



## CERTIFICATE OF ANALYSIS

### Pure Copper IMN-001

The assigned values<sup>1</sup> and uncertainties<sup>2</sup> in µg/g

Element	Mass fraction <sup>1</sup>	Uncertainty <sup>2</sup>
Ag	27.59	±0.42
As	3.17	±0.20
Bi	1.42	±0.09
Co	2.04	±0.35
Cr	3.55	±0.47
Mn	5.18	±0.38
Ni	3.42	±0.60
Pb	4.28	±0.69
Sb	2.33	±0.29
Se	1.38	±0.23
Sn	3.31	±0.65
Te	1.23	±0.38
Zn	4.57	±0.64
<b>Indicatory values</b>		
Cd	0.11	±0.06
Fe <sup>3</sup>	13.9	(±2.4)
S <sup>3</sup>	6.0	(±2.4)

<sup>1</sup>Unweighted mean value of the means of accepted sets of data, each set being obtained in a different laboratory and/or with a different method of determination.

<sup>2</sup>The certified uncertainty is the expanded uncertainty with a coverage factor k=2, corresponding to a level of confidence of about 95 %.

<sup>3</sup>Not homogenous in the volume of a single cylinder.

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Director of the Institute

Certified on October 2012  
Revised on December 2014



### Means of accepted data sets

(for one method at one laboratory, respectively)

### Mass fraction in $\mu\text{g/g}$

Lab./ method	Ag	As	Bi	Co	Cr	Mn	Ni	Pb	Sb	Se	Sn	Te	Zn	Fe	S	Cd
1	-	2.84	1.25	1.56	3.01	4.69	2.42	3.22	1.94	1.08	2.42	0.84	3.97	9.89	4.9	0.14
2	27.09	2.98	1.28	1.7	3.02	4.72	2.68	3.29	2.01	1.33	2.44	0.97	4.03	10.82	5.45	0.078
3	27.14	3.06	1.29	1.8	3.37	4.87	2.86	3.39	2.1	1.45	2.54	1.18	4.05	13.89	5.82	0.08
4	27.63	3.1	1.41	1.855	3.37	4.99	3.05	3.96	2.23	1.49	2.63	1.21	4.46	14.4	6.55	0.15
5	27.70	3.14	1.43	2.00	3.69	5.31	3.11	4.29	2.32	1.55	3.36	1.3	4.53	15.49	6.7	—
6	27.91	3.31	1.46	2.04	4.065	5.34	3.12	4.54	2.37		3.48	1.89	5.07	15.7	—	
7	28.06	3.36	1.48	2.65	4.34	5.43	3.45	4.89	2.68		4.02		5.86	16.99		
8	—	3.61	1.49	2.71		6.05	3.84	5.07	2.98		4.44		—			
9		—	1.66				4.75	5.83			4.44					
10							4.92									
<b>Mean</b>	<b>27.59</b>	<b>3.17</b>	<b>1.42</b>	<b>2.04</b>	<b>3.55</b>	<b>5.18</b>	<b>3.42</b>	<b>4.28</b>	<b>2.33</b>	<b>1.38</b>	<b>3.31</b>	<b>1.23</b>	<b>4.57</b>	<b>13.9</b>	<b>5.88</b>	<b>0.11</b>
<b>Std Dev.</b>	<b>0.397</b>	<b>0.243</b>	<b>0.129</b>	<b>0.424</b>	<b>0.508</b>	<b>0.454</b>	<b>0.842</b>	<b>0.899</b>	<b>0.351</b>	<b>0.186</b>	<b>0.844</b>	<b>0.364</b>	<b>0.689</b>	<b>2.62</b>	<b>0.753</b>	<b>0.038</b>

### Description of the material:

The reference material is available in a cylindrical form (diameter 3 mm, height 5 mm); in a bottle containing approx. 50 g. The mass of one cylinder is  $0,310\pm 0,004$  g.

