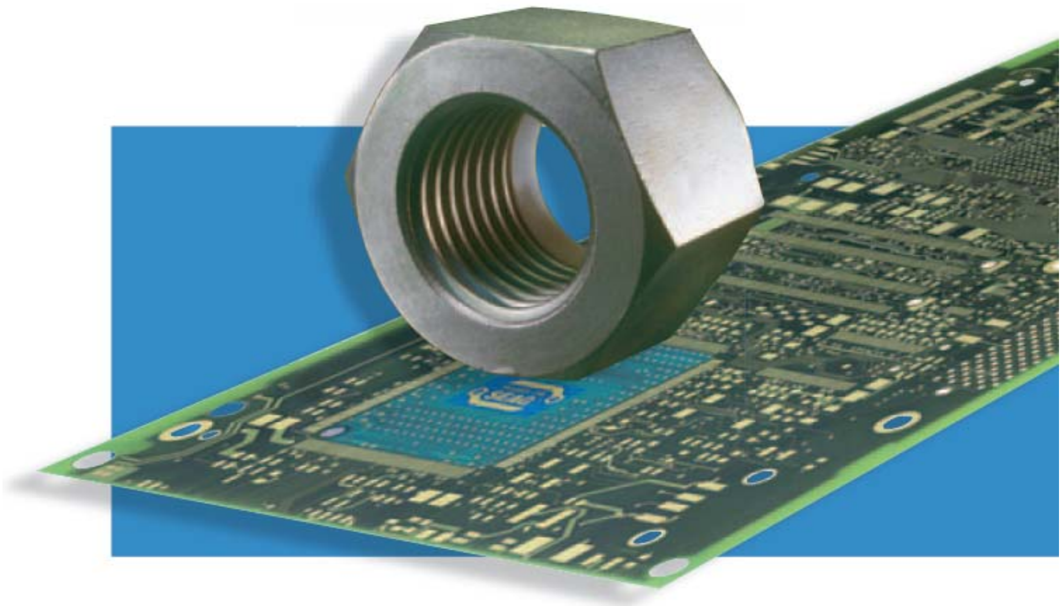
New Ionic Liquid Solvent Technology to Transform Metal Finishing

Products and Processes



www.ionmet.org

Supported by the European Commission
within the 6th Framework Programme

Deutsche Gesellschaft für Galvano- und Oberflächentechnik e.V.
Max-Volmer-Straße 1
D-40724 Hilden, Germany
dgo.info@zvo.org

c/o 2007

Content:

1. Preface

'New Ionic Liquid Solvent Technology to Transform Metal Finishing Products and Processes' (IONMET) is the title of a four-year integrated project with 33 partners mainly SME's but also higher education, research institutions, trade associations and large indutrial companies.

The overall objective of the project is the introduction of a breakthrough technology with the potential to transform the scope and competitiveness of industrial metal finishing processes. The new technology will introduce a novel generic group of ionic liquid solvents which will provide the tools to significantly transform the innovative capability of the huge number of traditional manufacturing SME's involved directly in the surface finishing and printed circuit board manufacturing industry sectors in particular. The radical new generic technology will enable the introduction of a large number of totally new products and processes, which cannot be produced using existing technology.

This project will significantly accelerate the opportunity to commercialise the use of ionic liquids in the metal finishing industry.

Dr. K. Shukri (Coordinator)
Genacys Ltd
298 Regents Park Rd
Finchley, London, N3 2UA, UK
Email: khalid@genacys.co.uk

2. Introduction

2.1. Objectives

The starting point of the project was the fact that for industrial application of the technology of ionic liquids there are a number of open questions like influence of water or conditions of the liquid-solid phase boundary as well as the influence of the ionic liquids itself on the deposition process. Therefore, the scientific objective is to broaden the knowledge and comprehension of systems, processes, materials and matter by characteristics of potentiality, constraints and governing mechanisms pertaining the plating process as well as the mechanism of crystal growth of the deposited layer.

Any deposition process requires special ionic liquids. The molecular mobility changes with water concentration and the type of anion. In most of cases, conductivity of ionic liquid decreases when metallic salt is added and viscosity increases. The resulting differences to the aqueous systems require investigation and development of special ionic liquids. In this context stability and speciation in imid-azolium systems were investigated. It was attempted to extend these systems to non-aromatic quaternary ammonium cations to improve stability and gain an IP position. It was found that the formation of charge transfer complexes governs the properties of the IL.

