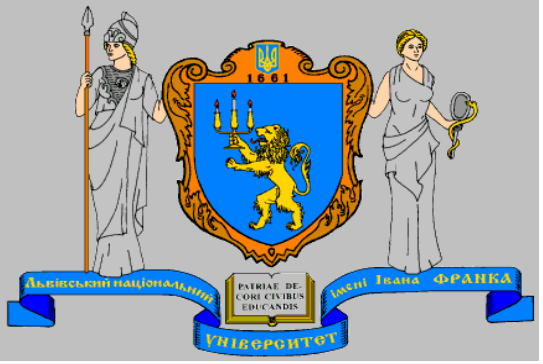


Advanced Solder Materials for
High-Temperature Application – HISOLD"
Expression of Interest for COST MP0602
WG1

Experimental methods for investigations of thermophysical and structure-sensitive properties of Pb-free solder alloys

Yu. Plevachuk

Ivan Franko National University, Department of metal physics
8, Kyrylo and Mephodiy Str.
79005 Lviv Ukraine
Tel.: +38-032-2394270, Fax: +38-032-2956908
E-mail: plevachuk@mail.lviv.ua

Laboratory of liquid metals of Ivan Franko National University of Lviv (LNU) can carried out the experiments in the frame of the Working Group 1 using the below listed equipment:

1. Original experimental technique for simultaneous electrical conductivity and thermoelectric power measurements in a wide temperature range (up to 1600 K) under high pressures (up to 50 MPa) by the contact 4-point-method.

2. Oscillating-cup viscosimeter for viscosity measurements.

3. Experimental arrangement based on the steady-state concentric cylinder method for the measurement of the thermal conductivity over a temperature range up to 1700 K under pressures (up to 1 MPa).

4. High-temperature microscope IMASH for investigation of mechanical, stress-strain, and other properties of solidified melts

5. Apparatus for the surface tension measurement by the by the sessile-drop method.

6. X-ray diffraction.

7. High-temperature furnaces for sample synthesis.

Main investigated systems and phenomena by the above listed equipment:

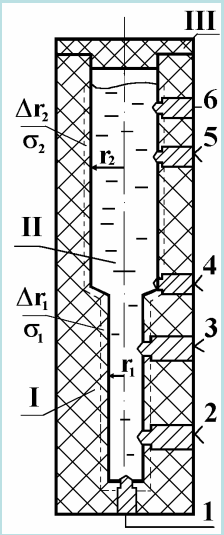
Eutectics: **Sn-Ag, Sn-Cu, Sn-Ag-Cu, Ga-In-Sn, In-Bi, Pb-Sn, Pb-Bi, Pb-Mg, Pb-Li.**
Phase separation in monotectics: Pb-Ga, Pb-Zn, In-Te, Tl-Te, In-Se, Tl-Se, In-Tl-Te, In-Tl-Se, In-Te-Se, Tl-Te-Se, Bi-Zn.
Intermetallics: Al-Ni, Al-Fe, Al-Cu.
Industrial alloys: Al-Si, Al-Si-Mg, Al-Si-Cu, Al-Cu-Ti-Mg, Mg-Al-Zn, Sn-Ti, Sn-Zr, Sn-Ti-Zr.
Refractory alloys: $Nd_2Fe_{14}B_1$, YNi_2B_2C, Er_2PdSi_3.
Metal-nonmetal transition: $Cu_x(CuAsSe_2)_{1-x}$, $CuTlSe_2$, $CuAsSe_2$, $TlAsSe_2$, $CuTlTe_2$, $CuAsTe_2$, $TlAsTe_2$, Se-Te.
Semiconductors: Te(Se)+TM (TM = Ti, V, Cr, Mn, Fe, Co, Ni, Cu), CdTe, CdTe+Zn, CdTe+(In,Ge,Sn), CdTe+As, Tl_2Te, Tl_2Se, Ag_2Te, Cu_2Te, Cu_2Se.

26 years progressive scientific experience, more than 200 publications, the methods described in:

- Yu. Plevachuk, V. Sklyarchuk. Meas. Sci. Technol. 12(1) (2001) 23
- B. Sokolovskii, V. Sklyarchuk, V. Didoukh, Yu. Plevachuk. High-Temp. Mater. Sci. 34 (1995) 275
- V. Sklyarchuk, Yu. Plevachuk. Meas. Sci. Technol. 16 (2005) 467
- Yu. Plevachuk, V. Sklyarchuk, A. Yakymovych, B. Willers, S. Eckert. J. Alloys Comp. 394 (2005) 63
- Yu. Plevachuk, V. Sklyarchuk, S. Eckert, G. Gerbeth. *J. of Nuclear Materials* (in press).

