Bundesanstalt für Materialforschung und -prüfung (BAM)

in co-operation with the Committee of Chemists of the GDMB
Gesellschaft der Metallurgen und Bergleute e.V.

Certified Reference Material

BAM-M383b

Pure Copper

Certified Values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Ag	10.6	0.4
As	2.8	0.4
Bi	1.85	0.21
Cd	0.93	0.05
Co	1.02	0.05
Fe	3.6	0.6
Mn	0.18	0.03
Ni	1.43	0.18
Pb	1.01	0.17
Sb	1.69	0.16
Se	1.17	0.28
Sn	0.8	0.4
Te	5.7	0.9
Zn	9.3	0.4

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 3 but usually 6 single results), each set being obtained by a different laboratory and/or a different method of measurement. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[2] Estimated expanded uncertainty U with a coverage factor of k=2, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the expression of uncertainty in measurement, (GUM, ISO/IEC Guide 98-3:2008).

Sample description

The Reference Material is available in the form of discs (38 mm diameter and 30 mm height).

Indicative values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Al	< 1.2	
Cr	< 1	
Mg	< 1	
P	< 1	
S	3.6	1.5
Si	< 2	
Ti	< 1	
Zr	< 1	

[1] Values were not certified, but given as indicative values, when the number of accepted data sets was considered to be too low (< 5) or when the uncertainty from the inter-laboratory certification was considerably larger than the expected range. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[2] Estimated expanded uncertainty U with a coverage factor of $k = 2$, as defined in the Guide to the expression of uncertainty in measurement, (GUM, ISO/IEC Guide 98-3:2008).

Informative Value

One laboratory determined oxygen and found 0.41 % mass fraction.

Recommended Use

The CRM is intended for establishing or checking the calibration of optical emission and X-ray spectrometers for the analysis of samples of similar matrix composition. The minimum sample size for wet chemical analysis is 0.5 g.

Participating Laboratories

Allgemeine Gold- und Silberscheideanstalt, Pforzheim, Germany
Aurubis AG, Hamburg, Germany
Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
Codelco, Chuquicamata, Chile
Institut Glörfeld, Willich, Germany
Johannes-Gutenberg-Universität Mainz, Institut für Kernchemie, Mainz, Germany
Montanwerke Brixlegg, Brixlegg, Austria
Outokumpu VDM, Werdohl, Germany
Umicore Precious Metals., Hobocken, Belgium
Wieland-Werke AG, Vöhringen, Germany

Means of Accepted Data Sets

Mass fraction in mg/kg

Certified values | Indicative values

Line no.	Ag	As	Bi	Cd	Co	Fe	Mn	Ni	Pb	Sb	Se	Sn	Te	Zn		*Al*	*Cr*	*Mg*	*P*	*S*	*Si*	*Ti*	*Zr*
1	9.84	2.00	1.45	0.84	0.97	---	0.17	1.00	0.62	1.32	0.63	0.28	---	---		*0.02*	*0.05*	*0.01*	*0.05*	*< 1*	*0.15*	*0.09*	*0.02*
2	10.01	2.32	1.50	0.85	0.99	2.85	0.18	1.08	0.86	1.37	0.92	0.39	---	8.67		*< 1*	*0.24*	*< 0.05*	*0.13*	*1.85*	*< 1*	*0.11*	*0.13*
3	10.19	2.53	1.53	0.86	1.00	2.94	0.18	1.25	0.95	1.60	1.00	0.52	4.50	8.80		*< 1*	*< 1*	*0.19*	*0.83*	*3.33*	*2.00*	*< 1*	*< 0.2*
4	10.25	2.68	1.90	0.89	1.00	3.66	0.18	1.33	1.00	1.66	1.07	0.62	4.98	9.00		*1.14*	*< 1*	*0.32*	*< 1*	*3.86*		*< 1*	*0.24*
5	10.38	2.79	1.94	0.90	1.00	3.66	0.20	1.42	1.00	1.70	1.14	0.64	5.07	9.30			*< 1*	*< 1*	*< 1*	*5.33*		*< 1*	*< 1*
6	10.54	2.98	1.96	0.90	1.01	3.67	0.20	1.42	1.00	1.71	1.20	< 1	5.53	9.31			*< 1*	*< 1*				*< 1*	*< 1*
7	10.59	3.00	1.97	0.90	1.01	3.78	---	1.45	1.07	1.72	1.62	< 1	5.74	9.52				*< 1*					*< 1*
8	11.00	3.03	2.00	0.97	1.02	3.86	< 1	1.56	1.07	1.77	1.78	1.31	6.00	9.53									
9	11.00	3.18	2.00	1.00	1.09	4.00	< 1	1.57	1.53	1.82	< 1	1.50	6.11	9.72									
10	11.25	3.28	2.25	1.00	1.15	4.31	< 1	1.58	< 1	1.82			6.20	9.87									
11	11.47				---			1.70		1.83			6.68	---									
12	---							1.83		2.00													
13																							
M	10.59	2.78	1.85	0.93	1.02	3.64	0.18	1.43	1.01	1.69	1.17	0.75	5.65	9.30		*< 1.2*	*< 1*	*< 1*	*< 1*	*3.59*	*< 2*	*< 1*	*< 1*
s_M	0.53	0.41	0.27	0.054	0.055	0.47	0.012	0.25	0.24	0.20	0.38	0.47	0.70	0.41						*1.44*			
$\bar{s}_i$	0.38	0.13	0.25	0.050	0.046	0.59	0.011	0.20	0.09	0.22	0.11	0.19	0.37	0.59						*0.31*			

The laboratory mean values have been examined statistically to eliminate outlying values. Where a " --- " appears in the table it indicates that an outlying value has been omitted (Grubbs 95 %). A data set consists of at least 3 but usually 6 single values of one laboratory.