The analysis performed indicated that the role of diluents is very important in determining the morphology of aluminum coatings from ionic liquids. In addition to reducing the viscosity of the liquid, thereby increasing the mobility of Al species in the liquid, the diluents also perturbs the equilibrium determining the speciation and, for example, the amount of charge-transfer complexes present at any time. Different chloro-aluminates species were observed whose equilibria are dependent on the addition of toluene as diluent.

The industrial important layers chromium and aluminum as well as the zinc-systems were successfully deposited on steel, in laboratory as well as in industrial scale. In the case of Zn, the difference of Reline and Ethaline were studied. The results show that nucleation in Reline is fast but bulk growth is slow, whereas nucleation in Ethaline is slow but bulk growth is relatively fast. Critical surface coverage necessary for the transition from nucleation to bulk growth is similar for both liquids. Surface effects like potential relaxation is slow compared to aqueous systems. It is also shown that the composition and morphology of Zn/Ni-alloys depend strongly on the composition of the plating bath. The deposition of chromium was also intensively investigated. Different compositions of electrolytes were compared, especially the influence of added water. Changes in concentration during the process are mainly caused by diversion of electrolyte throughout the deposition process.

Electroless plating was also successfully applied. An ionic liquid based process for silver plating of electronic component circuit boards was developed. Circuit boards are very often plated with silver to prevent atmospheric degradation of the surfaces of the circuit boards prior to assembly into a finished device.

Currently the water-based commercial process uses expensive metal catalyst and also strong inorganic acids. The latter can be particularly problematic because it tends to erode away the features of the circuit boards that are processed. Consequently when using this process the exposure time of the component has to be carefully controlled so as to balance the silver plating time with the detrimental corroding effects of the acid. In the new ionic liquids process developed here silver plating is just as effective in protecting the PCB components but no catalysts or strong acids are required.

One very promising application is the use of ionic liquids for eletropolishing. A commercial electropolishing process for forged and machined components manufactured from a high strength Ni/Co alloy have been developed and optimised.

2.2. Promising Technology Groups

The first promising results have enabled to classify the technological clusters into 7 “Technological Focus Groups” presented in this brochure:

1. Hard and Decorative Chomium
2. Zn Alloys and Novel Alloys
3. Aluminium Deposition
4. Composite
5. Plating on Magnesium and Titanium
6. Electropolishing
7. Silver and Other Electroless Coatings

2.3. Partners involved

The IONMET project gathers 33 European partners. The consortium consists of highly ranked RTD providers and leading European SME’s in plating and printed circuit technology:

1. Genacys Limited, UK (Coordinator)
2. Galvotech Limited, Ireland
3. Lacaze S.A., France
4. T&S Sistemi S.a.s., Italy
5. Fundacion Inasmet, Spain
6. Instytut Metali Niezelaznych, Poland
7. Deutsche Gesellschaft für Galvano und Oberflächentechnik e.V., Germany
8. C-Tech Innovation Ltd., UK
9. Faculdade de Ciências da Universidade do Porto, Portugal
10. Anopol Limited, UK
11. CEA - Commissariat a L’Energie Atomique, France
12. University of Leicester, UK
13. PW Circuits Limited, UK
14. Inter Euro Technology Ltd., Ireland
15. Groupe Mecachrome, France
16. Poeton Limited, UK
17. University of Clausthal, Germany
18. Rohm and Haas, Electronic Materials Deutschland GmbH, Germany
19. Ashton & Moore Limited, UK
20. Centre Technique des Industries Mécanique, France
21. Institut für Materialprüfung und Werkstofftechnik GmbH, Germany
22. Protection des Métaux, France
23. Association pour la Recherche et le Développement des Méthodes et Processus Industriels, France
24. European Institute of Printed Circuits, The Netherlands
25. MEP Applications BVBA, Belgium
26. KaHo - Katholieke Hogeschool Sint-Lieven, Belgium
27. Galvanotecnia y Derivados S.A., Spain
28. AKABA, Spain
29. Specialised Metals, Ireland
30. Franz Oberflächentechnik GmbH, Germany
31. Derost s.r.o., Czech. Rep.
32. SITA Aerospace, France
33. JMP Ingenerios, Spain

Technological Results

3. Hard and Decorative Chromium

Contact: Prof. P. Benaben
École Nationale Supérieure des Mines, Sciences des Materiaux et des Structures
158, Cours Fauriel - 42023 Saint-Étienne Cedex 2, France
benaben@emse.fr

3.1. Main advantages of ionic liquids

Hard Chromium deposition using hexavalent chromium solution has been pointed since about twenty years as a very polluting and toxic process due to the carcinogenic effect of hexavalent chromium. Currently in Europe the maximum concentration in liquid effluent has been fixed at about 0.1 µg/L.

