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# Journal of Nuclear Materials

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## Editorial

## Preface

The fifth edition of 'Plutonium Futures – The Science' Conference was held between July 7 and 11, 2008 at the Convention and Exhibition Centre in Dijon, the capital of Burgundy in France. This series of conferences, focusing on plutonium and other actinide elements in complex media and materials, was perhaps surprisingly only initiated in 1997 to enhance the dialogue among scientists on the fundamental properties of plutonium and their technological applications. The Conference has previously been held in Santa Fe (1997, 2000), Albuquerque (2003) and Asilomar (2006). For the first time, therefore, the Plutonium Futures – The Science Conference was held outside the United States. Co-organized by the Atomic Weapons Establishment of the United Kingdom, the French Commissariat à l'Energie Atomique, and the JRC-Institute of Transuranium Elements of the European Commission, in collaboration with Los Alamos National Laboratory and Lawrence Livermore National Laboratory, the Plutonium Futures Conference was co-sponsored by the European Commission, the AREVA company, the Côte d'Or Region, and the Pole Nucléaire de Bourgogne.

Today, nuclear energy is an unavoidable and increasingly attractive option in the world mix of energy sources. At short and medium term, it is the most advanced alternative to fossil fuels, and many countries worldwide are turning towards nuclear power generation as a viable, secure and sustainable answer to their energy needs. Consequently, this *nuclear Renaissance* has led to the development of innovative reactor concepts and alternative nuclear fuel cycles but it also raises many questions related to nuclear safety and security issues, including the storage and long-term management of large inventories of actinides. Convincing strategy to deal with these issues can only come from progress in the underlying science. The scope of the Plutonium Futures – The Science series of conferences is to facilitate such progress by offering scientists, engineers and students from universities, national laboratories, and nuclear complexes an international forum where current and emerging topics in actinide, and more particularly plutonium science, can be discussed openly.

This special issue of Journal of Nuclear Materials collects some of the contributions presented at the 2008 Conference, related to condensed matter physics, materials science and nuclear fuel cycles. The part of the proceedings dedicated to actinide chemistry, detection and speciation analysis forms a special issue of *Radiochimica Acta*.

Approximately 330 attendees from around the world came to Dijon to share their scientific accomplishments on the chemical, physical and metallurgical aspects of plutonium behaviour. At the opening session, delegates from 19 Countries were welcomed

by Bernard Bigot, the French High Commissioner for Atomic Energy, Richard Clegg, Director of the UK Dalton Nuclear Institute, and by Didier Haas, coordinator of the EURATOM work program at the European Commission on behalf of the Joint Research Centre.

Plenary lectures were delivered at the beginning of each morning and afternoon sessions. Oral contributions were presented in two parallel sessions and well-attended daily poster sessions also took place. The scientific program encompassed a broad range of issues relating to condensed matter physics, chemistry, safety and nuclear waste management, nuclear fuel cycles, surface and corrosion phenomena, speciation and analytical methods.

Among the highlights of the week, a number of presentations illustrated that Dynamical Mean Field Theory calculations have reached an impressive level of sophistication that allows for a detailed understanding of the electronic structure of plutonium, which indeed is a unique element. Competition between spin-orbit and exchange interactions, electronic coherence effects, spin fluctuations and quantum criticality in  $\delta$ -Pu were amongst the debated topics. On the experimental side, progress is emerging at a slower pace, certainly due to the difficulties associated to the radiotoxicity of the material, but also to fewer available dedicated facilities. Nevertheless, interesting new experimental results on elemental Pu were presented, based for instance on inelastic neutron scattering, photoemission spectroscopy, and electron energy-loss spectroscopy. The long-standing problem of the transition from localized to delocalized 5f-electrons was addressed in several talks, with emphasis on the effects of negative pressure (expanding the lattice by chemical doping) on the physical properties of Pu.

Despite the undeniable progress of the last few years, many unanswered questions on this enigmatic element remain, and arguments persist on topics such as the number of electrons in valence states, magnetism, angular momentum coupling and the character of the bonding.

Another topic that attracted a large interest during the Conference was that of exotic magnetism and superconductivity in strongly-correlated 5f electron systems. Several talks were dedicated to unconventional U-, Pu- and Np-based superconductors, and to the study of their parent compounds. The nature of the pairing bosons in these materials remains to be determined and this is a central issue in Current Condensed Matter Physics.

Conference sessions relating to the materials science and fuel cycle program were particularly rich. Several talks, both experimental and theoretical, were dedicated to the thermodynamics and the phase stabilization of actinide alloys, and to the effects of self-irradiation damage on the mechanical properties. The stabilization of the face-centered cubic Pu  $\delta$ -phase remains of

considerable interest, and the role of lattice defects, accumulated over many years of self-irradiation, has been thoroughly investigated. Advanced numerical simulations have opened the way to a predictive understanding of atomic scale processes even including helium-vacancy interactions in nuclear fuel materials. A comprehensive review on plutonium-containing fuel for sodium-cooled fast breeders and burners was presented in a plenary talk. Other interesting contributions included talks on new methods of preparing fuels containing minor actinides, on their thermo-chemical and thermo-physical properties, and on the proliferation-resistance characteristics of novel types of nuclear fuels.

The Conference also heard of advances in understanding the extremely complex chemical behaviour of plutonium and other actinides, including experimental and theoretical approaches. The discussions ranged from actinide hydration, hydrolysis and aggregation and redox chemistry of uranium, neptunium and plutonium compounds in controlled conditions. Thermodynamic studies of the complexation of plutonium by different ligands were presented, as well as studies concerning the interaction of actinides with peptides and proteins. Other topics were related to the solubility of plutonium in molten salts, the formation and stability of actinide oxides, the formation of Pu(IV) colloids and the formation and hydrolysis of An(IV) polynuclear complexes. Case histories of nuclear materials confiscations and the successful application of nuclear forensic investigation methods to the identification of their origin were presented in the speciation, analysis and detection session, together with novel analysis methods based on laser-induced spectroscopy. Environmental issues included the measurements of plutonium traces in atmospheric precipitations and the study of the impact assessment in the case of accidental atmospheric releases.

Societal aspects and public perceptions of plutonium were at the heart of round-table discussions, one on global security, and the other on environmental concerns. The lively debate between eminent scientists and policy makers highlighted clearly how Science and Society are strongly coupled.

Finally, to aid the digestion of the many new findings and ideas presented at this successful Conference, the participants were gi-

ven the opportunity to visit one of the temples of French gastronomy, Clos de Vougeot, where a memorable banquet took place in the Renaissance atmosphere of a beautiful château surrounded by one of the most famous vineyards of Burgundy. The banquet was introduced by welcome addresses from Jacques Bouchard, Chairman of the Generation IV Forum, and Philippe Garderet, Scientific Director of the Areva Corporation. Siegfried Hecker and Gerry Lander, the honorary Chairmen of the Conference, had the burden of delivering after dinner speeches; as always, they were brilliant and illuminating!

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