M : mean of laboratory means

s_M : standard deviation of laboratory means

$\bar{s}_i$: averaged repeatability standard deviation (square root of the mean of laboratory variances)

Note: "< - values" were not included into the calculation of M and s_M

Analytical Method used for Certification

Element	Line no.	Method
Ag	1, 2	GD-MS
	3, 5, 8, 9, 10, 11	ICP-OES
	4, 7	INAA
	6	ICP-MS
As	1, 8, 9, 10	ICP-OES
	2	ETV-ICP-OES
	3, 4	GD-MS
	5	ICP-MS
	6, 7	ET AAS
Bi	1	ETV-ICP-OES
	2, 5	ET AAS
	3, 8, 9, 10	ICP-OES
	4, 7	GD-MS
	6	ICP-MS
Cd	1	ICP-MS
	2, 4, 6, 7, 9, 10	ICP-OES
	3	ET AAS
	5, 8	GD-MS
Co	1	ICP-MS
	2, 4, 5, 7, 8, 10	ICP-OES
	3, 9	GD-MS
	6	ET AAS
Fe	2, 3, 4, 6, 7, 9	ICP-OES
	5	INAA
	8	ICP-MS
	10	GD-MS
Mn	1, 6, 8, 9, 10	ICP-OES
	2	ICP-MS
	3	ET AAS
	4, 5	GD-MS
Ni	1, 4, 6, 7, 10, 12	ICP-OES
	3	ETV-ICP-OES
	5	ICP-MS
	8, 9	ET AAS
	2, 11	GD-MS
Pb	1, 7, 9, 10	ICP-OES
	2, 8	GD-MS
	3, 5	ET AAS
	4	ICP-MS
	6	ETV-ICP-OES
Sb	1	ETV-ICP-OES
	2, 5, 9, 11, 12	ICP-OES
	3, 4	INAA
	6	ET AAS
	7, 10	GD-MS
	8	ICP-MS

Element	Line no.	Method
Se	1, 3, 8, 9	ICP-OES
	2	INAA
	4	ETV-ICP-OES
	5, 7	GD-MS
	6	ET AAS
Sn	1, 6, 7, 8	ICP-OES
	2, 4	GD-MS
	3	ETV-ICP-OES
	5	ICP-MS
	9	ET AAS
Te	3, 9	GD-MS
	4	INAA
	5, 11	ICP-OES
	6, 8, 10	ET AAS
	7	ICP-MS
Zn	2	FAAS
	3, 4, 6, 8	ICP-OES
	5, 10	GD-MS
	7	ICP-MS
	9	INAA
Al	*1*	*GD-MS*
	2, 3, 4	*ICP-OES*
Cr	*1*	*GD-MS*
	2, 3, 4, 5, 6	*ICP-OES*
Mg	*1, 2*	*GD-MS*
	3, 4, 5, 6, 7	*ICP-OES*
P	*1, 2*	*GD-MS*
	3	*Spectrophotometry*
	4, 5	*ICP-OES*
S	*1, 4*	*ICP-OES*
	2, 3	*GD-MS*
	5	*Combustion/iodometric titration*
Si	*1*	*GD-MS*
	2, 3	*ICP-OES*
Ti	*1*	*GD-MS*
	2	*ICP-MS*
	3, 4, 5, 6	*ICP-OES*
Zr	*1*	*ICP-MS*
	2, 5, 6, 7	*ICP-OES*
	3, 4	*GD-MS*

Abbreviations:

ET AAS – Electrothermal atomic absorption spectrometry
ETV-ICP-OES – Inductively coupled plasma - optical emission spectrometry plasma after electrothermal vaporisation
FAAS – Flame atomic absorption spectrometry
GD-MS – Glow discharge mass spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
ICP-OES – Inductively coupled plasma - optical emission spectrometry
INAA – Instrumental neutron activation analysis

Instructions for Use

Before use, the surface of the material must be prepared by milling or turning on a lathe. For wet chemical analysis chips have to be prepared by turning or milling of the sample surface.

Transport and Storage

The material should be stored in a dry and clean environment at room temperature (approx. 20 °C). Transport under normal ambient conditions.

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-M383b is available on request or can be downloaded from BAM website (www.bam.de/en/fachthemen/referenzmaterialien/index.htm).

Accepted as BAM-CRM on 23-01-2014

BAM Bundesanstalt für Materialforschung und -prüfung

Prof. Dr. U. Panne
Head of Department 1
Analytical Chemistry;
Reference Materials

Dr. S. Recknagel
Head of Division 1.6
Inorganic Reference Materials

This Reference Material is offered by:

BAM Bundesanstalt für Materialforschung und -prüfung
Richard-Willstätter-Str. 11, 12489 Berlin

Phone: +49 30 8104 2061
Fax: +49 30 8104 72061

Email: sales.crm@bam.de
Internet: www.webshop.bam.de