Europe - China Cooperation in Green Electronics Production Research (EC-GEPRO)

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Abstract

This paper presents a recently commenced project titled "Europe - China Cooperation in Green Electronics Production Research" (EC-GEPRO) which focuses on improving the level of collaboration between Europe and China on research in development of "Green Electronics" technologies. The project is coordinated by the Western Norway Research Institute, and aims at mobilization of crucial actors and stimulation of high-level debate and cooperation on the development and promotion of Green Electronics products and production processes. This will be achieved through formation of research teams, establishment of a dedicated Centre of Excellence in China, and organization of international conferences, all dedicated to Green Electronics.

Background

International efforts to phase out the use of hazardous materials such as lead and bromine in the electronics production sector have come a long way with the implementation of the WEEE (Directive 2002/96/EC on Waste Electrical and Electronic Equipment) and RoHS directives (Directive 2002/95/EC on the Restriction of certain Hazardous Substances Directive) in the legislation of most European Union (EU) member states. Still, however, non-biodegradable 'e-waste' continues to constitute a large and global environmental hazard (according to some estimates, as much as 4000 tonnes of toxic e-waste is discarded worldwide every hour, constituting a global environmental problem [1]. As an example, disposal of e-waste in landfills accounts for as much as 40% of the total lead found in landfills [2]. Western countries still export their hazardous e-waste to China through, for instance Guiyu (Guangdong province), where the e-waste is processed in ways extremely harmful to local ecology and human beings [3].

Although Chinese legislation in this realm is moving in the direction of the EU countries, the problem of e-dumping will prevail for years to come. The urgency and extent of the e-waste problem calls for efforts to promote new product designs and production processes of a greener nature. As such, technology transfers in the name of green electronics, as intended in the Technology Agreement between China and Europe, remain extremely important.

In this respect, the unique characteristic of EC-GEPRO is that it involves Chinese as well as European partners with world class leading competence within the field of green electronics. The project is coordinated by **Western Norway Research Institute (WNRI)**, a private Norwegian research institute with a long standing history of EU funded projects. The institute, which has participated in European Union Framework Programmes 4, 5 & 6, has previously coordinated and is currently coordinating large EU funded projects. The Sino-Swedish Microsystem Integration Technology (SMIT) Center at **Shanghai University (SU)** are experts in providing assistance to industrial companies in handling the scientific problems and challenges connected with electronics production.

Loughborough University (LU) has extensive knowledge and experience in relation to electronics packaging and manufacturing, including simulation and control of electronics manufacturing processes, soldering and conductive adhesive bonding, and novel packaging technologies utilising soluble and biodegradable polymers. This is being utilised in EC-GEPRO's contributions towards advancing the state of the art in Green Electronics. Loughborough's *Centre for **S**ustainable **MA**nufacturing and **R**euse/Recycling **T**echnologies (SMART*) will also contribute to EC-GEPRO in the areas of sustainable design and end of life management.

The Tele and Radio Institute of Warsaw (ITR) is the leading institute within Green Electronics research in Poland and particularly supports small and medium sized enterprises (SMEs) in application of selected electronic technologies. Moreover, ITR has unique experience with managing a large European and Chinese network of SMEs in the area of electronic packaging and adhesives.

Chalmers Technological University (CTU) has a longstanding record of participation in EU projects. Over time the participating IVF - The Swedish Institute of Production Engineering Research, Division of Electronics Packaging - has specialised in researching, organising and administering dissemination, exploitation and training programmes, as well as managing large projects in electronics assembly and life cycle assessment of electronic products.

Conpart is a Norwegian producer of high-value added polymer particles for use in the electronics industry. The

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particles are used either in anisotropic conductive adhesives (ACA) or in ball grid arrays (BGA).

Objectives

The overall objective of EC-GEPRO is to support the transition towards sustainable production and consumption in the electronics sector, through increasing knowledge and awareness. This will be facilitated through increased international collaboration in the development of eco-efficient and sustainable products within the electronics sector, under the heading Green electronics. Increasing the links between European researchers and Chinese scientists will contribute specifically to increased transition in this direction.

Research Areas

The EC-GEPRO project is targeted at large industrial actors, politicians, at both regional and national level; and other key decision makers, who use, develop and promote Green electronics in their countries. The research areas which are be covered, in cooperation between Europe and China are:

- Advance Green electronics design, production and products
- Optimizing the life-cycle properties of electronics products
- Novel materials and technologies for microelectronics integration

The European-Chinese Research Teams

Cooperation will be established through the creation of European-Chinese teams of excellence in topics related to Green electronics. The teams will focus on three aspects of Green electronics:

- Green electronics design
- Green electronics assembly
- Green electronics materials

On the level of *Green electronics design* the focus is to incorporate life-cycle environmental aspects into the design of electronic products and production processes, with the aim of reducing their life-cycle environmental impacts (including material and energy resource reduction).