Many research programmes through the world have been developed to define, to test and commercialise processes as substitute of Hard Chromium Plating using hexavalent chromium. For instance HCAT (Hard Chromium Alternative Team) which is a joint programme research between the US Department of Defence and The Canadian Ministery of Defence has been developed to study the substitution of hexavalent chromium in Military Aeronautic applications by dry process, in particular HVOF process. Results published in the web site (www.hcat.org) give the different aspects of the process applied to different parts of helicopter and Airplane.

Other programme developed by CTC Company in US or ECOCHROM in Europe (funded by The European Community in the course of an integrated project FP6) have shown that some encouraging results have been obtained: using electrolytic or electroless Nickel or Cobalt deposition with or without hard particles for the first, trivalent chromium for the second.

Following the development of the IONMET programme, a new approach using a solution of ionic liquid has been developed. The solution is prepared through dissolution of Trivalent Chromium Chloride in Choline Chloride. Concentration of the different species ($CrCl_3$, $6H_2O$ and Choline Chloride) is crucial as it has been shown that in certain conditions it is possible to obtain metallic chromium on steel substrate with interesting properties. An interesting point is that the solution is a non-toxic solution and is an environmentally friendly process.

This summary presents results that have been obtained in the course of our research works. Electrolytic deposition of hard chromium plating has been realised using a solution of trivalent chromium in Choline chloride.

The temperature of the electrolysis has been fixed at about 40°C, temperature at which the mixture is a green colour liquid.

Chromium deposition has been made on different substrate in particular, steel after “standard” surface preparation: polishing, degreasing, anodic etching in dilute sulphuric acid. The average current density is 15 A/dm² and the rate of deposition is about 0.7 to 1 µm/min depending on the condition (in particular iron and other “polluting” metals).

Measurements on micro-hardness have shown that under a load of 100 g, the Vickers micro-hardness is about 700 HV. An interesting point in this field is that after heat treatment (400°C – 1 h, under nitrogen atmosphere), the micro-hardness increase from 700 to 1400-1500 HV). In fact, the influence of temperature on micro-hardness seems to be the same as for other hard trivalent chromium: the micro-hardness increases from 700HV as deposit, to about 1400-1500 HV at about 400°C, and then decreases at a value of about 700 HV for a heat treatment at a temperature of 700°C.

X-Ray diffraction tests have shown that during the heat treatment, there is an evolution of the structure between simple cubic to FCC structure.

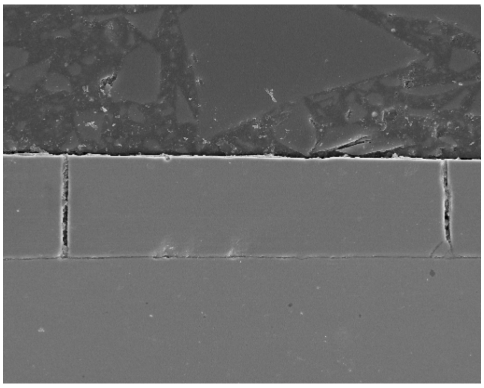
3.2. Practical application

Tests on duration of trivalent chromium electrolytic solution made during one year have shown that the process is robust: it is possible by maintaining the Cr concentration at the good value to obtain chromium deposition without structural or characteristic modifications.

Some tests have been made in an industrial environment and results have confirmed the validity of the process.

Following are pictures showing some results: chromium deposit on steel.

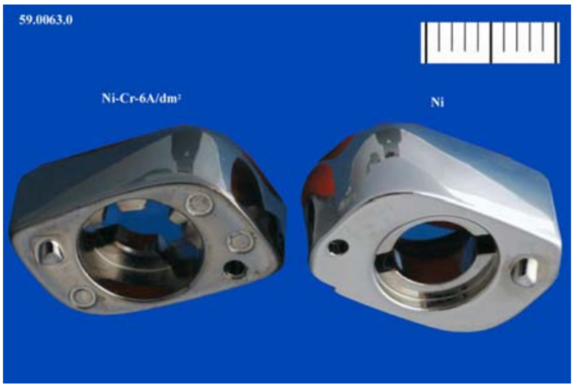
Sample with Hard chromium deposit: (thickness: 25-30 µm)



Cross section of a deposit on steel (thickness: 30 µm)

It is foreseen that this process could be developed during the IONMET programme until an industrial application (Pilot scale).

Currently an improvement by scaling up the process to about 500 l is in progress.



