

# **Phase diagram investigations in the Au-Ge-X, Au-Si-X and Au-Sb-X (X = Cu, Ni, Ti) systems**

COST MP0602 HISOLD  
Expression of Interest

Dr. C. Leinenbach, EMPA Dübendorf, Switzerland

Dr. U. Klotz, FEM Schwäbisch-Gmünd, Germany

# Motivation

- Au based filler metals with low melting point interesting as lead free solders

- Eutectic Au-20Sn solder widely applied

- Advantages

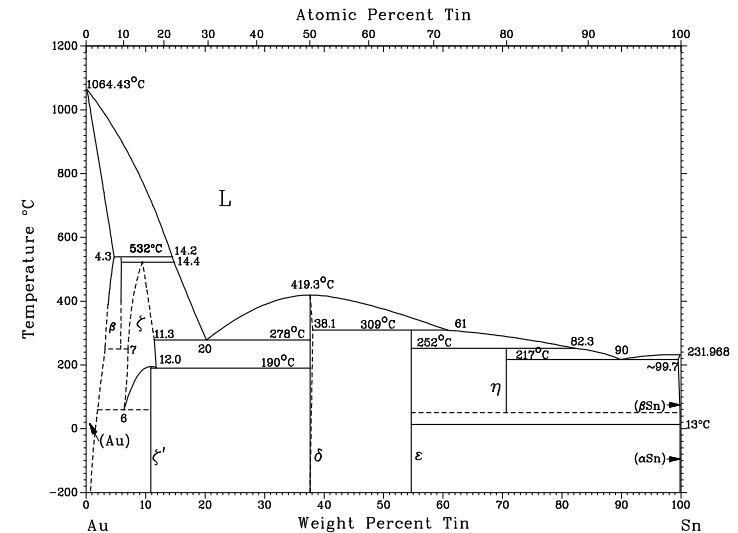
- High corrosion resistance
- High thermal and electrical conductivity
- Fluxless soldering

- Disadvantages

- Expensive
- $T_m = 278\text{ °C}$

- Current & possible future applications for Au based lead free solders

- Optoelectronic packages
- MEMS devices
- Biomedical devices
- Sensors in aggressive environment
- Space technology

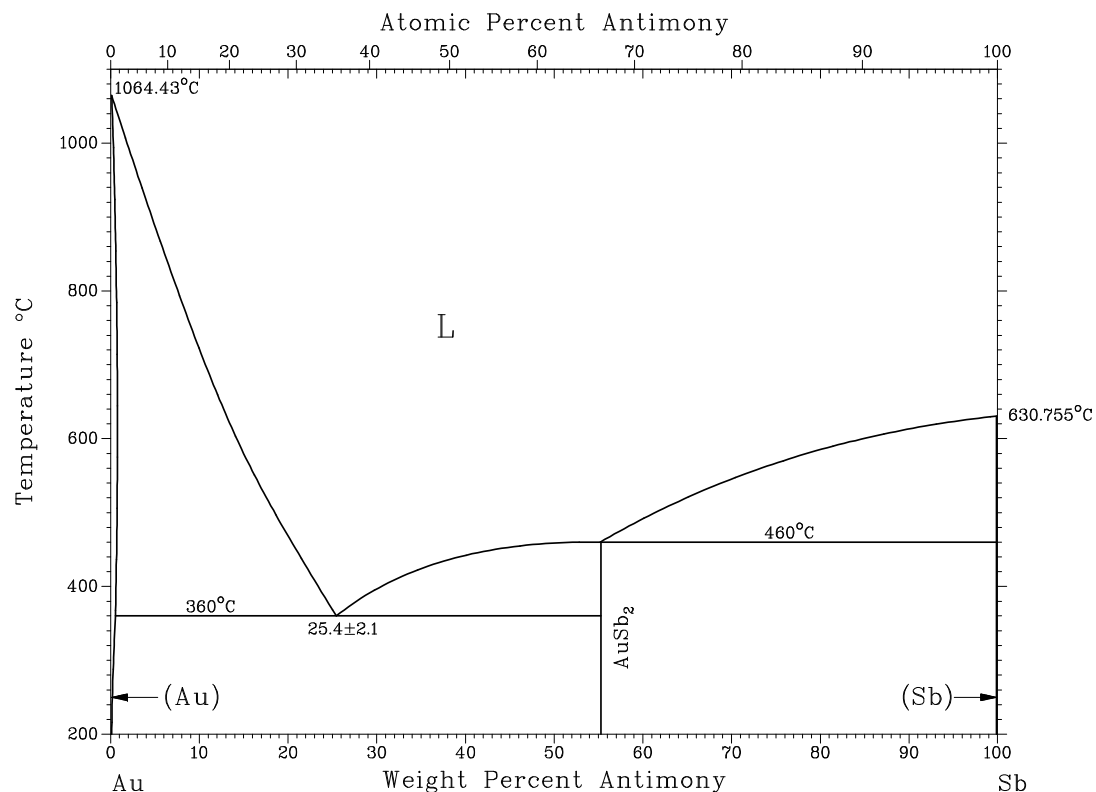


# Literature survey

- Other Au based binary alloys with low melting point
  - Au-3.15Si ( $T_m = 363^\circ\text{C}$ )
  - Au-12Ge ( $T_m = 356^\circ\text{C}$ )
  - Au-25.4Sb ( $T_m = 360^\circ\text{C}$ )
- Phase diagram data for binary and ternary systems partly available

