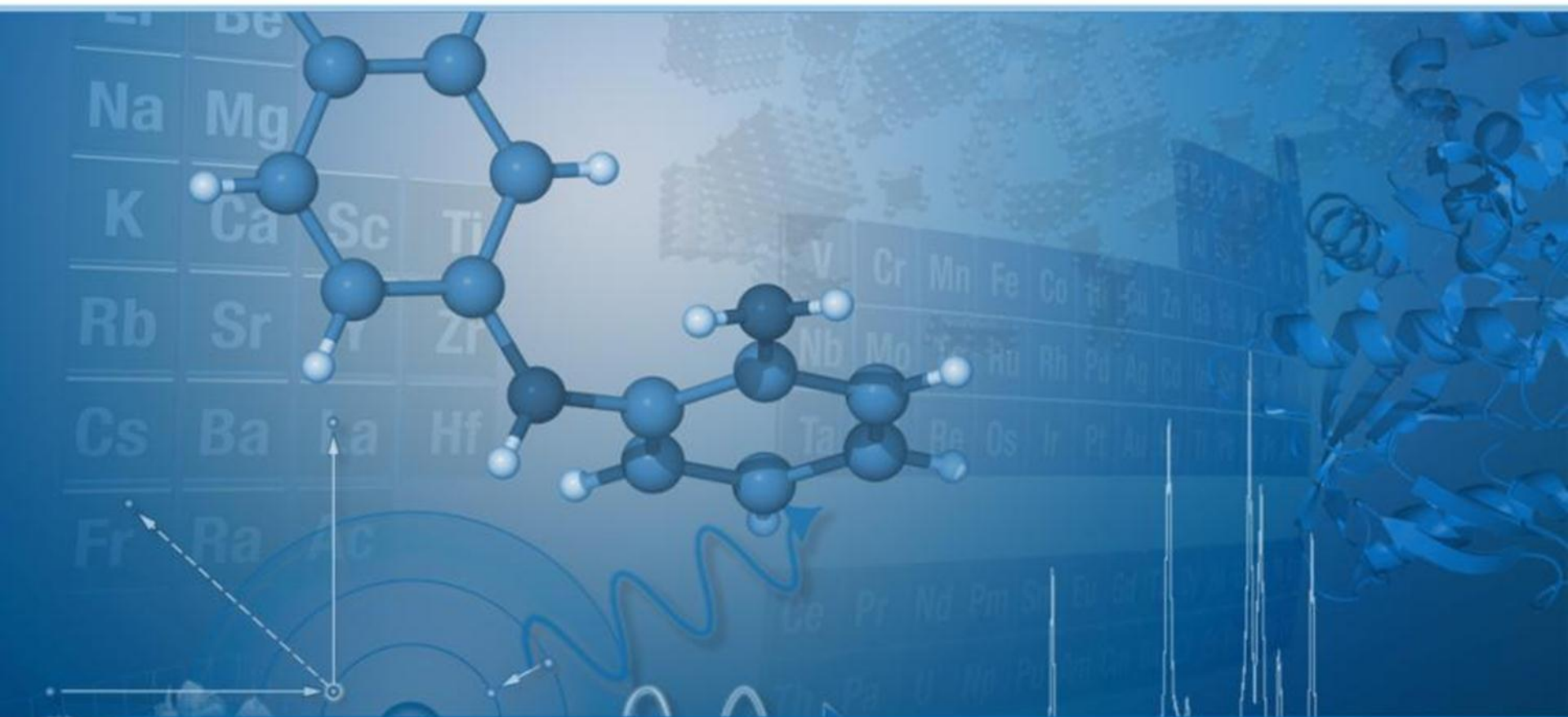




Going for the Gold: Authentication of Coins and Precious Metals

Presented by: Alexander Seyfarth, Bruker, Kennewick, WA
Richard Haddock, CoinSecure Inc., Palo Alto, CA



Welcome



Topics

- Why use XRF for precious metals and coins?
 - Comparison with other techniques
 - XRF from Handheld to Benchtop: does size matter?
- Going for the gold
 - Use of HH-XRF for precious metal identification and quantification
 - Where it works
 - Where it is limited
 - Use of HH-XRF for authentication of "ancient" and recent collector coins
 - Where it works
 - Where it is limited
- Conclusion
 - We get the gold, but there is *no golden bullet* for this application



Alexander Seyfarth
Global Product Manager HH-XRF
Bruker



Richard Haddock
President
CoinSecure Inc.