Decorative Chromium on steel from ionic liquids on various samples (INASMET)

4. Zn Alloys and Novel Alloys

Contact: Dr. Ian Dalrymple
C-Tech Innovation Limited
Capenhurst Technology Park, Capenhurst, Chester CH1 6EH, UK
ian.dalrymple@ctechinnovation.com

4.1. Main advantages of ionic liquids

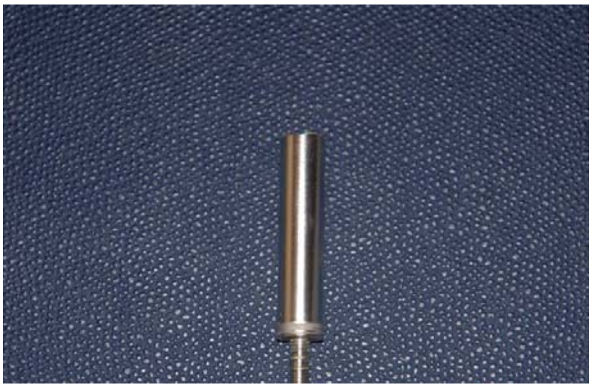
Zn alloys

Zn-Ni and Zn-Sn alloy coatings on mild steel substrates have been prepared using deep Eutectic Solvent electrolytes based on mixtures of choline chloride and ethylene glycol. A range of deposit compositions have been produced with over 80% Zn content possible. The processes have been scaled up to a large laboratory scale using an electrolyte volume of 10 litres and plate 150 x 80 mm mild steel cathodes. Further work is required to improve the quality of the coatings. The electrodeposition of Zn-Cr alloys has been demonstrated using deep eutectic solvents containing Cr(III) in Hull Cell experiments.

Other alloys

The electrodeposition of Ni-Sn alloys has been successfully and reproducibly scaled up using an electrochemical reactor containing 10 litres of deep eutectic solvent electrolyte based on a mixture of choline chloride and ethylene glycol. The electrodeposition of Ni-Cr alloys has been demonstrated using deep eutectic solvents containing Cr(III) in Hull Cell experiments.

Zn-Sn deposit on Ti substrate



Zn-Sn (10% Zn content) on mild steel

4.2. Advantages in comparison to existing technologies

- Elimination of hydrogen embrittlement in Zn-Ni alloys for aerospace applications
- Deposition of high Zn content coatings with Sn
- Deposition of higher Fe content Zn-Fe alloys than achievable by aqueous systems
- Replacement of the strong acids and alkalis or toxic complexants that are currently used by ionic liquid electrolytes with a lower environmental impact
- The preparation of Cr alloys using Cr(III) in the electrolyte

4.3. Possible industrial application

Possible applications include: Alloy coatings to replace Cd, Cr(VI) and novel alloys that are not possible to plate using aqueous electrolytes

Electroplated coatings containing Zn, Zn-Ni and Zn-Sn are currently plated from aqueous systems to provide corrosion resistant coatings for mild steel. Automotive requirements are either Zn-Ni or Zn-Fe. Aeronautic requirements are Zn-Ni with a good coefficient of friction, or Zn-Sn with at least 70% Zn content, otherwise the coating is too soft.

Ni-Sn alloys are resistant to corrosion and tarnishing, and are therefore potential replacements for decorative chromium. Other industrial applications of potential interest are as etch resists and diffusion barriers between solder and copper on printed circuit boards.

Electrodeposition of Zn-Cr using ionic liquid solution could have a good corrosion resistance in some applications.

5. Aluminium Deposition

Contact: Francisco Cano
INASMET San Sebastián
Mikeletegi Pasealekua, 2, Parque Tecnológico / Teknologi Parkea
E-20009 Donostia – San Sebastián, Spain
fcano@inasmet.es

5.1. Main advantages of ionic liquids for aluminium plating

Metal finishing processes using traditional electrolytes in aqueous solutions have many limitations and disadvantages. The range and quality of coatings that can be produced is limited by the chemistry of the plating baths. Metal ions with reduction potentials below that of the H^+ have either low current efficiencies or cannot be electroplated at all from aqueous solutions. This precludes the electrodeposition of many important metals including Al, Mg, W and Ti from aqueous baths. In this sense, the main advantage of using ionic liquids solvents over aqueous baths is that they allow the electroplating of the aforementioned metals, including aluminium.

Within the IONMET project, Inasmet, University of Clausthal, University of Leicester and C-Tech have developed a process for aluminium electroplating on steel samples based on imidazolium type ionic liquids. Uniform, adherent, corrosion resistant aluminium coatings have been obtained with no evidence of red corrosion after 800 hours of salt spray fog corrosion testing (for thicknesses of 10 microns approximately). Bright aluminium electroplating is also feasible. At this stage of the project, a significant knowledge has been achieved both in the fundamentals and in the control of the electrodeposition process parameters. A pilot rig is also being constructed at C-Tech that is sized to allow Al coated samples up to 400 cm^2 and can contain up to 37 litres of plating solution.

