

**Introduction to COST 531-A
European Action on Lead-free
Soldering**

Hyuck-Mo Lee
(KAIST/Korea)

Introduction to COST 531

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KAIST

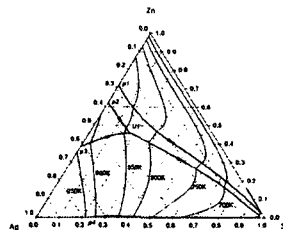
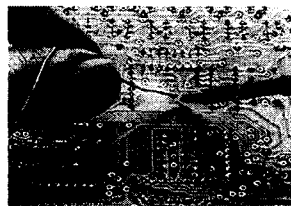
MS Computational Materials
Science Laboratory

COST 531

A European Action on
Lead-free Soldering

Herbert Ipser

Chairman of the Management Committee
Institut für Anorganische Chemie, Universität Wien
A-1090 Wien, Austria



<http://www.ap.univie.ac.at/users/www.cost531/>
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COST

COopération européenne dans le
domaine de la recherche **S**cientifique
et **T**echnique

European **CO**operation in the Field of
Scientific and **T**echnical Research



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What is COST ?

<http://www.cordis.lu/cost/>

- **Intergovernmental co-operation (basic, pre-competitive research)**
 - founded 1971
 - 19 Scientific & Technical domains (one of them: Materials)
- **Participation**
 - 34 COST Member States + 1 Co-operating Country (Israel)
 - International organizations and research establishments from non-COST countries
 - The European Commission
- **COST Actions**
 - Concerted Actions (Networks) of nationally funded R&D
 - Memorandum of Understanding (MoU)



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COST Countries



COST Member States

- The 25 EU Member States¹
- EFTA Member States
 - Iceland
 - Norway
 - Switzerland
- Candidate Countries
 - Bulgaria
 - Romania
 - Turkey
- Other Countries
 - Serbia and Montenegro²
 - Croatia²
 - FYR of Macedonia (FYROM)²

COST Co-operating States

- Israel

¹ from 1 May 2004

² not associated to FP



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COST Characteristics

- Individual projects of a COST Action must be financed nationally
- COST provides financial support for networking
 - a) Meetings, conferences, workshops
 - b) Exchange of (young) scientists (STSMs = Short Term Scientific Missions)
- Individual projects grouped into Group Projects (at least three projects from at least two different countries)
- Group projects may be collected in Working Groups
- COST Action is coordinated by a Management Committee (MC)
- All Actions within a Scientific Domain are coordinated by a Technical Committee (TC)
- Above all Committee of Senior Officials (CSO) as political level



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Organizations from non-COST countries

May participate on an Action by Action basis, given:

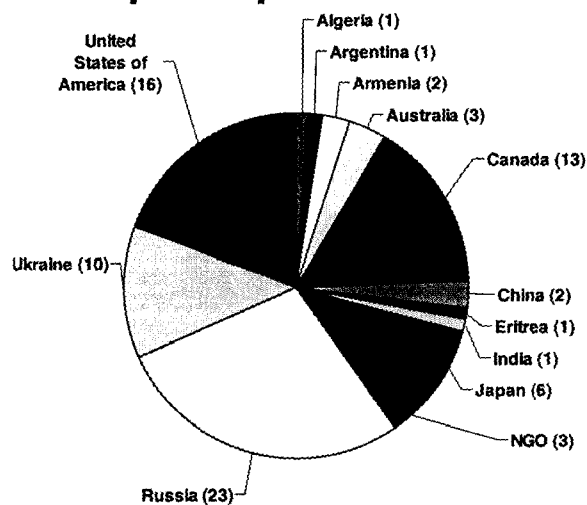
- there is mutual S&T benefit
- the CSO approves (following MC and TC approval)
- participation is confirmed by an exchange of letters between the organization and the CSO
- Non-COST institutions may not vote in the MC



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Non-COST Participation 2002 (No. of participations / 82 total)



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COST Action 531

Lead-free Solder Materials

Background

No lead anymore in electrical and electronic equipment in Europe from July 1st, 2006, on!

- Directive on Waste Electrical and Electronic Equipment (WEEE)
- Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RHS)

published in the *Official Journal of the European Union* 13.02.2003



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COST Action 531

Lead-free Solder Materials

Aim

- **A better lead-free solder**

Better than what?

