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-M505a

Electronic Scrap

Certified Values

Element	Mass fraction [1] in %	Uncertainty [2] in %
Cu	16.76	0.04
Ni	0.694	0.006
Ag	0.0633	0.0009
Pb	1.13	0.05
Cr	0.980	0.017
Sn	0.468	0.015
	in mg/kg	**in mg/kg**
Au	52.4	0.9
Pd	48.0	0.8
Pt	5.7	0.4
As	372	20
Be	6.8	0.9
Cd	16.4	0.7

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 2 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 $k = 2$, 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 06/2049.

Description of Material

The reference material is a mixture of used printed circuit boards, ashed and melted with pyrite (FeS_2). After milling and grinding the material was sieved to a particle size below 150 µm and homogenised thoroughly. It is supplied in the form of powder (< 150 µm), packed in amber glass bottles containing 200 g.

Values for information

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
In	43	6
Hg	< 5	

[1] Value was not certified, but given for information, because the uncertainty from the inter-laboratory certification was too large.

[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).

Transport and Storage

The material has to be stored in a dry and clean environment at room temperature. Transport under normal ambient conditions.

Recommended Use

The reference material is intended for development, validation and quality control of analytical methods for the determination precious metals and other elements in electronic scrap. The minimum sample size for chemical analysis is 0.2 g.

Metrological Traceability

The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry or carefully checked standard solutions.

Participating Laboratories

Alfred Knight Int. Ltd, St. Helens (United Kingdom)
Allgemeine Gold- und Silberscheideanstalt AG, Pforzheim (Germany)
ALS Minerals Division, Prescot (United Kingdom)
AnRec GmbH & Co. KG, Gelnhausen (Germany)
Aurubis AG, Hamburg (Germany)
Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin (Germany)
Forschungsinstitut Edelmetalle & Metallchemie, Schwäbisch Gmünd (Germany)
Inspectorate International Ltd, Shanghai (China)
Inspectorate International Ltd, Witham (United Kingdom)
Institut für Materialprüfung Glörfeld GmbH, Willich (Germany)
Ledoux & Company, Teanec NJ (United States of America)
Petrographisches Labor, Seulingen (Germany)
Umicore Precious Metals, Hoboken (Germany)
W.C. Heraeus GmbH, Hanau (Germany)
WRC World Resources Company GmbH, Wurzen (Germany)

Means of Accepted Data Sets

Certified values mass fraction in %								mass fraction in mg/kg							values for information mass fraction in mg/kg	
Line-No.	**Cu**	**Ni**	**Ag**	**Pb**	**Cr**	**Sn**		**Au**	**Pd**	**Pt**	**As**	**Be**	**Cd**		***In***	***Hg***
1	16.62	0.677	0.0615	1.023	0.948	0.430		50.6	46.5	4.9	320	5.1	14.3		*33.8*	*0.30*
2	16.72	0.682	0.0617	1.040	0.951	0.432		50.6	46.7	4.9	325	5.4	14.5		*37.9*	*0.37*
3	16.73	0.687	0.0618	1.044	0.966	0.455		51.2	46.7	5.0	341	6.1	16.2		*38.6*	*< 1*
4	16.73	0.693	0.0623	1.103	0.975	0.459		51.6	47.2	5.5	345	6.4	16.3		*39.1*	*1.57*
5	16.74	0.693	0.0623	1.140	0.978	0.460		51.9	47.4	5.7	375	6.5	16.4		*39.4*	*2.03*
6	16.74	0.695	0.0634	1.142	0.980	0.470		51.9	47.6	5.9	376	6.7	16.8		*39.7*	*< 5*
7	16.75	0.698	0.0635	1.145	0.991	0.476		52.2	47.8	5.9	382	6.9	16.9		*40.4*	*< 5*
8	16.77	0.698	0.0637	1.174	0.998	0.480		52.7	48.1	5.9	383	7.2	16.9		*41.4*	*< 5*
9	16.80	0.699	0.0638	1.180	1.032	0.481		52.9	48.6	6.1	385	8.8	17.0		*42.8*	*< 5.02*
10	16.80	0.702	0.0640	1.196		0.500		53.5	48.8	6.3	400	9.4	17.7		*50.8*	*< 20*
11	16.84	0.709	0.0642	1.231		0.502		54.8	49.9	6.3	404	< 20	18.0		*55.8*	
12	16.85		0.0649					55.3	50.4	6.5	429		< 20		*59.3*	
13	16.85		0.0662													
14																
M	16.76	0.694	0.0633	1.129	0.980	0.468		52.4	48.0	5.7	372	6.8	16.4		*43.2*	
s_M	0.07	0.010	0.0014	0.068	0.026	0.024		1.5	1.3	0.6	34	1.4	1.2		*7.9*	
$\bar{s}_\mathrm{i}$	0.05	0.008	0.0008	0.012	0.013	0.009		2.2	0.8	0.5	7	0.3	0.5		*2.0*	

A data set consists of at least 2 but usually 6 single values of one laboratory.