Electrical conductivity, σ(T), and thermoelectric power, S(T) *

- A contact method in accordance with the 4-point scheme
- Argon atmosphere
- Graphite electrodes BN-ceramic measuring cell
- WRe-5/20 thermocouples in close contact with a liquid
- Temperature gradients of 3-4~K/cm along the cell
- The resultant error of σ(T) ~ 2%
- The resultant error of S(T) ~ 5%
- 2-radii cell



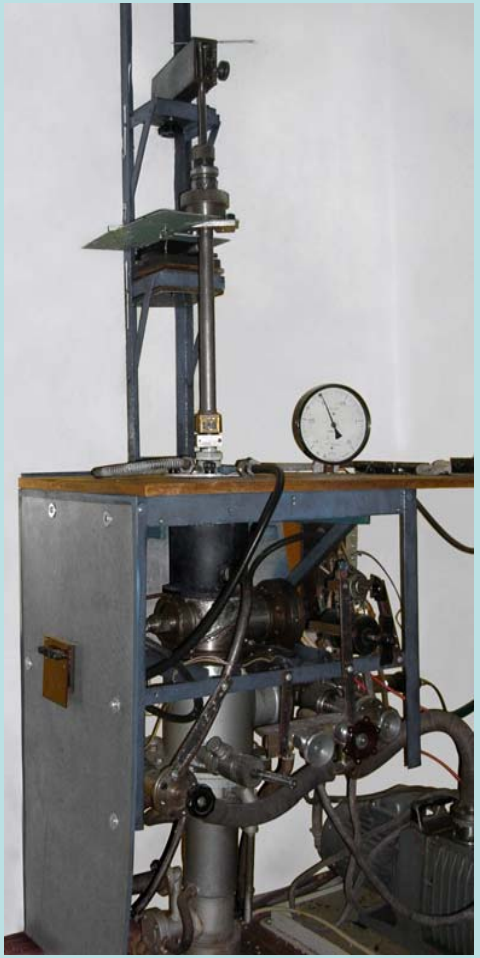
Elimination of errors connected with:

- convective flows
- jamming signals
- systematic deviation of devices
- diffusion of the sample into ceramic

**Yu. Plevachuk, V. Sklyarchuk. Meas. Sci. Technol. 12(1) (2001) 23*

Viscosity, $\eta(T)$ *

- **Computer-controlled oscillating-cup viscosimeter**
- **Roscoe equation**
- ***He*-atmosphere under pressure of ~ 0.02-0.03 MPa**
- **Sample composition accurate to 0.02 wt.%**
- **No loss of mass after the measurement**
- **WRe-5/20 thermocouple**
- **Accuracy ~ 3%**



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J. Alloys Comp. 394 (2005) 63

Thermal conductivity, λ(T) *

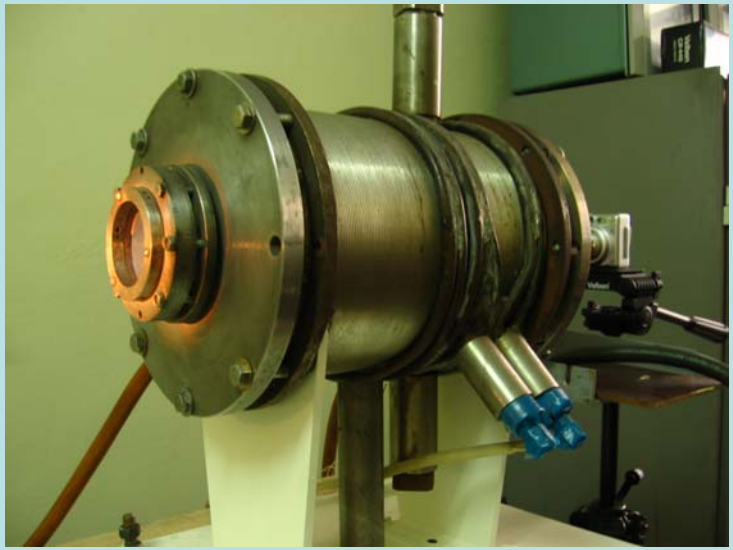
- **Steady-state concentric cylinder method**
- **2 coaxial cylinders (stainless steel, BN or graphite)**
- **WR5/20 thermocouples**
- **Temperature range between liquidus and 1700 K**
- **Argon pressure up to 1 MPa**
- **Heat leakage and convection heat flow minimization**
- **Analysis of different experimental errors**
- **Accuracy ~ 7%.**

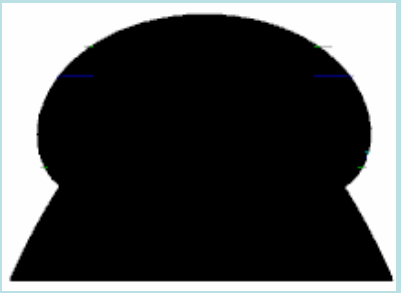
*V. Sklyarchuk, Yu. Plevachuk. Meas. Sci. Technol. 16 (2005) 467

Surface tension, γ(T)

- **“Large drop" method**
- **atmosphere of 90 % Ar + 10 % H_2**
- **WRe5/20 thermocouple**
- **CCD camera and a computer-controlled equipment**
- **Laplace-Young equation**
- **Accuracy ~ 0.5 %.**

$$\Delta P = \gamma\left(\frac{1}{R1} + \frac{1}{R2}\right) = \rho g Z + C$$





High-temperature microscope IMASH for investigation of mechanical, stress-strain, and other properties of solidified melts

High-temperature X-ray diffractometer with horizontal axis

X-ray diffractometer

Proposed field of Study:

Sn-Bi-Ag, Sn-Bi-Cu, Sn-Sb-Ag and Sn-Sb-Cu alloys for high-temperature soldering.

Measurements in a wide temperature range above liquidus of :
electrical conductivity, thermal conductivity, thermoelectric power, viscosity, surface tension, density, X-ray.

Cooperation with:

- Prof. G. Borzone, Genova, Italy
- Prof. W. Hoyer, Dr. I. Kaban, Chemnitz, Germany
- Prof. J.-G. Gasser, Metz, France
- Prof. H. Ipser, Prof. A. Mikula, Vienna, Austria