⇒ Sn-37Pb, Sn-3.8Ag-0.7Cu

On what criteria?

⇒ Processability, Performance, Price



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COST Action 531

Lead-free Solder Materials

Systems of Interest

- n tin-silver (Sn-Ag) based systems
- n tin-copper (Sn-Cu) based systems
- n tin-indium (Sn-In) based systems
- n tin bismuth (Sn-Bi) based systems
- n tin-zinc (Sn-Zn) based systems
- n alternate solder systems



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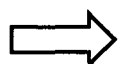


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Lead-free Solder Materials

20 Signatory Countries in Europe

Austria	Greece	Slovenia	Hungary
Bulgaria	Ireland	Spain	applied
Croatia	Italy	Sweden	
Czech Republic	Netherlands	Switzerland	Belgium
Finland	Poland	United Kingdom	???
France	Portugal	Yugoslavia	
Germany	Slovakia		



approx. 40 research institutions
from 15 European countries



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Lead-free Solder Materials

2 non-COST Institutions:

- MMO (Materials and Manufacturing Ontario, Canada)
- CMAP (Centre for Microelectronics Assembly and Packaging, Canada)

letter of application to join from:

- National Cheng Kung University (Tainan, Taiwan)



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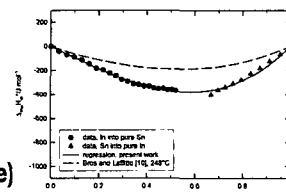


COST Action 531

Lead-free Solder Materials

4 Working Groups

WG 1: Experimental thermodynamic properties of alloy systems and experimental phase diagrams
(Coordinator: *Bernard Legendre*, Paris, France)



WG 2: Theoretical modeling of phase diagrams
(Coordinator: *Leszek Zabdyr*, Kraków, Poland)



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COST Action 531

Lead-free Solder Materials

4 Working Groups

WG 3-4: Physical and chemical properties of alloy systems as well as of solder joints

(wettability, surface tension, viscosity, ...;
ductility, strength, fatigue, ...; toxicity, ...)

(Coordinator: *William J. Plumbridge*, Milton Keynes, United Kingdom)

$\alpha = 90^\circ$

α

WG 5-6: Reliability issues, packaging and miniaturization

(thermal fatigue, mechanical fatigue, ...)

(Coordinators: *Bernd Michel*, Berlin, Germany,
and *John Botsis*, Lausanne, Switzerland)

Assemblies



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10 Group Projects

No.			
GP1	PL 1-1 Leszek A. Zabdry (5 partners: A, POL, UK)	Krakow (POL)	Physico-chemical properties of some Ag-based ternary alloys as possible materials for lead-free solders
GP2	IT 2-1 Riccardo Ferro (6 partners: I, F, UK)	Genoa (I)	Contribution to the constitutional characterisation of lead-free alloys as soldering materials
GP3	FR 3-1 Fiqiri Hodaj (5 partners: A, F, NL, FIN)	Grenoble (F)	Interfacial reactions in SnAgCu based solder interconnects and multilayer assemblies
GP4	AT 4-1 Herbert Ipser (7 partners: A, I, CZ, POL)	Vienna (A)	Silver-Indium-Tin Alloys as Possible Lead-free Soldering Materials: Interaction with Ni and Pd as Substrates
GP5	PT 5-1 Delfim Soares (7 partners: PT, POL, BG, F)	Minho (PT)	Physical and technological properties of Sn-Zn- and Sn-Bi-X based lead-free alloys
GP6	DE 6-1 Günter Effenberg (3 partners: D, UK, NL)	Stuttgart (D)	Lead-free tin based solders and coatings, wetting behaviour, interdiffusion, phase equilibria
GP7	PL 7-1 Natalia Sobczak (7 partners: POL, CH, SK, A, BG, UK)	Krakow (POL)	Prediction of the next generation of lead-free solders
GP8	PL 8-1 Krzysztof Fitzner (6 partners: POL, YU, F, CZ, SLO)	Krakow (POL)	Thermodynamic Properties and Phase Equilibria of Silver Ternary Alloys with Indium, Antimony and Tin
GP9	DE 9-1 Georg Schmitz (6 partners: D, UK, POL, CH)	Aachen (D)	Control of Microstructure Evolution and Its Impact on Solder Joint Performance
GP10	CH10-1 John Botsis *	Lausanne (CH)	Identification of mechanical behavior of lead-free materials subjected to structural constraints



