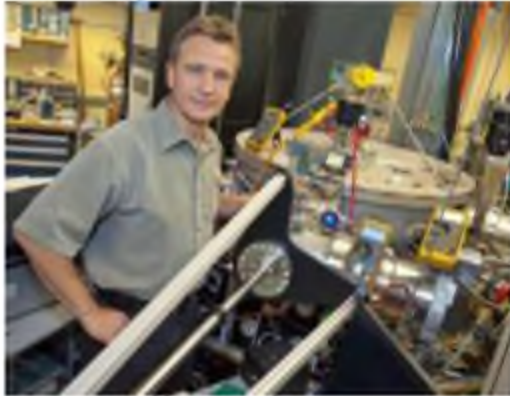


MXenes

Since the discovery of a large new family of two-dimensional materials by Drexel University researchers in 2011, continued exploration has revealed their exceptional ability to store energy, block electromagnetic interference, purify water and even ward off bacteria. And, as recent research now suggests, MXenes are also very durable — the strongest material of its kind, according to a new study in the journal Science Advances.



Thin Films@Coating



André Anders

Director, Leibniz Institute of Surface Engineering (IOM), and
Professor of Applied Physics, Leipzig University

Leipzig, Saxony, Germany

Since July 2014, he is the Editor-in-Chief for Journal of Applied
Physics, published by AIP Publishing.

Thin films are often synthesized using a flux of metals atoms stemming from evaporation or sputtering sources. Since the 1960s it is known that the microstructure of films and coatings can be engineered with energetic particles from plasma or ion sources. Here, sources of gas, metal, and mixed species are relevant. Depending on the energy and fluxes desired, one generally distinguishes plasma sources (without special ion acceleration means) and ion sources (having an ion acceleration stage such as a three-grid extractor system). Prominent modern sources of metal plasma include various forms of ionized sputtering, most importantly high power impulse magnetron sputtering (HiPIMS), which has especially gained interest in reactive HiPIMS [1]. Additionally, unfiltered and filtered arc plasma [2] are lesser known but important and educational, however, are quite different. In this brief overview I will show various energy and charge state distributions of plasma and ion beam tools, their applications, and include a discussion of benefits and shortcomings.

SYNTHESIS@PROPERTIES



Denise Erb

Institute of Ion Beam Physics and Materials Research

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Nanostructure arrays via templated growth: Fabrication methods and physical properties

Nanostructured materials have the potential to make substantial contributions to solving our society's present challenges, e.g. in the fields of medicine, information technology, or energy harvesting from renewable sources. The possibility to fabricate them at industrially relevant scales will maximize the impact of such materials.

We present bottom-up nanopatterning approaches which promise easy implementation and scale-up by combining well-established techniques and effects:

(a) spontaneous nanopatterning of crystalline surfaces upon heating,

(b) surface nanopatterning induced by low-energy ion irradiation,

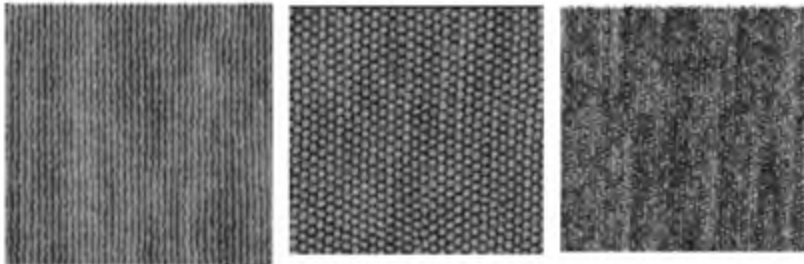
(c) diblock copolymer self-assembly

(d) physical vapor deposition with selective wetting,

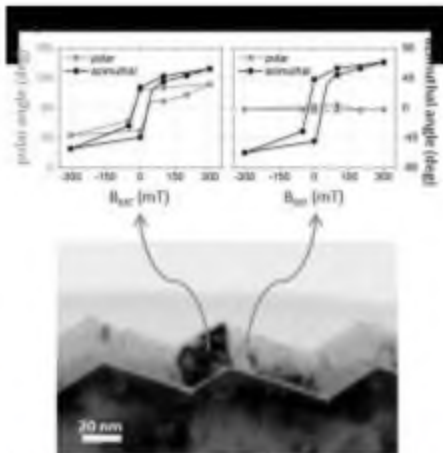
(e) physical vapor deposition with geometrical shading.

