Bundesanstalt für Materialforschung und -prüfung (BAM)

in cooperation with the Committee of Chemists of the GDMB
Gesellschaft der Metallurgen und Bergleute e.V.

Certified Reference Material

BAM-M385a

Pure Copper

Certified Values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Ag	25.4	0.5
Al	13.3	3.2
As	9.4	2.0
Bi	5.64	0.28
Cd	2.75	0.28
Co	7.4	0.4
Cr	10.4	0.8
Fe	44.2	1.2
Mn	9.9	0.9
Ni	10.8	0.6
P	10.0	1.3
Pb	10.8	1.0
Sb	14.9	0.8
Se	5.0	0.7
Si	7.3	0.8
Sn	16.1	1.1
Te	8.1	1.2
Ti	6.6	1.1
Zn	9.2	0.7

[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.

[2] Estimated expanded uncertainty U with a coverage factor of $k = 2$ (Si: $k = 2.5$), 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).

This certificate is valid until 11/2047.

Values for information

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Mg	32	7
S	35.4	2.5
Zr	18	7

[1] Values were not certified, but given for information, 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 or in case there were hints that the material was not homogeneous enough.

[2] Estimated expanded uncertainty *U* with a coverage factor of *k* = 2.5, 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 (approx. 40 mm diameter and 30 mm height).

Recommended Use

The CRM is intended for establishing or checking the calibration of spark optical emission and X-ray spectrometers for the analysis of samples of similar matrix composition. The minimum sample size for wet chemical analysis is 0.2 g.

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. Transport under normal ambient conditions.

Participating Laboratories

Allgemeine Gold- und Silberscheideanstalt AG, Pforzheim, Germany
Aurubis AG, Hamburg, Germany
Aurubis AG, Olen, Belgium
Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
Diehl Metall Stiftung & Co KG, Röthenbach, Germany
Inspectorate International Limited, Witham, United Kingdom
Institut Glörfeld, Willich, Germany
Johannes-Gutenberg-Universität Mainz, Germany
KM Europa Metal AG, Osnabrück, Germany
Umicore AG & Co. KG, Hanau, Germany
VDM Metals, Werdohl, Germany
Wieland-Werke AG, Vöhringen, Germany

Means of Accepted Data Sets

Certified values
Mass fraction in mg/kg

Values for information
Mass fraction in mg/kg

Line No.	Ag	Al	As	Bi	Cd	Co	Cr	Fe	Mn	Ni	P	Pb	Sb	Se	Si	Sn	Te	Ti	Zn	*Mg*	*S*	*Zr*
1	---	11.2	8.75	5.18	2.39	6.67	9.6	41.4	9.29	---	9.01	9.2	13.8	4.30	---	13.3	6.38	5.00	---	*24.0*	*29.7*	---
2	---	11.3	8.75	5.21	2.45	6.91	10.1	43.0	9.39	10.08	9.38	9.6	14.2	4.75	6.44	14.0	6.59	5.63	8.50	*28.0*	*31.6*	---
3	24.4	11.4	8.83	5.22	2.48	7.05	10.1	43.0	9.40	10.28	9.53	10.0	14.3	4.79	6.73	14.5	7.40	6.03	8.70	*28.8*	*31.7*	*16.2*
4	24.6	11.7	8.90	5.40	2.63	7.11	10.2	43.2	9.41	10.43	9.88	10.2	14.5	4.85	7.13	15.5	7.99	6.12	8.79	*29.2*	*32.0*	*17.0*
5	24.9	12.7	9.12	5.49	2.65	7.26	10.2	43.6	9.55	10.72	9.97	10.2	14.7	4.96	7.64	15.6	8.03	6.21	8.93	*30.9*	*32.2*	*17.9*
6	25.3	13.2	9.15	5.53	2.72	7.30	10.3	43.6	9.67	10.72	10.16	10.3	14.8	4.97	7.77	15.9	8.10	6.60	8.98	*31.4*	*35.7*	*18.0*
7	25.1	13.3	9.21	5.57	2.75	7.33	10.5	44.1	9.82	10.72	10.17	10.6	14.8	5.00	7.92	16.3	8.12	6.65	8.99	*32.4*	*37.0*	*19.1*
8	25.4	14.0	9.30	5.70	2.85	7.33	10.5	44.7	9.98	10.73	10.17	11.1	14.9	5.08		16.8	8.29	6.78	9.34	*34.8*	*37.2*	*19.7*
9	25.4	14.5	9.36	5.84	2.87	7.38	10.6	45.0	10.00	10.80	10.21	11.2	15.0	5.18		16.8	8.33	7.00	9.42	*35.3*	*39.2*	
10	25.6	14.8	9.87	5.87	2.93	7.47	10.7	45.1	10.33	10.92	10.29	11.5	15.0	5.28		17.5	8.65	7.07	9.43	*35.5*	*39.3*	
11	25.7	15.5	9.97	5.89	2.97	7.67	10.8	45.3	10.35	11.01	10.65	11.7	15.2	5.35		17.5	8.68	7.40	9.53	*35.7*	*39.5*	
12	26.3	16.6	10.01	6.00	2.98	7.92	11.0	45.5	10.73	11.28	11.07	11.9	15.5	5.90		17.7	8.83	7.57	9.94	*36.4*	*40.0*	
13	26.5		10.77	6.44	3.02	8.03	---	46.0	10.78	11.33		13.0	15.5	---		18.3	9.94	7.70	9.95	*36.9*	---	
14						8.33		46.0					15.6									
15													15.6									
M	25.4	13.3	9.38	5.64	2.75	7.41	10.4	44.2	9.90	10.75	10.04	10.8	14.9	5.03	7.27	16.1	8.10	6.60	9.21	*32.2*	*35.4*	*18.0*
s_M	0.5	1.8	0.61	0.37	0.22	0.45	0.4	1.4	0.52	0.37	0.56	1.1	0.6	0.39	0.60	1.6	0.93	0.79	0.47	*4.0*	*3.8*	*1.3*
$\overline{s}_{\mathrm{i}}$	0.7	1.1	0.37	0.43	0.12	0.21	0.2	1.2	0.28	0.33	0.92	1.0	0.8	0.33	0.51	1.0	0.51	0.51	0.48	*1.4*	*2.1*	*2.1*