* proposed

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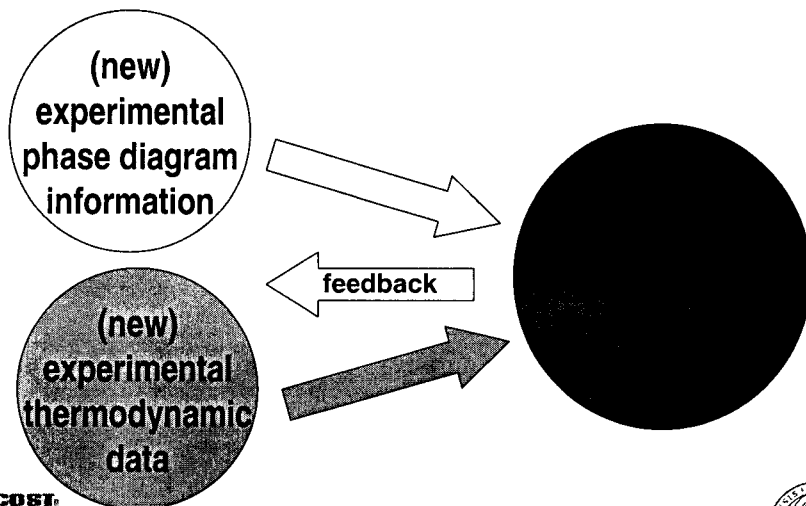
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Working Groups 1+2

Thermochemistry and Phase Diagrams (Experimental + Modeling)



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Working Groups 1+2

Thermochemistry and Phase Diagrams (Experimental + Modeling)

Systems:

- Sn-Ag-Cu + Au
+ Ni
+ Pd
- Sn-Ag-Bi + Ni
- Sn-Bi-Zn + Pd
- Sn-Ag-In + Au
+ Cu
+ Pd
- Sn-In-Zn + Pd

to increase efficiency



Mutual Agreement with
SGTE*
to use data bases

* SGTE = Scientific Group Thermodata Europe



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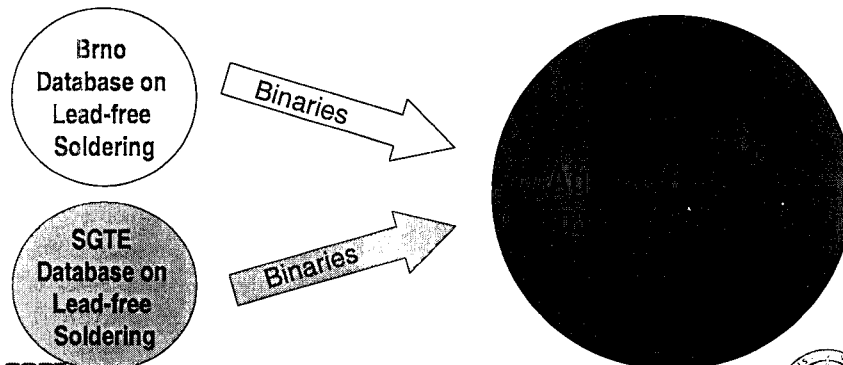


Working Groups 1+2

Thermochemistry and Phase Diagrams (Experimental + Modeling)

May 5-10, 2004, "AAA Meeting" in Brno:

A. Dinsdale and A. Watson on Short Term Scientific Mission (STSM),
meeting A. Kroupa and J. Vřeštal



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Working Groups 1+2: Work in Vienna

Group Project GP4:

"Ag-In-Sn Alloys as Possible Lead-free Soldering Materials:
Interaction with Ni and Pd as Substrates"