Denise Jennifer Erb

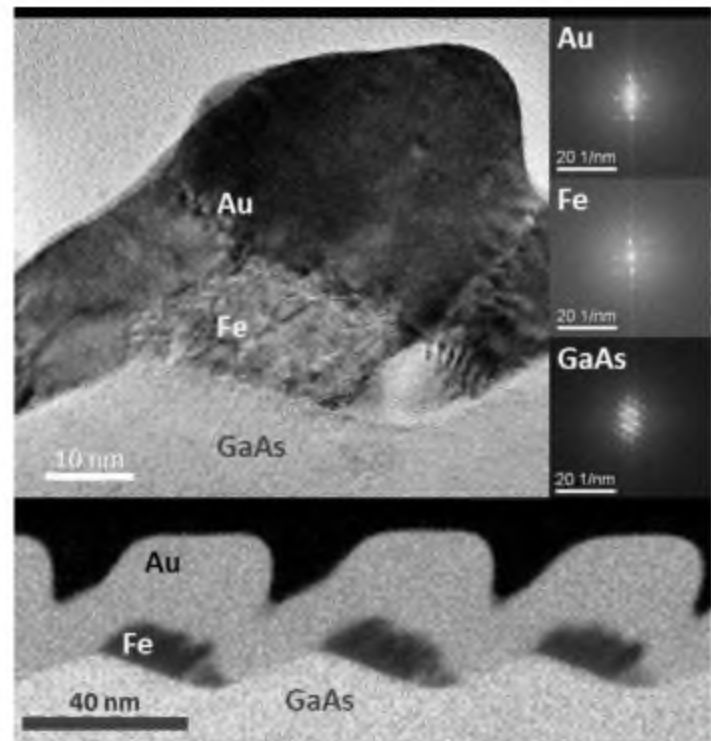
Combinations of these techniques and effects can result in highly regular nanostructure arrays of various morphologies and are applicable to a wide range of materials. The versatility of these approaches enables creative research and may lead to beneficial applications in diverse fields, ranging from optics and magnetism to catalysis



Atomic force microscopy of metal nanostructure patterns, via combination (a) + (c) + (d)



Fe thin film with periodic variation of magnetic anisotropy, via combination (a) + (e) [2]



Electron microscopy of epitaxially grown Fe nanowires with Au cap, via combination (b) + (e)

NANOBIOMEDICINE

- ❖ Uem Y., Kim C. *Facile synthesis of hybrid magnetic and spin crossover nanoparticles*
- ❖ Jurga S., Wereszczynska B., Skupin S., Mrugalska P., Zalewski T. *Enhanced Relaxivity of Paramagnetic Liposomal Theranostics Achieved by Photosensitizer Incorporation*
- ❖ Ramanavicius A., Deshmukh M., Bagdžiūnas G., Ramanavičienė A. *Synthesis of a Conducting Polymer Polyaniline Based Layers Suitable for the Application in Electrochromic Sensors*
- ❖ *and 12 more reports*

IEEE



JAMES E. MORRIS is a Professor of Electrical & Computer Engineering at Portland State University, Oregon, and Professor Emeritus at the State University of New York at Binghamton.



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INERDISCIPLINARY

- ❖ X-ray Luminescence of Y₂O₃ Nanopowder and Nanoceramics Sintered at Different Temperatures
Kononenko S., Mysiura I., Kalantaryan O., Skiba R., Zhurenko V., Chishkala V., Azarenkov M
- ❖ Effects of External Parameters on Formation of Nanoparticles in Argon-Acetylene Plasma
Ivko S., Denysenko I.B., Azarenkov N.A. ...

S. Konenko, I. Mysiura, O. Kalantaryan, R. Shiba, V. Zhurenko, V. Chishkalo, M. Azarenko

V. N. Karazin Kharkiv National University, Kharkiv, Ukraine, sergij.konenko@gmail.com


Introduction

Yttrium oxide has received special attention among other wide oxides due to great achievements in efficient energy utilization of visible radiation with dense and homogeneous structure. Yttrium oxide has the following physicochemical characteristics: high refractive index (1.8), high thermal conductivity in a case of high purity, melting point (2400 °C), ceramic resistance, thermal stability, light transparency at visible infrared wavelength range, high density (5.04 g/cm³) and high effective atomic number (36.7).

Yttrium oxide applications not only as a structural material as important for biological material, such as for ceramics, optical elements and special glasses, operated at high temperatures and in oxidative environments, alloying element in the production of chrome steel, large-area electronics, etc., but also, because of the extremely high luminescence efficiency, Y_2O_3 sintered glasses covers an interdisciplinary engineering use: yttrium oxide, activated by europium and cerium, to change light emission capabilities and modify luminescent properties.

The sintering of yttrium nano- and micro-powders is used for production of optical elements. This technology has become widespread recently due to the well-developed production of nanoparticles as well as progress in sintering methods. When sintering ceramics from a powder, its optical properties, especially luminescence spectra change. It is reasonable to find the differences in properties between bulk and nano-scale states.

The paper deals with experimental X-ray luminescence study of yttrium oxide nanoceramic powder and its compounds sintered at different temperatures.



Experiment

X-ray source: 5-ray vacuum tube (Cu anode, for emitting operating voltage up to 40 kV, current up to 10 mA, incidence angle $\alpha=45^\circ$).

Micro-detector: (300 mm² x 1.3 mm per mm).