### Traceability:

Most of the analytical work performed to assess this material has been carried out by laboratories with proven competence, often indicated by the national authority. This certified reference material is traceable to: IMN CP (CP1-CP6) and CF (CF1-CF5) series and BAM-M381.

### Analytical methods applied:

Ag	2	Spark optical emission spectrometry (AES)
	3, 4	Flame atomic absorption spectrometry (FAAS)
	5	Globule arc optical emission spectrometry (DC Arc)
	6, 7	Inductively coupled plasma optical emission spectrometry (ICP)
As	1,3	Inductively coupled plasma optical emission spectrometry (ICP)
	2	Hydride generation inductively coupled plasma optical emission spectrometry (HG ICP)
	4	Inductively coupled plasma mass spectrometry (ICP MS)
	5	Glow discharge mass spectrometry (GD MS)
	6	Electrothermal atomic absorption spectrometry (ET AAS), $\text{Fe}(\text{OH})_3$ -precipitation
	7	Electrothermal atomic absorption spectrometry (ET AAS), $\text{Zr}(\text{OH})_4$ -precipitation
	8	Globule arc optical emission spectrometry (DC Arc)
Bi	1,3	Hydride generation inductively coupled plasma optical emission spectrometry (HG ICP)
	2	Spark optical emission spectrometry (AES)
	4	Globule arc optical emission spectrometry (DC Arc)
	5	Inductively coupled plasma optical emission spectrometry (ICP), $\text{Zr}(\text{OH})_4$ -precipitation
	6	Glow discharge mass spectrometry (GD MS)
	7	Electrothermal atomic absorption spectrometry (ET AAS), $\text{Zr}(\text{OH})_4$ -precipitation
	8	Electrothermal atomic absorption spectrometry (ET AAS), $\text{Fe}(\text{OH})_3$ -precipitation
	9	Inductively coupled plasma mass spectrometry (ICP MS)



Cd	1	Electrothermal atomic absorption spectrometry (ET AAS)
	2	Inductively coupled plasma mass spectrometry (ICP MS)
	3	Flame atomic absorption spectrometry (FAAS), electrolytic Cu-separation
	4	Glow discharge mass spectrometry (GD MS)
Co	1, 5	Inductively coupled plasma mass spectrometry (ICP MS)
	2	Globule arc optical emission spectrometry (DC Arc)
	3	Electrothermal atomic absorption spectrometry (ET AAS), electrolytic Cu-separation
	4	Inductively coupled plasma optical emission spectrometry (ICP)
	6	Spark optical emission spectrometry (AES)
	7	Electrothermal atomic absorption spectrometry (ET AAS)
	8	Glow discharge mass spectrometry (GD MS)
	Cr	1, 3
2		Flame atomic absorption spectrometry (FAAS), electrolytic Cu-separation
4, 5		Electrothermal atomic absorption spectrometry (ET AAS)
6		Inductively coupled plasma optical emission spectrometry (ICP)
7		Glow discharge mass spectrometry (GD MS)
Fe	1	Spark optical emission spectrometry (AES)
	2, 5, 6	Flame atomic absorption spectrometry (FAAS)
	3	Glow discharge mass spectrometry (GD MS)
	4, 7	Inductively coupled plasma optical emission spectrometry (ICP)
Mn	1	Spark optical emission spectrometry (AES)
	2	Glow discharge mass spectrometry (GD MS)
	3	Inductively coupled plasma mass spectrometry (ICP MS)
	4, 5	Electrothermal atomic absorption spectrometry (ET AAS)
	6	Flame atomic absorption spectrometry (FAAS), electrolytic Cu-separation
	7	Inductively coupled plasma optical emission spectrometry (ICP)
	8	Flame atomic absorption spectrometry (FAAS)
	Ni	1
2		Globule arc optical emission spectrometry (DC Arc)
3		Inductively coupled plasma mass spectrometry (ICP MS)
4		Spark optical emission spectrometry (AES)
5, 9		Flame atomic absorption spectrometry (FAAS)
6, 10		Inductively coupled plasma optical emission spectrometry (ICP)
7		Flame atomic absorption spectrometry (FAAS), electrolytic Cu-separation
8		Glow discharge mass spectrometry (GD MS)
Pb	1	Spark optical emission spectrometry (AES)
	2, 8	Flame atomic absorption spectrometry (FAAS), Fe(OH) <sub>3</sub> -precipitation
	3, 7	Inductively coupled plasma optical emission spectrometry (ICP)
	4	Inductively coupled plasma mass spectrometry (ICP MS)
	5	Inductively coupled plasma optical emission spectrometry (ICP), Zr(OH) <sub>4</sub> -precipitation
	6	Globule arc optical emission spectrometry (DC Arc)
9	Glow discharge mass spectrometry (GD MS)	
S	1,5	Carrier gas hot extraction with IR detection
	2	Spectrophotometry, methylene blue
	3	Spark optical emission spectrometry (AES)
	4	Inductively coupled plasma optical emission spectrometry (ICP)
Sb	1	Globule arc optical emission spectrometry (DC Arc)
	2, 8	Inductively coupled plasma mass spectrometry (ICP MS)
	3	Electrothermal atomic absorption spectrometry (ET AAS), Fe(OH) <sub>3</sub> -precipitation
	4	Glow discharge mass spectrometry (GD MS)
	5	Hydride generation inductively coupled plasma optical emission spectrometry (HG ICP)