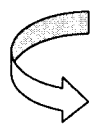
	<i>Partners</i>	<i>City / Country</i>	<i>Main Contribution</i>
AT 4-1	H. Ipser (Coordinator)	Vienna / A	Phase diagram investigations and experimental thermodynamics (calorimetry)
AT 4-2	R. Stickler	Vienna / A	(Retired)
AT 4-3	B. Weiss	Vienna / A	Mechanical properties of solder joints
IT 4-4	G. Borzone	Genoa / I	Calorimetric measurements
PL 4-5	L. Zabdyr	Cracow / PL	emf-measurements
CZ 4-6	J. Vřeštal	Brno / CZ	Phase diagram calculations
CZ 4-7	A. Kroupa	Brno / CZ	Phase diagram calculations



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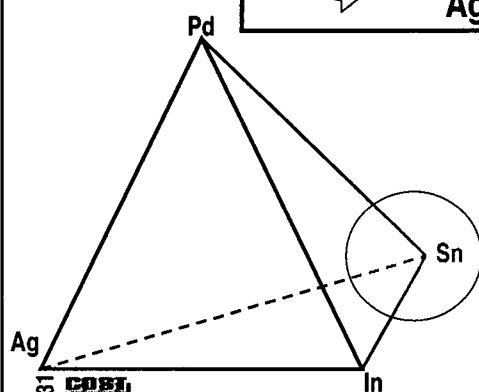


Working Groups 1+2: Work in Vienna



Ag-In-Sn solders + Pd substrates

Ag-In-Pd-Sn phase diagram



6 binaries:

Ag-In, Ag-Pd, Ag-Sn,
In-Pd, In-Sn, Pd-Sn

4 ternaries:

Ag-In-Sn, Ag-Pd-Sn,
Ag-In-Pd, In-Pd-Sn

1 quaternary

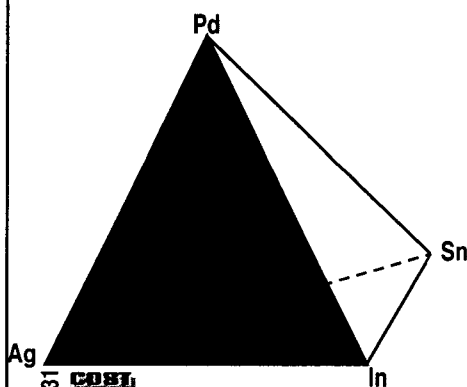
Ag-In-Pd-Sn



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Ag-In-Pd-Sn phase diagram



1. Ag-In-Pd ternary
phase diagram



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Isotherm 700°C

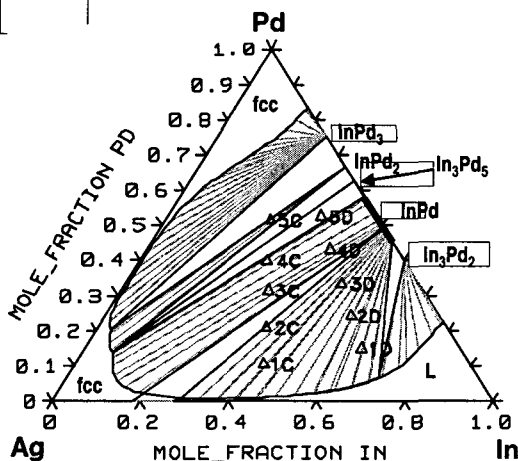
PI-11

Ag-In-Pd

calculated (with THERMO-CALC)
from binary data only

A. Zemanová, A. Kroupa, J. Vzeštál;
Brno

Δ1C: samples



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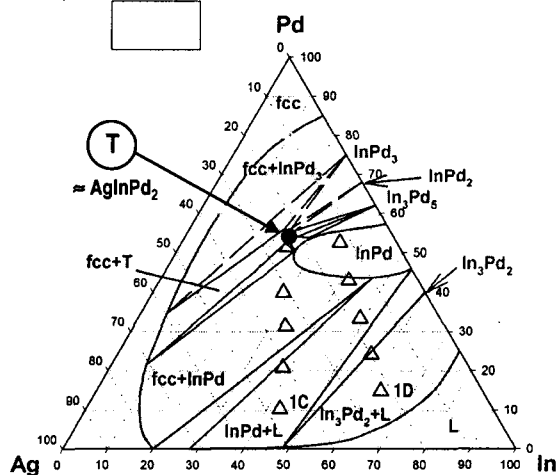
Isotherm 700°C

PI-11

Ag-In-Pd

experimental
(XRD, DTA, EPMA)