Why use XRF for precious metals and coins?



1 H 1.01 0.0007 Hydrogen																	2 He 4.00 0.0002 Helium										
3 Li 6.94 0.53 Lithium	4 Be 9.01 1.85 Beryllium Kα 0.108																	5 B 10.81 2.34 Boron Kα 0.183	6 C 12.01 2.27 Carbon Kα 0.277	7 N 14.01 0.001 Nitrogen Kα 0.392	8 O 16.00 0.001 Oxygen Kα 0.525	9 F 19.00 0.001 Fluorine Kα 0.677	10 Ne 20.18 0.0009 Neon Kα 0.849				
11 Na 22.99 0.97 Sodium Kα 1.040	12 Mg 24.31 1.74 Magnesium Kα 1.254																	13 Al 26.98 2.70 Aluminium Kα 1.486	14 Si 28.09 2.33 Silicon Kα 1.740	15 P 30.97 1.82 Phosphorus Kα 2.010	16 S 32.07 2.07 Sulfur Kα 2.309	17 Cl 35.45 0.003 Chlorine Kα 2.622	18 Ar 39.95 0.002 Argon Kα 2.958				
19 K 39.10 0.86 Potassium Kα 3.314	20 Ca 40.08 1.54 Calcium Kα 3.692 Lα 1.924	21 Sc 44.96 2.99 Scandium	22 Ti 47.87 4.54 Titanium Kα 4.512 Lα 0.452	23 V 50.94 6.11 Vanadium Kα 4.953 Lα 0.510	24 Cr 52.00 7.15 Chromium Kα 5.415 Lα 0.572	25 Mn 54.94 7.44 Manganese Kα 5.900 Lα 0.637	26 Fe 55.85 7.87 Iron Kα 6.405 Lα 0.705	27 Co 58.93 8.86 Cobalt Kα 6.931 Lα 0.775	28 Ni 58.69 8.91 Nickel Kα 7.480 Lα 0.849	29 Cu 63.55 8.93 Copper Kα 8.046 Lα 0.928	30 Zn 65.38 7.13 Zinc Kα 8.637 Lα 1.012	31 Ga 69.72 5.91 Gallium Kα 9.251 Lα 1.098	32 Ge 72.64 5.32 Germanium Kα 9.886 Lα 1.188	33 As 74.92 5.78 Arsenic Kα 10.543 Lα 1.282	34 Se 78.96 4.81 Selenium Kα 11.224 Lα 1.379	35 Br 79.90 3.12 Bromine Kα 11.924 Lα 1.481	36 Kr 83.80 0.004 Krypton Kα 12.648 Lα 1.585										
37 Rb 85.47 1.53 Rubidium Kα 13.396 Lα 1.692	38 Sr 87.62 2.64 Strontium Kα 14.165 Lα 1.806	39 Y 88.91 4.47 Yttrium	40 Zr 91.22 6.51 Zirconium Kα 15.775 Lα 2.044	41 Nb 92.91 8.57 Niobium Kα 16.615 Lα 2.169	42 Mo 95.94 10.22 Molybdenum Kα 17.480 Lα 2.292	43 Tc (98) 11.50 Technetium Kα 18.367 Lα 2.423	44 Ru 101.07 12.37 Ruthenium Kα 19.279 Lα 2.558	45 Rh 102.91 12.41 Rhodium Kα 20.216 Lα 2.697	46 Pd 106.42 12.02 Palladium Kα 21.177 Lα 2.838	47 Ag 107.87 10.50 Silver Kα 22.163 Lα 2.983	48 Cd 112.41 8.69 Cadmium Kα 23.173 Lα 3.133	49 In 114.82 7.31 Indium Kα 24.210 Lα 3.286	50 Sn 118.71 7.29 Tin Kα 25.271 Lα 3.444	51 Sb 121.76 6.69 Antimony Kα 26.359 Lα 3.604	52 Te 127.60 6.23 Tellurium Kα 27.473 Lα 3.768	53 I 126.90 4.93 Iodine Kα 28.612 Lα 3.938	54 Xe 131.29 0.006 Xenon Kα 29.775 Lα 4.110										
