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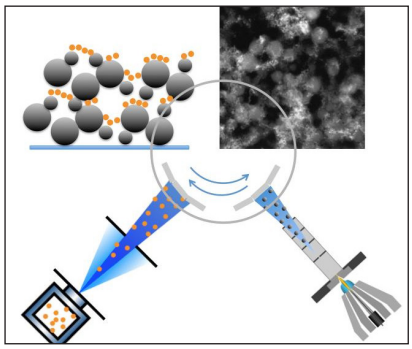
Transition metal – spinel nanoporous multi--layers by double--beam cluster beam deposition

E. Barborini and S. Vinati
Tethis SpA, Italy



The integration of nanostructured layers into devices is the pivotal step to exploit peculiar properties of nanoscale systems. This particularly holds for atomic clusters and nanoparticles, whose manipulation is known to be a cumbersome process. For instance, wet-chemistry approach may leave contaminations affecting the final application, while high-temperature calcination step of sol-gel approach severely limits the choice of the platform hosting the nanomaterial. Cluster Beam Deposition (CBD) has been recognized as a method overcoming many of those drawbacks and carrying beneficial features such as room temperature deposition, huge porosity due to nanoparticles soft-assembling, hard-mask patterning. We report on a study where a double-beam deposition system has been developed to combine on the same substrate nanoparticles produced by Flame Spray Pyrolysis (FSP), through FlameBeam source, and atomic clusters produced by electrical discharges, through Pulsed Microplasma Cluster Source (PMCS). FlameBeam source exploits the combination of a FSP burner, operating at atmospheric pressure, with a "quenching nozzle" that captures the nanoparticles generated by FSP and concentrates them into a gas stream directed into a vacuum deposition chamber. PMCS exploits a pulsed plasma jet impinging on a metal target to vaporize atoms in Argon atmosphere. Atoms then re-aggregate in clusters that are carried by nozzle expansion towards the same vacuum deposition chamber to which FlameBeam is faced. FlameBeam materials library includes simple oxides, complex oxides, noble metals and their combinations. PMCS materials library includes transition metals, noble metals, alloys. As paradigmatic example of the capabilities of the double-beam deposition system described here, results on nanoporous Cu-$MgAl_2O_4$ multi-layer synthesis and characterization will be shown, where Cu clusters layer by PMCS is deposited on $MgAl_2O_4$ nanoparticles layer by FlameBeam. Remarkably, $MgAl_2O_4$ layer shows the spinel structure. This suggests possible interesting roles in catalysis field for the nanoporous metal-spinel systems by FlameBeam-PMCS combination.

Recent Publications

1. Xu J et al. (2018) Cluster Beam Deposition of Ultrafine Cobalt and Ruthenium Clusters for Efficient and Stable Oxygen Evolution Reaction. ACS Applied Energy Materials 1 (7), 3013--3018.
2. Barborini E (2013) Microhotplates and Integration with Metal Oxide Nanomaterials, in Metal Oxide Nanomaterials for Chemical Sensors, M.A. Carpenter S. Mathur A. Kolmakov (Eds.), Springer Series: Integrated Micro--analytical Systems, 503--537.
3. Wegner K et al. (2012) High--rate Production of Functional Nanostructured Films and Devices by Coupling Flame Spray Pyrolysis with Supersonic Expansion. Nanotechnology 23, 185603.

Biography

Emanuele Barborini received the PhD in Physics from the University of Milan in 2000. In 2004 he was co-founder of Tethis, a Nanotech-Biotech SME born as Spin-off of the University of Milan. Since 2007 he serves as Head of Applicative Research and R&D Special Projects Manager at Tethis, where he manages Applied Research and related Technology Transfer projects. His main achievements regard: atomic clusters and nanomaterials production methods, chemoresistive micro-sensing, nanomaterial-based devices for oncology and proteomics. In 2015 he was Visiting Scientist at the University of Helsinki, where he coordinated the research on the use of nanostructured surfaces in MALDI mass spectrometry. Dr. Barborini is author of 97 scientific publications and inventor of 10 national (Italy) and international (EU, USA) patents. He has h-index 26 and 2325 citations (Scopus, July 2018). In 2017 he has been awarded the “Abilitazione Scientifica Nazionale 02/B1 Prima Fascia”.

emanuele.barborini@tethis-lab.com