Summarising, the following general advantages have been identified:

- ⇒ High electrochemical window of ionic liquids: Feasibility of aluminium electroplating from ionic liquids (impossible from aqueous solutions due to water hydrolysis)
- ⇒ Aprotic character of ionic liquids: Hydrogen embrittlement free aluminium coatings (a major problem caused by gaseous hydrogen produced during water electrolysis)

The specific achievements in the IONMET project are the following:

- ⇒ Uniform, adherent, corrosion resistant aluminium coatings on steel components based on imidazoliun type ionic liquids; Possibility to produce bright aluminium coatings
- ⇒ Basic knowledge in the fundamentals of the process
- ⇒ Basic knowledge in the control of the process parameters
- ⇒ Scaling-up of the process in progress

5.2. Advantages in comparison to existing technologies

Aluminium metal deposition is considered as a potential alternative for cadmium replacement. Al is a highly reactive metal (E^0=-1,67V vs. NHE) and its electrodeposition in aqueous solutions is impossible. Nowadays, there are various methods for making an aluminium coating, such as hot dipping, thermal spraying, sputter deposition, vapour deposition and electroplating in organic solvents. The electroplating process is a valuable tool, since varying parameters such as over-voltage, current density and bath composition, the properties of the deposits can be adjusted.

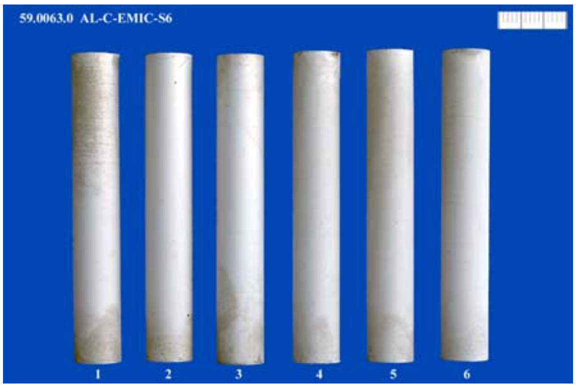
The electrodeposition of aluminium in organic solvents has had limited success due to its low electrochemical window, low electrical conductivity, volatility, flammability and toxicity of the solvents, such as benzene or toluene.

Other competing methods such as vapour deposition require much higher capital investment. None of the alternative processes are entirely satisfying.

5.3. Possible industrial application

Deposition of adherent layers of aluminium is of first importance for the industry, in particular as substitute of cadmium electroplating. The conventional aqueous electroplating baths are often highly toxic and/or corrosive baths, creating hazardous conditions in the workplace and producing numerous hazardous effluent streams. This is the case of cadmium electroplating, a strictly regulated process due to its toxicity.

Alternative processes to cadmium deposition are an important target for the plating technology as for the moment there only exist some alternative process such as Zn-Ni plating, IVD Al and Al electrodeposition from organic solvents. However, all of these processes are not entirely satisfying.



Aluminium deposition of various substrates of mild steel

6. Plating on Magnesium and Titanium

Contact: Prof. Dr. Volkmar Neubert
Institut für Materialprüfung und Werkstofftechnik Dr. Neubert GmbH
Freiberger Str. 1, D-38678 Clausthal-Zellerfeld
Volkmar.Neubert@tu-clausthal.de