55 Cs 132.91 1.87 Cesium Kα 30.973 Lα 4.285	56 Ba 137.33 3.59 Barium Kα 32.194 Lα 4.466	57 La 138.91 6.15 Lanthanum	72 Hf 178.49 13.31 Hafnium Kα 7.899 Mα 1.646	73 Ta 180.95 16.65 Tantalum Kα 8.146 Mα 1.712	74 W 183.84 19.25 Tungsten Kα 8.398 Mα 1.775	75 Re 186.21 21.02 Rhenium Kα 8.652 Mα 1.843	76 Os 190.23 22.61 Osmium Kα 8.911 Mα 1.907	77 Ir 192.22 22.65 Iridium Kα 9.175 Mα 1.980	78 Pt 195.08 21.46 Platinum Kα 9.442 Mα 2.050	79 Au 196.97 19.28 Gold Kα 9.713 Mα 2.123	80 Hg 200.59 13.53 Mercury Kα 9.989 Mα 2.195	81 Tl 204.37 11.85 Thallium Kα 10.269 Mα 2.271	82 Pb 207.20 11.34 Lead Kα 10.551 Mα 2.342	83 Bi 208.98 9.81 Bismuth Kα 10.839 Mα 2.423	84 Po (209) 9.32 Polonium Kα 11.131 Mα 2.499	85 At (210) 7.00 Astatine Kα 11.427 Mα 2.577	86 Rn (222) 0.01 Radon Kα 11.727 Mα 2.654										
87 Fr (223) 1.87 Francium Kα 12.031 Mα 2.732	88 Ra (226) 5.50 Radium Kα 12.339 Mα 2.806	89 Ac (227) 10.07 Actinium Kα 12.652 Mα 2.900																									
58 Ce 140.12 6.77 Cerium Kα 4.839 Mα 0.884	59 Pr 140.91 6.77 Praseodymium Kα 5.035 Mα 0.927	60 Nd 144.24 7.01 Neodymium Kα 5.228 Mα 0.979	61 Pm (145) 7.26 Promethium Kα 5.432 Mα 1.023	62 Sm 150.36 7.52 Samarium Kα 5.633 Mα 1.078	63 Eu 151.96 5.24 Europium Kα 5.849 Mα 1.131	64 Gd 157.25 7.90 Gadolinium Kα 6.053 Mα 1.181	65 Tb 158.93 8.23 Terbium Kα 6.273 Mα 1.240	66 Dy 162.50 8.55 Dysprosium Kα 6.498 Mα 1.293	67 Ho 164.93 8.80 Holmium Kα 6.720 Mα 1.348	68 Er 167.26 9.07 Erbium Kα 6.949 Mα 1.404	69 Tm 168.93 9.32 Thulium Kα 7.180 Mα 1.462	70 Yb 173.04 6.97 Ytterbium Kα 7.416 Mα 1.526	71 Lu 174.47 9.84 Lutetium Kα 7.655 Mα 1.580	90 Th 232.04 11.72 Thorium Kα 12.968 Mα 2.996	91 Pa 231.04 15.37 Protactinium Kα 13.291 Mα 3.082	92 U 238.03 18.95 Uranium Kα 13.614 Mα 3.171	93 Np (237) 20.45 Neptunium Kα 13.946 Mα 3.250	94 Pu (244) 19.84 Plutonium Kα 14.282 Mα 3.339	95 Am (243) 13.69 Americium Kα 14.620 Mα 3.438	96 Cm (247) 13.51 Curium Kα 14.79	97 Bk (247) 14.79 Berkelium	98 Cf (251) 15.1 Californium	99 Es (252) 13.5 Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

Atomic number

Atomic weight

Density (g/cm³)

Symbol

Element name

Energy (keV)

Spectral line

35 79.90
Br 3.12
Bromine
Kα 11.924
Lα 1.481



First steps in any precious metal test

- Weighing the sample: g or ounce
- Locate stamps and identifying marks
- Conversion
 - 28.3495231 grams per ounce
 - 14.175 grams per half ounce
- Find gold price and gold scrap price (scrap price is below gold price)

Kitco Spot Prices are quoted in USD \ Troy Oz.