	6	Inductively coupled plasma optical emission spectrometry (ICP), Zr(OH) <sub>4</sub> -precipitation
	7	Inductively coupled plasma optical emission spectrometry (ICP)
Se	1, 4	Inductively coupled plasma mass spectrometry (ICP MS)
	2	Glow discharge mass spectrometry (GD MS)
	3	Electrothermal atomic absorption spectrometry (ET AAS), Fe(OH) <sub>3</sub> -precipitation
	5	Globule arc optical emission spectrometry (DC Arc)
Sn	1	Inductively coupled plasma optical emission spectrometry (ICP), Zr(OH) <sub>4</sub> -precipitation
	2	Glow discharge mass spectrometry (GD MS)
	3, 8	Inductively coupled plasma mass spectrometry (ICP MS)
	4	Globule arc optical emission spectrometry (DC Arc)
	5	Electrothermal atomic absorption spectrometry (ET AAS), Zr(OH) <sub>4</sub> -precipitation
	6	UV-VIS
	7	Spark optical emission spectrometry (AES)Electrothermal atomic absorption
	8	Inductively coupled plasma optical emission spectrometry (ICP)
Te	1, 6	Inductively coupled plasma mass spectrometry (ICP MS)
	2	Glow discharge mass spectrometry (GD MS)
	3	Hydride generation inductively coupled plasma optical emission spectrometry (HG ICP)
	4	Electrothermal atomic absorption spectrometry (ETAAS), Fe(OH) <sub>3</sub> -precipitation
	5	Globule arc optical emission spectrometry (DC Arc)
Zn	1, 7	Inductively coupled plasma optical emission spectrometry (ICP)
	2, 3, 6	Flame atomic absorption spectrometry (FAAS),
	4	Flame atomic absorption spectrometry (FAAS), electrolytic Cu-separation
	5	Globule arc optical emission spectrometry (DC Arc)

#### Participants:

- Institute of Non-Ferrous Metals, Analytical Chemistry Department, Gliwice, Poland
  - Laboratory P-1 (Classical Analysis)
  - Laboratory P-2 (Atomic Absorption Spectrometry)
  - Laboratory P-4 (Optical Emission Spectrometry)
- Centrum Badań Jakości, Poland
  - Laboratory WBJ-1
  - Laboratory WBJ-2
- Sargam Metals Pvt Ltd, India
- Shiva Technologies, USA
- Teledyne Leeman Labs, USA
- Bundesanstalt für Materialforschung und –prüfung (BAM), Germany

#### Intended use:

- Globule arc optical emission spectrometry
- Inductively coupled plasma optical emission spectrometry (ICP)
- Inductively coupled plasma mass spectrometry (ICP MS).