6.1. Main advantages of ionic liquids

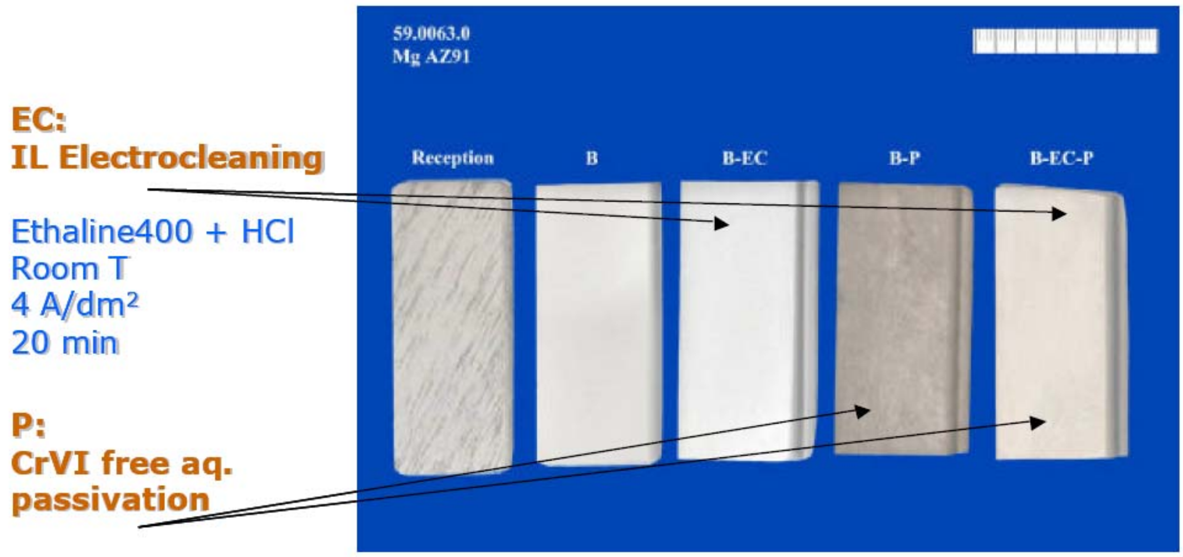
Magnesium and its alloys are very reactive and therefore their electroplating in aqueous solutions is hazardous. They are classified as water sensitive substrates from the electrodeposition point of view, and thus the importance of ionic liquids (IL) as non-aqueous electrolytes for electrodeposition. Electro-polishing in choline chloride IL produced clean, shiny and smooth Mg surfaces.

6.2. Advantages in comparison to existing technologies

It is extremely difficult to coat magnesium electrochemically by any metal in aqueous solutions as it reacts extremely with water forming loose corrosion layers. The corrosion rate of Mg in the IL ChCl/urea is four orders of magnitude lower than that in the aqueous electrolyte used for Zn electrodeposition. Air and water stable ionic liquid “2 ChCl:1 urea” has been successfully used as an electrolytic solvent for electrodeposition of Zn onto Mg alloys.

6.3. Possible industrial application

- Electrodeposition of metallic Zn layers onto Mg-RE alloys in the ionic liquid 1ChCl:2urea. The Zn coats are uniform, dense and free of defects. Zn-coated Mg alloys exhibit a corrosion behaviour similar to that of pure Zn.
- Electro-polishing of Mg alloys in IL



7. Electropolishing

Contact: Dr Karl Scott Ryder
Scionix Laboratory, Department of Chemistry,
University of Leicester, Leicester, LE1 7RH, UK.
KSR7@LE.AC.UK

7.1. Electropolishing of Stainless Steel

A new process has been developed for electropolishing stainless steel. The operating conditions are the similar to the existing acid based solutions and represent simple drop in replacement technology. The process has the following benefits:

- Non-acidic formulation and non corrosive
- Improved surface finish on cast pieces
- 4 fold improvement in current efficiency
- Reduced and simplified waste treatment
- Less gassing
- Metal waste is recoverable

300 Series stainless steels:

Pieces polished using ionic liquids

These benefits mean that the new liquids are less hazardous to use and carry out the same electropolishing process in a more efficient way. The process improvements are accomplished through a new ionic technology that uses salts that are liquid at room temperature.

These new liquids can also be applied to the electropolishing of high specification alloys that are currently inaccessible to acid based solutions.

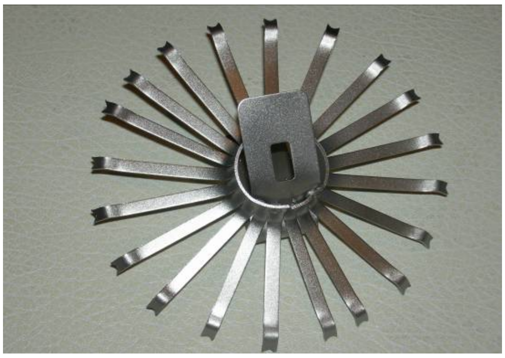
- Process operating temperature: 30-50 ^{o}C
- Polishing regime: typically 3-5 V for10 minutes
- Scale up process in 100L tank, with additives now in operation.

7.2. Electropolishing of Non-ferrous metals

- Attempts to polish high Ni content alloys all successful!
- One of the most reliable / consistent IL electropolishing processes.
- Good solubility of Ni oxide in Ethaline

Ni Alloys

70% Ni automotive cam bolt Electro-polishing in Ethaline 200 additionally increases strength



Titanium

Ti and Ti/Al alloy, Ta6V, chemical de-passivation (acid); electropolishing in Ethaline bath.