No.	experimental	calculated
1C	L, InPd	L, InPd
2C	L, InPd	L, InPd
3C	fcc, InPd	fcc, InPd
4C	fcc, InPd	fcc, InPd
5C	fcc, InPd, T	fcc, InPd ₂
1D	L, In ₃ Pd ₂	L, InPd
2D	L, InPd, In ₃ Pd ₂	L, InPd
3D	L, InPd	L, InPd
4D	fcc, InPd	fcc, InPd
5D	InPd	InPd, fcc, In ₃ Pd ₅



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Enthalpies of Mixing of
liquid alloys (in kJ mol⁻¹)
by drop calorimetry
at 900°C

In-Pd-Sn

exp. values fitted by a
Redlich-Kister-Muggianu
polynomial

liquid at 900°C



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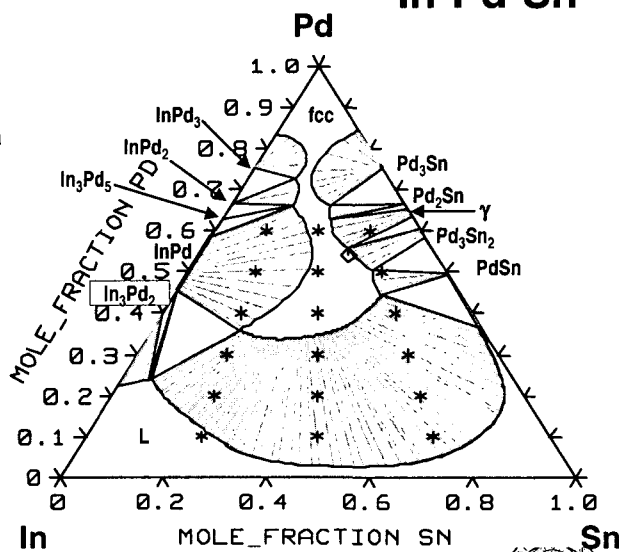
Isotherm 700°C

calculated
(with THERMO-CALC)

using ternary parameters for
liquid phase from experimental
enthalpies of formation

V. Buchtová, A. Kroupa,
J. Vřeštal;
Brno

In-Pd-Sn



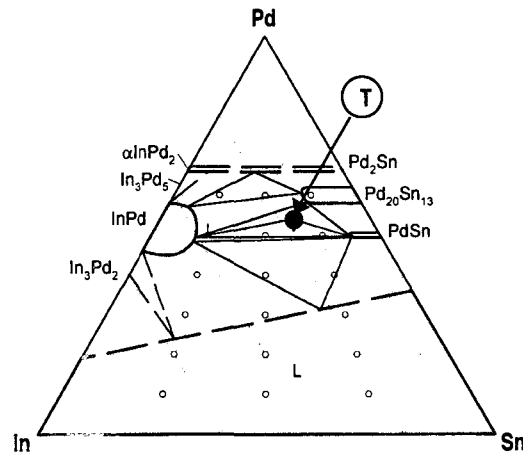
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In-Pd-Sn

Isotherm 700° C

experimental
(XRD, DTA, EPMA)



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ELFNET

(European Lead-Free Soldering NETWORK)
a Coordination Action within FP6

- Coordinated by ITRI Ltd. (International Tin Research Institute)
- 36 participants from 19 European countries
- Budget of 2.3 million EURO
- Contract signed in April 2004
- Overlap with COST 531 (alphabetical):
 - EMPA (Swiss Fed. Lab. for Materials Testing and Research)
 - Helsinki University of Technology
 - Institute of Metallurgy and Materials Science, Polish Academy of Sciences
 - Institute of Physics of Materials, Czech Academy of Sciences
 - (NMRC – University College Cork)
 - (Siemens Germany)
 - TU Berlin / Fraunhofer Institute for Reliability and Microintegration IZM
 - University of Vienna



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COST 531: Wrap-up

- **March 3/4, 2005:**
**COST 531 Midterm-Conference
in Lausanne, Switzerland**
organized by *Prof. John Botsis* (EPFL)



- **Information on COST 531**
<http://www.ap.univie.ac.at/users/www.cost531/>
- **Information on COST**
<http://cost.cordis.lu/cost>



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