Green electronics assembly concerns the processes connected to assembling electronics components and also the life-cycle environmental impacts of the materials being used in the processes. These include substrate interconnects as well as components and process equipment used in the assembling of electronics.

With *Green electronics materials* the focus is on the specific types of materials used, such as lead (Pb) -free solder pastes, conductive adhesives, halogen-free substrates and components. These materials give the possibility to eliminate the use of the environmentally harmful Pb and bromine (Br) flame retardant compounds that are traditionally used in materials for interconnecting electronic components on printed circuit board substrates. Substitution of non-recyclable thermosetting polymer based composites with recyclable materials is another important materials issue that will be addressed.

In this project's research on environmentally friendly electronics, a significant focus is on lead-free joining processes, particularly on the use of lead free solders and metal plated monospheres provided by Conpart, a Norwegian firm. These are investigated in green electronics primarily in anisotropic conductive adhesives (*Figure 1*).

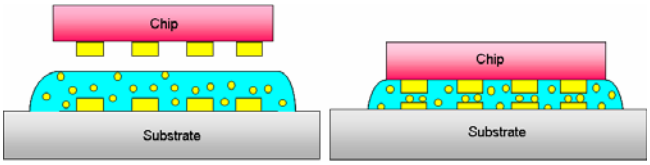

Figure 1 *Anisotropic conductive adhesives (ACA). (Figure provided by Helge Kristiansen, Conpart)*

The Conpart monospheres will also be applied as a compliant core for the conductive balls used in ball grid arrays (Figure 2).

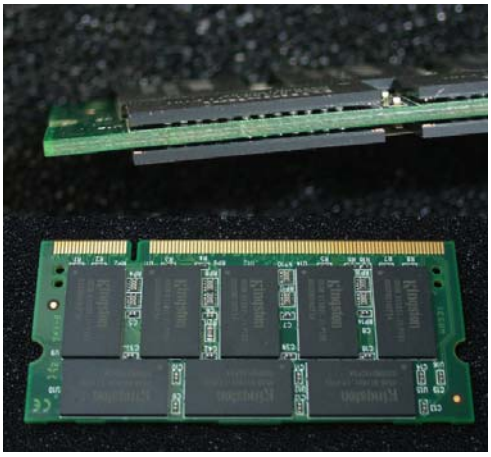

Figure 2 *Memory module showing components mounted as Ball Grid Arrays (BGAs). (Photo provided by Helge Kristiansen, Conpart)*

Figure 3 shows a novel approach to green electronic manufacture using thermoplastics not only to replace non-recyclable thermosetting polymers, but which through over-moulding of the components and subsequent sequential build up of the interconnection also removes the need for soldering or other joining processes altogether.

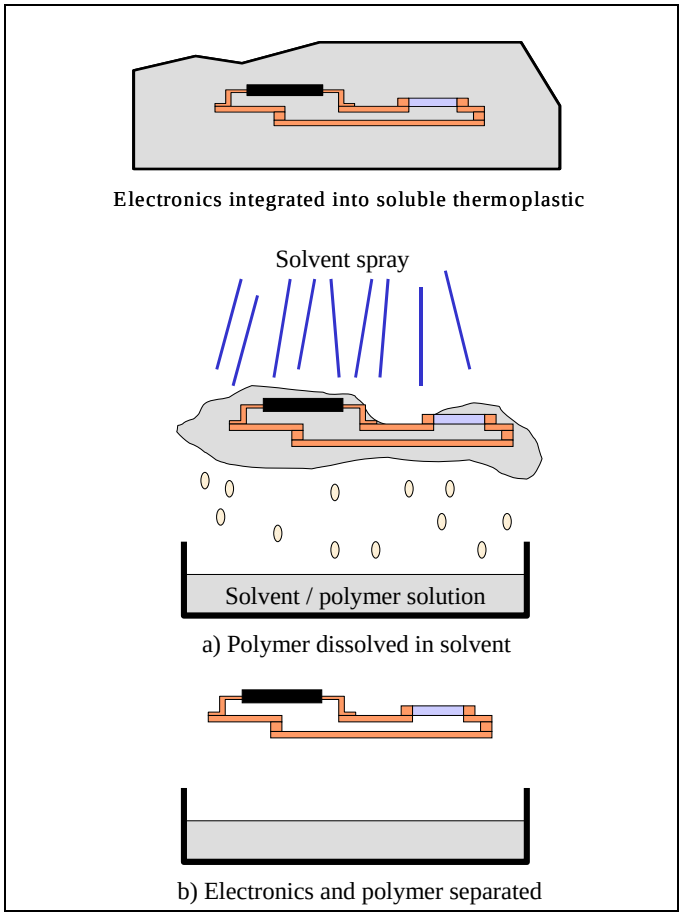

Figure 3 *Proposed highly recyclable electronics packaging technology*

Centre of Excellence

This work package consists of establishing a Centre of Excellence dedicated to cooperation between Europe and China on research and promotion of Green electronics. The Centre will be located in Shanghai in connection with the already established Sino-Swedish Microsystem Integration Technology (SMIT). The initial tasks of the Centre of Excellence will be to facilitate project events organisation, and later promoting continued Europe and China cooperation and research on Green electronics, beyond the project period, on a self-sustainable basis.