7.3. Conclusions and future:

- Reliable / consistent electropolishing of pressed and cast 300 series stainless steel parts in Ethaline 197 (200)
- Oxalic acid additives give excellent finish comparable to current industrial process (aqueous acid), scale-up successful for small pieces
- Polishing of high Ni content alloys successful and consistent but commercial process is suspended
- Al polishing possible but high current density will limit applications
- Very encouraging results continue for polishing of Ti and Ti alloys

8. Silver and Other Electroless Coatings

Contact: M. Weinhold
EIPC Services B.V.
Hertogsingel 49B, 6211 ND Maastricht, The Netherlands
mweinhold@eipc.org

8.1. New opportunities with Ionic liquids:

The PCB fabrication technology has gone under drastic changes over the last 20 years. This was mainly due to the limitation of using chlorinated and or fluorinated solvents in the fabrication process. As a result, certain photo polymer resist materials used for conductor imaging and solder masking could no longer being processed. The newer resist that are processed in alkaline solution did not withstand the high pH of the electroless Cu plating bath. Direct electroless plating of conductor lines, as used in additive processing of PCBs, could no longer being performed. The PCB fabrication processes using additive technology stopped because of the lack of suitable materials.

The introduction of Ionic liquids as a new plating technology for electroless or electro plating offered a new opportunity for the re-introduction of additive technology.

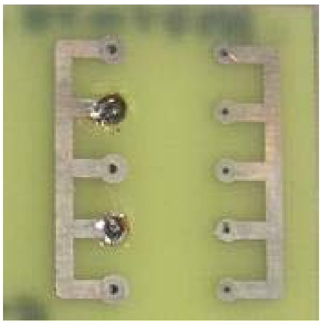
First results in chromium plating, copper plating of aluminium, electropolishing and electroless silver plating proved functionally of ionic liquids in the field of electro and electroless plating.

8.2. Electroless Deposition of Silver on Copper (University of Leicester)

A new process has been developed for the electroless deposition of silver on to a copper substrate. The process is particularly designed for silver plating on multi-track circuit boards. The operating conditions are the same as the existing water based solutions and represent simple drop in technology. The process has the following benefits:

- Thick, bright, adherent silver layers possible
- Reduced light sensitivity of solution
- Decreased soldering temperature
- Uniform deposition rate
- Non-acidic formulation
- Non-cyanide

These benefits are accomplished through a new ionic technology which uses salts that are liquid at room temperature.



Silver metal coatings on polished Cu lines
deposited at r.t. for 15 min.

8.3. Electroless Deposition of Copper on Aluminium (University of Leicester)

A new process has been developed for the electroless deposition of copper adhesion layers onto aluminium substrates. The process is designed to facilitate electrolytic coatings of other metals onto aluminium components. The operating conditions are very mild and the process is very simple. Thickness of the copper adhesion layer is controlled by exposure time but typically thin, even, adherent, homogeneous films can be deposited in a few minutes. The process has the following benefits:

- Dip coating process
- No catalyst of surface treatment required
- Rapid deposition time
- Simple process operation
- Acid-free
- Low toxicity

This process uses new liquids that are less hazardous to use than established aqueous technologies but are otherwise drop-in replacements. This process has the benefit that electrolytic plating on top of the copper ad-layer is easily accomplished using any other conventional electroplating process. For example good adherent coatings (10 μm) of Ni were achieved from an aqueous Watts bath on an Al rod plated with electroless Cu from the ionic liquid.

Al plate coated with electroless Cu and then electrolytic Zn

10 mm (dia.) Al rod coated with electroless Cu and then adherent electrolytic Ni (10 μm)

9. Environmental Aspects

Contact: Dr. L. Yurramendi
INASMET San Sebastián
Mikeletegi Pasealekua, 2, Parque Tecnológico / Teknologi Parkea
E-20009 Donostia – San Sebastián, Spain
lyurrame@inasmet.es

9.1. Importance to ionic liquids

The objective is the identification and development of techniques for control and recycling of materials to ensure close to zero environmental discharges. Risk analysis and possible contingencies will be studied and compared with the risks that can occur in the use of traditional chemical formulations.

Evaluation procedures are normalised by governmental procedures and have to comply with national laws and European directives. Results of this task are being contrasted against recommendations of IPPC Integrated Pollution Prevention and Control. IPPC related with surface treatment activities will be implemented in the near future and will have a severe effect on industrial activities. A comprehensive assessment of the environmental impact of the use of ionic liquid solvents in metal finishing processes is being carried out, and targets will be set for the performance of treatment technologies. A detailed risk assessment analysis will be completed covering the use of the chemicals selected for each process to be studied and developed. Methods for removing and recovering salts and metal ion components from rinse baths to be recycled to plating baths are being assessed: ion exchange, sorption, extraction, evaporation. Technical and economic aspects will be covered. Post treatment and recovery/recycling stages will be developed and integrated with the prototype systems developed during Work Package 5. Maintenance of bath condition and determination of lifetime are being investigated. Post treatment protocols are in evaluation, e.g. rinsing and drying procedures.

