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Flame aerosol synthesis of materials: The impact of embedded Pd on SnO_2 sensors

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Αμφιθέατρο Πολυτεχνικής "Π. Παναγιωτόπουλος"

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The seminar will start with a cultural overview of the connection between Greece with ETH Zurich & Switzerland. Then it will be shown how advancing the fundamentals of combustion synthesis of materials facilitated the process design for nanoparticle synthesis at kg/h even in our lab with such units now in UK, Spain, India etc. creating novel applications and even spinoffs with biomedical materials and highly selective gas sensors. After this introduction, our most recent discovery of a novel gas sensing material configuration will be presented as we have capitalized on the unique capacity of combustion aerosol processes to embed noble metals into semiconducting nanoparticles. So, the role of embedded Pd in sensing acetone, CO and NO_2 even at room temperature is elucidated by varying the SnO_2 crystal size and the embedded fraction of Pd into SnO_2 from 20 to 70% of the total Pd by careful selection of the combustion process variables. Such embedding increases the gas sensitivity up to two orders of magnitude, most likely due to formation of nanoelectrodes within the SnO_2.

Sotiris E. Pratsinis has a 1977 Diploma in Chemical Engineering from Aristotle Univ. of Thessaloniki, Greece and a 1985 PhD from Univ. of California, Los Angeles. He was in the faculty of the Univ. of Cincinnati, USA from 1985 to 1998 until he was elected Professor of Process Engineering & Materials Science at ETH Zurich, Switzerland. There he teaches Mass Transfer, Micro- & Nano-Particle Technology and Combustion Synthesis of Materials. He has graduated 46 PhDs, published 400+ articles, has filed 20+ patent families that are licensed to industry and have contributed to creation of four spinoffs. One of them (HeiQ Materials AG) was the first ever from ETH Zurich to enter the London Stock Exchange in December 2020. He first measured the oxidation rate of $TiCl_4$ for synthesis of TiO_2 that has been recognized as "… *a landmark contribution to … (pigment) industry…*". He has led the development of 2-dimensional population balances for reaction, coagulation and sintering. These models along with his proof of the rapid attainment of both *self-preserving* size distribution and *fractal-like* structure during aerosol synthesis of materials enabled creation of simple and reliable particle dynamics models that are interfaced readily with fluid mechanics greatly facilitating process design for particle manufacture and processing. For example, his model for production of optical fiber preforms was the first of its kind and still used in industry.

Motivated by this quantitative understanding, he showed experimentally, how to control flame-made particle size, crystallinity and, for the first time, morphology: from perfectly spherical particles to highly ramified agglomerates. Most notably, he developed the flame spray pyrolysis (FSP) process for synthesis of sophisticated particle compositions, up to 5 kg/h in his labs, perhaps world's largest such facility for manufacture of nanoparticles at an academic institution. With FSP he prepared novel heterogeneous catalysts (primarily for environmental remediation) and, for the first time, flame-made gas sensors and nutritional supplements as well as dental and theranostic materials. Also his FSP contributed decisively to environmental policy by identifying the origins of nanosilver toxicity and even developed processes for "curing" it.