IMPRESS

New Industrial Materials with the Help of Space Research

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Introduction

The ESA-led IMPRESS (Intermetallic Materials Processing in Relation to Earth and Space Solidification) project was recently selected by the European Commission as a 'flagship project' in materials science and applications. It comprises a large multidisciplinary consortium of 43 research groups and companies, with a total budget of €40 million from the EC, ESA, industry and others.

ESA is leading a research project into the materials of the future ...

By combining the industrial and academic expertise of more than 200 leading scientists from 15 countries, IMPRESS now has the potential to make Europe a world-leader in this strategically important area of materials science over the next 5 years.

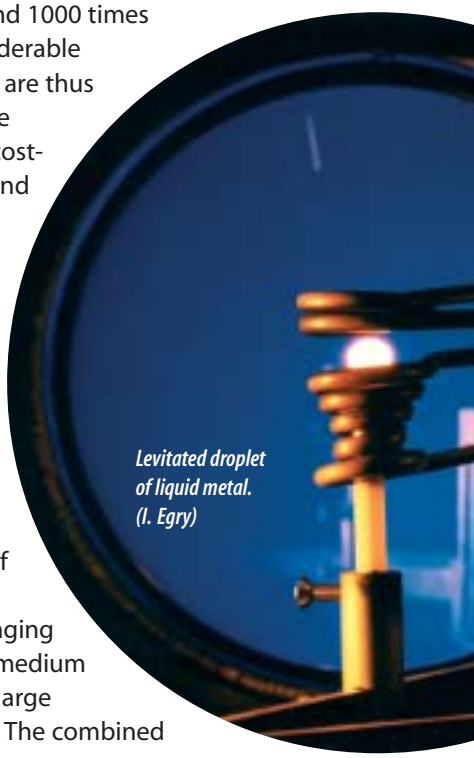
Project Objectives

The scientific objective of the project is to study the relationship between the processing, structure and properties of intermetallic alloys. These special crystalline alloys are the materials of the future, with many different applications ranging from aerospace components to power generation systems. Titanium aluminides, for example, have remarkable mechanical and physical properties at temperatures up to 800°C. It is the combination of high melting point, high strength and low density that make them ideal for high-performance gas turbine blades. These blades, produced by advanced casting techniques, will be used in the next generation of turbines for modern power stations and aero-engines. Using titanium aluminide would result in a 50% weight reduction of turbine components, possibly leading to improved thrust-to-weight ratios of aero-engines, higher efficiency, reduced fuel consumption and lower exhaust emissions.

Intermetallic alloys are equally important for advanced catalytic powders. Catalysts speed up chemical reactions, thereby saving considerable time and energy. There are many uses of catalysts in, for instance, the pharmaceutical, food and energy industries. In IMPRESS, scientists will investigate catalytic powders made from nickel and cobalt aluminides.

Rapidly-solidified, nano-structured particles will be produced by gas atomisation and, after some further processing, will be used by industry to speed up hydrogenation reactions, which are vital for the production of certain chemicals and plastics.

Companies developing and using hydrogen fuel cells will also benefit greatly from this research, since catalytic electrodes based on nickel and cobalt powders are effective alternatives to conventional platinum electrodes – and 1000 times cheaper. Considerable improvements are thus expected in the performance, cost-effectiveness and sales potential of these pollution-free power-generation systems.



Levitated droplet of liquid metal. (I. Egry)

Industry

IMPRESS has the active participation of 14 European companies, ranging from small-to-medium enterprises to large multinationals. The combined

annual turnover of these companies is of the order €9 billion. They have diverse interests in IMPRESS, notably in aerospace propulsion, power generation, hydrogen fuel cells, software development, coating technology, casting and powder production – not to mention space hardware development. Other companies have expressed a strong interest in joining as the project evolves. One of the gratifying aspects of IMPRESS is the fact that industry has been energetically involved from the outset and has defined the measurable targets of the project. These companies will now have direct exposure to the new knowledge and will be first in line for licensing and patenting.

International Space Station (ISS)

The ISS, as well as other microgravity platforms, will be used extensively to perform benchmark experiments on these intermetallic alloys. The unique data will make a vital contribution to the project, by generating fresh knowledge, confirming theories, validating computer models and optimising industrial processes.

The ISS facilities that will be used by the IMPRESS team include:

- the Materials Science Laboratory (MSL), which will permit solidification experiments of high-temperature intermetallic alloy samples;
- the Electromagnetic Levitator (EML), which will allow containerless melt processing and non-contact measurement of thermo-physical properties;
- the IMPACT facility, which will permit well-defined experiments in nano-particle formation and agglomeration.

Research activities have already begun in these areas and numerous precursor experiments on parabolic flights and sounding rockets have been defined and secured.

Impact of IMPRESS

The impact of IMPRESS will be felt on many different levels. Firstly, it has the potential to give European industry a world-leading position in turbine production and fuel cell development. The economic significance of this should certainly not be underestimated because these two sectors are steadily growing; conservative market projections suggest that global demand could reach at least €45 billion by 2011.

Not only will IMPRESS greatly strengthen the global competitiveness of the European industries involved, but it will also lead to major environmental and energy-efficiency benefits. It is hoped that the results of the project will make a valuable contribution to the Kyoto Protocol on Climate Change.

On a regional level, many educational and training activities are foreseen to promote industrial research and inspire a new generation of young scientists. Dissemination via museum and trade exhibitions, TV reports, interviews and newspaper articles will also bring the new knowledge to a wider audience and, in particular, to the general public.

Not least, a number of scientific research groups from newly-acceded EU countries of Slovakia, Poland and Hungary, plus Russia, are involved and significant efforts will be made to ensure their full and active participation.

Conclusion

By integrating ground-based and space resources over the next 5 years, it is believed that IMPRESS will greatly contribute to the fabric of European research. Furthermore, it will combine the promise of great economic opportunities with environmental benefits.

ESA, as coordinator, is now in the final stage of contract preparation; the start date is expected to be July 2004. Once off the ground, IMPRESS will undoubtedly become a shining example of trans-national cooperation in materials science, with many applications that could support future space programmes. ■

IMPRESS Project Participants

ESA (Project Coordinator)
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University of Birmingham (UK)
Institut National Polytechnique de Toulouse (F)
Helsinki University of Technology (FIN)
Kungl Tekniska Högskolan (S)
Slovak Academy of Science (SK)
Research Institute for Solid State Physics and Optics (HUN)
Centro National de Investigaciones Metalurgicas (E)
Deutsches Zentrum für Luft- und Raumfahrt (D)
British Ceramic Research Ltd. (UK)
University of Wales Swansea (UK)
Turbocoating S.p.A. (I)
University of Leeds (UK)
University of Greenwich (UK)
Magnitec Oy. (FIN)
Calcom ESI S.A. (CH)
National University of Ireland (IRL)
ACCESS e.V. (D)
Leibniz-Institut für Festkörper- und Werkstoffforschung (D)
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ALD-Vacuum Technologies AG (D)
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