M : mean of laboratory means

s_M : standard deviation of laboratory means

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

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

Analytical Method used for Certification

Element	Line Number	Method
Cu	1, 2, 10, 12	ICP-OES, dissolution with aqua regia
	3, 4, 5, 6, 8, 9	Electrogravimetry
	7	ICP-OES, dissolution with acid, separation with thiocyanate
	11	ICP-OES, alkaline fusion
	13	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
Ni	1, 4, 5, 10, 11	ICP-OES, dissolution with aqua regia
	2	ICP-OES, dissolution with acid
	3	ICP-OES, dissolution with $HNO_3/H_2SO_4/HCl$
	6, 8, 9	ICP-OES, alkaline fusion
	7	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
Ag	1	FAAS, alkaline fusion
	2	Gravimetry after fire assay
	3. 9, 11	ICP-OES, dissolution with aqua regia
	4, 12	ICP-OES, fire assay, Pd-collection
	5, 6, 13	ICP-OES, fire assay, Pb-collection
	7	FOES on PbO-beads
	8	ICP-OES, alkaline fusion
	10	Gravimetry after fire assay, Pb-collection
Pb	1, 5, 6	ICP-OES, dissolution with acid
	2, 4, 7	ICP-OES, alkaline fusion
	3, 8, 10, 11	ICP-OES, dissolution with aqua regia
	9	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
Cr	1, 3, 6, 7	ICP-OES, alkaline fusion
	2	ICP-OES, dissolution with $HNO_3/H_2SO_4/HCl$
	4, 8	ICP-OES, dissolution with aqua regia
	5	ICP-OES, dissolution with acid
	9	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
Sn	1	ICP-OES, dissolution with acid
	2, 4, 5, 7	ICP-OES, alkaline fusion
	3, 8, 9, 11	ICP-OES, dissolution with aqua regia
	6	ICP-OES, dissolution with $HNO_3/H_2SO_4/HCl$
	10	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
Au	1, 2, 4, 12	ICP-OES, fire assay, Pb-collection
	3	ICP-OES, fusion with PbO/Ag
	5	Gravimetry after fire assay, Pb-collection
	6, 11	ICP-OES, fire assay, Ag-collection
	7, 8	Gravimetry after fire assay
	9	ICP-OES, fire assay, PbO
	10	ICP-OES, fire assay, Pd-collection

Element	Line Number	Method
Pd	1, 5, 7, 9, 10, 11	ICP-OES, fire assay, Pb-collection
	2	ICP-OES, fire assay, Au-collection
	3	ICP-OES, fire assay, PbO
	4, 6	ICP-OES, fire assay
	8	ICP-OES, fusion with PbO/Ag
	12	ICP-OES, fire assay, Ag-collection
Pt	1	ICP-OES, fusion with PbO/Ag
	2, 3, 4, 7, 10	ICP-OES, fire assay, Pb-collection
	5, 6	ICP-OES, fire assay
	8	ICP-OES, fire assay, PbO
	9, 12	ICP-OES, fire assay, Au-collection
	11	ICP-OES, fire assay, Ag-collection
As	1, 4, 5, 11, 12	ICP-OES, dissolution with aqua regia
	2	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
	3	ICP-OES, dissolution with $HNO_3/HF/H_2SO_4$
	6	ICP-MS, dissolution with acid
	7, 8, 10	ICP-OES, dissolution with acid
	9	ICP-OES, alkaline fusion
Be	1	ICP-MS, dissolution with acid
	2, 3, 4, 6, 8	ICP-OES, dissolution with aqua regia
	5	ICP-OES, dissolution with $HNO_3/HF/H_2SO_4$
	7, 9	ICP-OES, dissolution with acid
	10	ICP-OES, dissolution with $HCl/HNO_3/HBF_4$
	11	ICP-OES, alkaline fusion
Cd	1, 3, 6, 7, 10	ICP-OES, dissolution with aqua regia
	2	ICP-OES, dissolution with $HNO_3/HF/H_2SO_4$
	4, 5	ICP-OES, dissolution with acid
	8, 12	ICP-OES, alkaline fusion
	9	ICP-MS, dissolution with acid
	11	ICP-MS, dissolution with $HCl/HNO_3/HBF_4$
In	*1, 2, 4, 7, 10*	*ICP-OES, dissolution with aqua regia*
	3	*ICP-OES, dissolution with HCl/HNO_3/HBF4*
	5	*ICP-MS, dissolution with acid*
	6	*ICP-OES, dissolution with $HNO_3/HF/H_2SO_4$*
	8, 9, 11	*ICP-OES, dissolution with acid*
	12	*LIBS*
Hg	*1*	*Direct mercury analyser (CVAAS)*
	2	*CVAAS, dissolution with acid*
	3, 6	*ICP-OES, dissolution with aqua regia*
	4, 5, 7, 8	*ICP-OES, dissolution with acid*
	9	*ICP-OES, dissolution* with $HCl/HNO_3/HBF_4$
	10	*ICP-OES, dissolution with HCl/Br_2*

Abbreviations: FAAS – Flame atomic absorption spectrometry
CVAAS – cold vapour atomic absorption spectrometry
ICP-OES – Inductively coupled plasma - optical emission spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
LIBS – laser induced plasma spectroscopy

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-M505a is available on request or can be downloaded from BAM website (www.bam.de).

Accepted as BAM-CRM on

Bundesanstalt für Materialforschung und -prüfung (BAM)

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