Light optics: 200-700 nm.

Collimation (microfluorescent spectrometer) tests the spectra were carried out by the spectral sensitivity of the detector.




Fig. 1. Experimental setup.

Sample:

- Y_2O_3 powder (nano- and micro-sized particles) with purity of 99.99% (Fig. 2).
- Y_2O_3 oxides sintered at different temperatures following micro-analytical furnace (5, 10 °C) in an atmosphere of oxygen at temperatures of 1300-1600 °C, time 1 hour.




Fig. 2. Compositions of Y_2O_3 powder (photo from electron microscopy).

Results

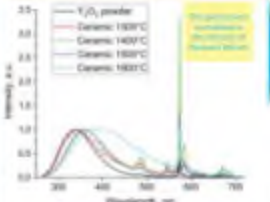


Fig. 3. The luminescence spectra of yttrium powder and samples sintered at different temperatures.

Several narrower bands are observed at visible part of the spectra (Fig. 3), which have a structure similar to molecular spectra (regions 472-488, 530-541, 567-586, 605-609 nm). The most intense of these bands has a maximum of about 575 nm for the powder. These bands are hardly distinguishable.

The highest intensity of the UV band corresponds to sintering temperatures of 1300-1400 °C. In addition, one can find a weak band with a maximum of about 515 nm, which was observed earlier by other authors [2]. It is associated with the presence of europium in the samples.

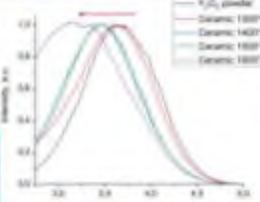


Fig. 4. UV band of normalized spectra for Y_2O_3 luminescence powder and samples sintered at different temperatures.

The position of the UV band maximum shifts with increasing sintering temperature toward longer wavelengths.

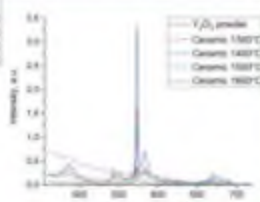


Fig. 5. Visible part of Y_2O_3 luminescence spectrum powder and bulk samples sintered at different temperatures.

Spectrum Gaussian Fitting

To determine the structure of luminescence spectra, a mathematical treatment was performed, namely fitting by the Gaussian function (Fig. 6). The peaks with maximum (amplitude of 0.49) and 1.75 eV are observed in the spectra for micro-powder and samples sintered at 1300 °C (Fig. 6). Changes in the shape of the luminescence band are explained by the changes in the size of their amplitude. The luminescence spectra of compounds obtained at temperatures of 1400 and 1500 °C are good fitted by one peak with a center of 1.45 eV (see, for example, Fig. 6). For a sample sintered at 1600 °C, a mathematical treatment results in the appearance of a peak of 1 eV together with the other two (0.45 eV and a very small peak at 1.78 eV). A similar procedure was applied to the microfluorescence spectra of yttrium Y_2O_3 oxides [1]. It can be seen from Fig. 6, that the UV peak also consists of a superposition of peaks of 1 and 1.45 eV.

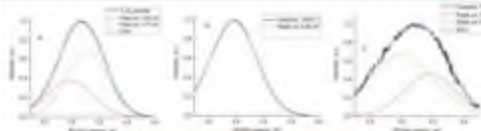


Fig. 6. The results of fitting the luminescence spectra of yttrium oxide powder (in the sample sintered at a temperature of 1300 °C) in data taken from [1].

Conclusions

We performed the study of the changes in the luminescence spectra of Y_2O_3 based on the powder state and bulk samples prepared by sintering at various temperatures in oxygen atmosphere. Luminescence was excited by X-ray photons with energies up to 40 keV.

- The spectra showed the samples and powder have a multiband structure and an oxide. The intensity of the different bands varies differently with the sintering temperatures, but for the majority there is growth.
- The exception is the UV band, in which the shape and position of the maximum (ranges 0 and 60) of the spectrum is observed with increasing sintering temperature.
- The performed mathematical treatment shows that the UV band is a superposition of 2 peaks namely 1.45 and 1 eV.
- The intensity of UV Y_2O_3 luminescence spectra depends on sintering temperature. There is a danger of drawing too general conclusions about the intensity of X-ray luminescence results.
- In addition, it should be noted the presence of an intense oxide of luminescence radiation in a relatively narrow spectral band with a maximum of 575 nm.

A mathematical model of the X-ray luminescence spectra of yttrium oxide powder and samples sintered at different temperatures in oxygen atmosphere was developed. The model shows that the UV band is a superposition of two peaks, namely 1.45 and 1 eV. The intensity of UV Y_2O_3 luminescence spectra depends on sintering temperature. There is a danger of drawing too general conclusions about the intensity of X-ray luminescence results. In addition, it should be noted the presence of an intense oxide of luminescence radiation in a relatively narrow spectral band with a maximum of 575 nm.