The Centre of Excellence will be established with the help of a reference group, which will, more specifically, assist in recommending specific research topics to be conducted by the Green electronics Centre of Excellence.

The Center is planned to be located in Chongming island of Shanghai, in which a green electronics park will be developed. The Chinese government, together with entrepreneurs and large industrial actors, are currently constructing this park. In this industrial park, the focus will be on the development of Green electronics and "eco-compatible" products. A research and development centre has already been set up. Shanghai University is closely connected to this development and has made a contribution in the form of a laboratory focussing on green and eco-compatible electronics, which is intended to accommodate further research developments in this area. Further on, a plan will be developed for the Centre of Excellence in Green electronics in Shanghai for how the continued Europe and China cooperation and research on Green electronics can be promoted on a self-sustainable basis after the project period. The plan for continuous operation of the centre includes applying for project funding from the Chinese government and Chinese companies, applying for project funding from the EC, organizing conferences on green electronics, and holding reference group meeting once per year.

Sino-European Exchange Programme

As part of the project, an exchange programme for students and researchers within the area of Green electronics will be established, allowing students and researchers to spend time at host universities in Europe and China. The programme will be coordinated by the Green electronics Centre of Excellence in Shanghai. In collaboration with European partners, universities and research institutes the programme will facilitate increased mobility for both students and researchers dedicated to improving their knowledge connected to Green electronics.

The program will allow the exchange of three students from Shanghai University to European universities or institutes for a period of 1-4 months a year to focus on environmental research (e.g. in Norway or Sweden). One additional student may spend time in the UK working with eco-friendly processes for one month. Furthermore, one researcher from Europe will be spending 6-12 months in China, connected to the Green electronics Centre of Excellence in Shanghai. For the purpose of these exchanges, the necessary funding schemes will be developed during the 2-year project period.

International Conferences

Organising two international conferences on green electronics, with participants from Europe and China, are also included in the work packages of this project.

The operational objective of the conference is to identify research needs and develop concrete research initiatives in the area of Green electronics.

The participants will cover all life cycle stages of electronics from design and manufacture, to use and final disposal, and come from a variety of sectors including government, industry, and research institutes/universities.

The conference will be supported from all EC-PEPRO partners. It will include invited speakers from Europe and China, and be open to the general public. Dedicated workshops and an exhibition of advances in green electronics will be organised in connection with the conference.

Web course development

As part of the collaboration, the SMIT Center, Shanghai University and Chalmers University of Technology will be co-developing internet based courses on lead free solders for

semiconductor packaging applications in collaboration with EU and other international partners.

Tin-lead solders have been used for a long time in the electrical industry due to its many advantages compared to other materials. The problem with the alloy is that lead is toxic even in small amounts. Lead binds to proteins in the body and inhibits normal processing and functions. Therefore there is a political ambition to replace use of lead in products wherever possible. Lead in gasoline and paint has been forbidden in many countries for years and now the time has come to replace lead in electronics. In Europe, through the ROHS directive, and in China for example lead in the manufacture of most products must be replaced before the end of 2006.

The ambition with this web based information is to provide knowledge of lead-free soldering for semiconductor packaging applications through open access modules that allow self training. The content of the web course will be divided into the following parts:

- Introduction to Lead Free Solders
- Basic Process Technology for Lead Free Soldering
- Semiconductor Lead Free Flip-Chip Packaging Technology
- Semiconductor Lead Free BGA, CSP and Wafer Level Packaging Technology
- Mechanical Properties of Lead Free Solders –Tensile, Aging and Creep properties
- Mechanical Properties of Lead Free Solders – Fatigue Properties
- Failure mechanisms and reliability issues
- Life Cycle Analysis (LCA) and Future Challenges for Lead Free Technology
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The course will include a large number of exercises, examination questions and video demonstrations of the experimental work for self study. For the exercises and examinations, answers will be provided. The course will provide an off-line possibility to contact the instructor, who will answer student questions through email. It is believed that such internet training courses can be an efficient way to transfer and exchange knowledge between the EU and China.

Acknowledgments

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