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

$\overline{s}_{\mathrm{i}}$: averaged repeatability standard deviation (square root of the mean of laboratory variances)

Analytical Method used for Certification

Element	Line Number	Method
Ag	3, 7, 9, 11	GDMS
	4	INAA
	5, 6, 8, 10	ICP-OES
	12	FAAS
	13	ICP-MS
Al	1, 6, 9	GDMS
	2, 3, 5, 7, 8, 10, 11, 12	ICP-OES
	4	ICP-MS
As	1, 6, 9, 10	GDMS
	2, 3, 4, 5, 7, 8	ICP-OES
	11	ETAAS
	12, 13	ICP-MS
Bi	1, 13	ICP-MS
	2, 3, 4, 6, 7	ICP-OES
	5, 8, 9, 11	GDMS
	10, 12	ETAAS
Cd	1, 2, 3, 4, 5, 7	ICP-OES
	6, 9, 11, 12	GDMS
	8, 13	ICP-MS
	10	ETAAS
Co	1, 5, 9, 13	GDMS
	2, 4, 6, 8, 10, 12	ICP-OES
	3,7	ICP-MS
	11	ETAAS
	14	INAA
Cr	1, 2, 4, 7, 11	ICP-OES
	3, 9	ICP-MS
	5, 6, 12	GDMS
	8	INAA
	10	ETAAS
Fe	1	ICP-MS
	2, 4, 7, 9, 10, 11, 12, 14	ICP-OES
	3, 5, 6, 13	GDMS
	8	ETAAS
Mn	1, 3, 4, 6, 10, 12, 13	ICP-OES
	2, 8, 9, 11	GDMS
	5	ICP-MS
	7	ETAAS
Ni	2, 6	ICP-MS
	3, 5, 7, 9	GDMS
	4, 7, 8, 10, 11, 13	ICP-OES
	12	ETAAS

Element	Line Number	Method
P	1	Spectrophotometry
	2, 6, 9, 11	GDMS
	3, 4, 5, 7, 8, 10, 12	ICP-OES
Pb	1, 2, 3, 4, 10	ICP-OES
	5, 12	ICP-MS
	6, 7, 8, 9	GDMS
	11, 13	ETAAS
Sb	1, 4, 6, 10, 12, 15	ICP-OES
	2, 3, 5, 11	GDMS
	7, 14	ICP-MS
	8	INAA
	9	Spectrophotometry
	13	ETAAS
Se	1, 4, 11	ICP-MS
	2, 3, 8, 12	ICP-OES
	5, 6, 7, 9	GDMS
	10	ETAAS
Si	2, 5, 6	GDMS
	3, 7	ICP-OES
	4	ICP-MS
Sn	1, 3, 10, 11	GDMS
	2, 4, 5, 9, 13	ICP-OES
	6, 8, 12	ICP-MS
	7	ETAAS
Te	1, 6, 13	ICP-MS
	2, 5, 8, 9	ICP-OES
	3, 4, 7, 10	GDMS
	11, 12	ETAAS
Ti	1, 6	ICP-MS
	2, 4, 8, 9, 10, 12, 13	ICP-OES
	3, 5, 7, 11	GDMS
Zn	2, 3, 6, 8, 12	ICP-OES
	4, 7, 10, 11	GDMS
	5, 13	ICP-MS
	9	INAA
Mg	*1, 3, 4, 6*	*GDMS*
	2	*ICP-MS*
	5, 7, 8, 9, 10, 11, 12, 13	*ICP-OES*
S	*1, 3, 5, 7, 9, 10, 11*	*ICP-OES*
	2, 6	*Combustion/IR*
	4, 8, 12	*GDMS*
Zr	*3, 5, 6, 7*	*ICP-OES*
	4	*GDMS*
	8	*ICP-MS*

Abbreviations:

ETAAS – Electrothermal atomic absorption spectrometry
FAAS – Flame atomic absorption spectrometry
GDMS – Glow discharge mass spectrometry
ICP-OES – Inductively coupled plasma - optical emission spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
INAA – Instrumental neutron activation analysis
IR – Infrared spectrometry

Metrological Traceability

The ensure traceable of the certified mass fractions to the SI (Système International d'Unités) calibration was performed using certified standard solutions or pure metals or substances of known stoichiometry.

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-M385a is available on request or can be downloaded from BAM website (www.bam.de).

Accepted as BAM-CRM on 16.04.2018

Bundesanstalt für Materialforschung und -prüfung (BAM)

Dr. F. Emmerling
Abteilungsleiterin 1
Analytische Chemie; Referenzmaterialien

Dr. S. Recknagel
Fachbereichsleiter 1.6
Anorganische Referenzmaterialien

BAM holds an accreditation as a reference material producer according to ISO Guide 34 in combination with ISO/IEC 17025. This accreditation is valid only for the scope as specified in the certificate D-RM-11075-01-00. DAkkS is a signatory of the multilateral agreement (MLA) between EA, ILAC and IAF for mutual acceptance.

DAkkS Deutsche Akkreditierungsstelle D-RM-11075-01-00

This Reference Material is offered by:

Bundesanstalt für Materialforschung und -prüfung (BAM)
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