9.2. Risk analysis

A common procedure has been established for environmental risk analysis, suitable for use by all project partners, tailored to the needs of ionic liquids processes being studied in all work packages. The following BREF's are under revision: common waste water and waste gas treatment and management in the chemical sector, surface treatment of metals, waste treatment and surface treatment using solvents; the objective is to define their requirements in relation to possible IL electroplating industrial units.

9.3. Health&Safety in the Workplace

The potential hazards by the use of ionic liquids in the industrial workplace are being identified, also by establishing protection mechanisms and an action plan in case of accident.

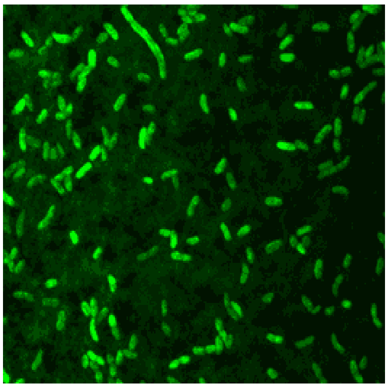
9.4. Control and recycling of Materials

A laboratory study of possible treatment options for removing and recovering salts and metal ions from rinse baths are being carried out, leading to incorporation of devices into pilot systems to be constructed during WP5

Also, different rinsing procedures are being examinated, calculating carry-over and treatment of the rinsing solutions containing metals, choline chloride and ethylene glycol.

Tests on ultra/nanofiltration to recover of organic compounds from IL plating workshop effluents and purification of these effluents by classic active sludge method are being investigated.

Some ecotoxicological tests to evaluate environmental risk analysis:



Vibrio Fisheri

Daphnia Magna

10. Economic Aspects

Contact: P. Négré
Protection des Metaux
ZA Le terminal - 4, rue Gracchus Babeuf - BP 113
93135 Noisy le sec Cedex, France
pascal@negre.be

10.1. Economic chances

The new technologies will be relevant to very large numbers of SME's and other stakeholders, therefore economic activities will be linked closely to the outputs from the RTD activities. Special requirements concerning safety and confidentiality of the information and documents as well as a control of the access are necessary. These items were also a topic in the Management of Knowledge and Intellectual Property and the Exploitation of the results.

The target of IONMET to find ways to apply the technology of ionic liquids to the industry requires an analysis of the needs and demands of the SME's. With increasing amount of knowledge the definitions of these requirements become more and more important. A number of questions result from various discussions inside the project itself and with other plating companies.

1. Technical acceptance
   - Replacement of running techniques has only slight chances. Systems that are successfully applied to aqueous electrolytes are of little interest.
   - Better chances for acceptance seems the concentration on presenting chances of the new technology and specialized systems (e.g. Al, Ag, other noble metals, electropolishing).
   - New techniques must be incorporated into the existing production systems
   - Availability of IL
   - Compatibility with organic additives
   - Scavenging/rinsing of the units
2. Market chances
   - The utilisation of IL in practice by SME should take into account 100 years of history in plating
   - The majority of the plating industry is not yet ready to use non-aqueous electrolytes like IL.
   - The short-term target should concentrate on specialized application with high current revenue and acceptance of higher costs.
3. Human acceptance
   - Education of the employees to use the new chemicals
   - Dangerousness in practical use
   - Acceptance of employees

10.2. Main results with promising issues

The market chances of the results are regulary summarized by a template that is sent to all partners. It integrates:

- New IL ready to exploit
- New applications/markets covered
- Time to market
- Contacts in partnership and outside

The current survey shows that at present the following topics have very promising economic chances

1. **Electropolishing of stainless steel**

   It obtains very good polishing results and 1000 l demonstration is in progress

   Future Market aims at development towards 2008 as an alternative to current electro polishing, with also possible polishing of high Ni alloys (impossible by traditional means)

2. **Electropolishing of Titanium**

   Is getting good lab scale results, development is also in progress, it is possible to polish complex parts; the market shows possible development towards 2009 for professional electronics and surgical prosthesis

3. **Electroless Silver**

   Is upgrading from lab scale to demonstration scale and obtains good results on Cu: the market is for PCB (printed circuits) with an Industrialisation towards 2008

4. **Chromium**

   However Chrome issues are not very far also from possible commercial exploitation and further development are in progress in this area.