- Au-Si
- Au-Si
- Au-Sb
- Au-Sn
- Au-Ag
- Au-Pt
- Au-Ag

- Phase diagram and Au-S



# Project Tasks

- Experimental verification of **phase equilibria** in the above mentioned systems (diffusion couples, individual alloys)
- Determination of **equilibria involving the liquid phase** (thermal analysis)
- Investigation of **interface reactions** between Au-Ge, Au-Si and Au-Sb alloys, respectively, and possible **substrate materials** (Cu, Ni, Ti) (metallography, electron microscopy...)
- **CALPHAD** assessment and modelling

# Resources & collaboration

## Experience @ EMPA:

- Au and Ag based alloys as brazing filler metals (e.g. Au-Ni, Ag-Pd, Au-Ag-Pd)
- Active brazing of ceramic, diamond, cBN
- Phase diagram investigations (e.g. Fe-Ni-Ti-Al, COST 535)
- CALPHAD modeling

## Resources available @ EMPA:

- Laboratory of Joining and Interface Technology is a multidisciplinary materials science research group with expertise in the fields of joining, physical metallurgy, nano-technology.
- The Laboratory possesses a wide range of processing and test equipment that may be utilised for the proposed work

## Available Infrastructure and Instruments:

- Process laboratory with various equipment for soldering and welding processes
- Laboratory with various furnaces, microscopy/analysis rooms, rooms for sample preparation

## Skills or expertise sought from other partners:

- The team seeks collaborations with groups on similar activities and complementary expertise

# Project Partners and Effort

- Dr. Christian Leinenbach, Dr. Manfred Roth  
EMPA Dübendorf, Switzerland
- Dr. Ulrich Klotz  
FEM Schwäbisch-Gmünd, Germany
- Dr. Andrew Watson  
University of Leeds, UK
- ???

Project duration: 3 years  
Total planned effort: 1 PostDoc  
0.5 Senior scientists  
0.2 Technicians



forschungsinstitut  
**fem**  
edelmetalle &  
metallchemie

**Research Institute  
Precious Metals & Metals Chemistry**

# Organisation

## Director

Dr. Andreas Zielonka

## Administration

## Physical Metallurgy

Dr. Ulrich Klotz

## Elektrochemie - Electroplating - Corrosion

Dr. Renate Freudenberger

## Light Metals Surface Technology

Dipl.-Ing. (FH) Judith Pietschmann

## Plasma Surface Technology / Materials Physics

Dr. Martin Fenker

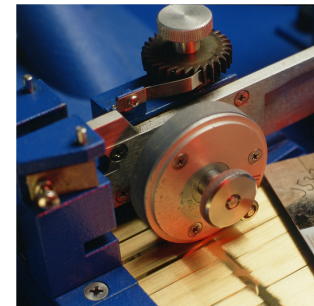
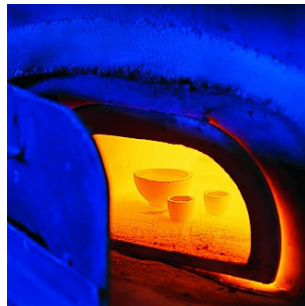
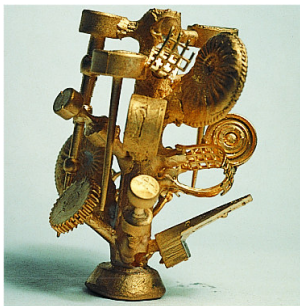
## Analysis – Environmental Analysis

Dr. Martin Völker



# Physical Metallurgy

- Constitution of Precious Metals Alloy Systems
- Alloy Development for Jewellery and Dental Applications
- Development and Simulation of Casting Processes
- Development of Functional Materials
- Expertises, Consulting, Failure Analysis
- Materials Testing, Electron microscopy
- Staff members: 13



# Equipment (Selection)

## → Alloy preparation

- arc furnace, induction furnace, rapid quenching, centrifugal casting investment casting (lost wax technique)
- Rolling, wire drawing

## ▪ Metallography / Characterisation

- optical microscopy with image analysis, Ion etching, high resolution field emission SEM with EDX
- X-ray diffraction (XRD), X-ray reflectometry (XRR), measuring of magnetic, electrical and superconducting properties
- differential thermal analysis (DTA), calorimetry (DSC), thermal gravimetry (TGA), dilatometry

## ▪ **Materials Analysis**

- emission and absorption spectroscopy (ICP-OES, GDOS, AAS), photometry (UV-VIS, IR), chromatography (GC, GC-MS, HPLC, IC), gas/non-metal analysis (H, N, O, C, S), standard analyses, fineness of precious metals, fire assay

# WWW.FEM-ONLINE.DE



## Home

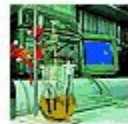
- Aktuelles
- Über das FEM
- Arbeitsgebiete
- Veranstaltungen
- Kontakt
- Stellenangebote
- Ansprechpartner

Quick-Finder

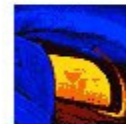
Freie Suche

[e-mail](#) [english](#)

## Home



**FORSCHEN.  
ENTWICKELN.  
MESSEN.**



Forschungsinstitut für  
Edelmetalle und Metallchemie Tel.: 07171 / 1006-0  
Katharinenstr. 17 Fax: 07171 / 1006-54  
D-73525 Schwäbisch Gmünd e-mail: [fem@fem-online.de](mailto:fem@fem-online.de)

design 