Spot Prices Feb 08, 2013 at 17:15 New York Time

www.kitco.com Please Press Reload or Refresh to Update

▼ GOLD	▼ SILVER	▼ PLATINUM	▲ PALLADIUM	◆ RHODIUM
1667.20	31.43	1712.00	752.00	1225.00
-3.80	-0.03	-5.00	+2.00	+0.00

Show London Price Fix Show 30 Day Gold/Silver Charts Show Form View Base Currency:

Gold Spot Price: 1666.80 [USD] Currency: United States Dollars

Step 1. Select weight type
Grams (g) ▼

Step 2. Select the purity
24 Karat .9999 (99.99%) ▼

Step 3. Enter the weight
15 Grams (g)

Troy Ounces of .999 Pure Gold	Gross Melt Value	Profit \ Loss Value
0.4823	\$ 803.83 [USD]	\$ 803.83 [USD]

Step 4. Calculate Reset Profit \ Loss +/- +0 %



Hallmarking Built-in Grade

Much of the gold jewelry manufactured before 1980 is slightly below its marked karat value. For example, jewelry marked 18K would actually be between 17K and 17.5K. In 1980, the laws changed regarding the marking and purity of gold jewelry (Europe).

Hallmark Symbol	Other mark variations	Carat Rating	Gold Purity
375	9ct 9k, 9kt	9ct	37.5%
585	14ct, 14k, 14kt	14ct	58.3%
750	18ct, 18k, 18kt	18ct	75.0%
916	22, 22ct, 22k, 22kt	22ct	91.6%
990 999	999, 999.9	24ct	100%



Calculation Example

- Nice "older" gold chain 35 g
 - No readable markings
 - 14K (58.3%) 1093 melt value
 - 18k (75%) 1406 melt value
 - 17k (70.8%) 1328 melt value
 - 19K (79.2%) 1485 melt value
- The more accurate the concentration is known, the more money you make

SOURCE http://www.silverrecyclers.com/Calculators/gold_calculator.aspx

Analysis Techniques (1)



Acid Tests / Scratch Tests

- A set of acidic solutions is used to “dissolve” the scratched-off material from a “touch” stone (different solutions for gold and platinum)
 - Qualitative test tells you if the scratched-off material was 14K, 18K etc.
 - Comparison with “scratch” from known material
- PROs
 - Low cost and easy to obtain
 - Very efficient by experienced users
- CONS
 - Not an exact value (approximate)
 - 4K “intervals” affect price
 - Can be fooled
 - Somehow destructive, consumables



© Van Dijk Toetsstenen

Analysis Techniques (2)



Electronic Gold Testers

- Electrochemical principle with either consumable probe or gel
- Can determine karat value and distinguish different gold grades (white, pink etc.) 6-24K
- PROs
 - Portable, fast 2-5 sec
 - Mid-range pricing < 1K \$
- CONS
 - +/- 0.5 K
 - Can be fooled
 - Consumables





The ultimate and reference method

- The accepted reference method for precious metal analysis is fire assay
- Time-tested art/method since medieval times
- Fully destructive with an accuracy of 1 to 10000 in metal
- **ASTM E1335 - 08 Standard Test Methods for Determination of Gold in Bullion by Fire Assay Cupellation Analysis**
- Gravimetric determination of the gold
 - Ir and Ru are also deliberately doped in jewelry as their melting points are over 2500° C and cannot be detected by fire assay or acid tests.
 - More weight, more \$\$\$

Why XRF?



- Non-destructive for the sample
- No consumables
- Portable to handheld
- Simple to use: One click or trigger pull to get results in % and KARAT
- Accuracy comparable to fire assay, e.g. within 1/8 of a fire assay value(*)
- Most analyses can be done within seconds
- Measures all elements in the sample

XRF: X-ray Fluorescence Analysis or X-ray Spectrometry

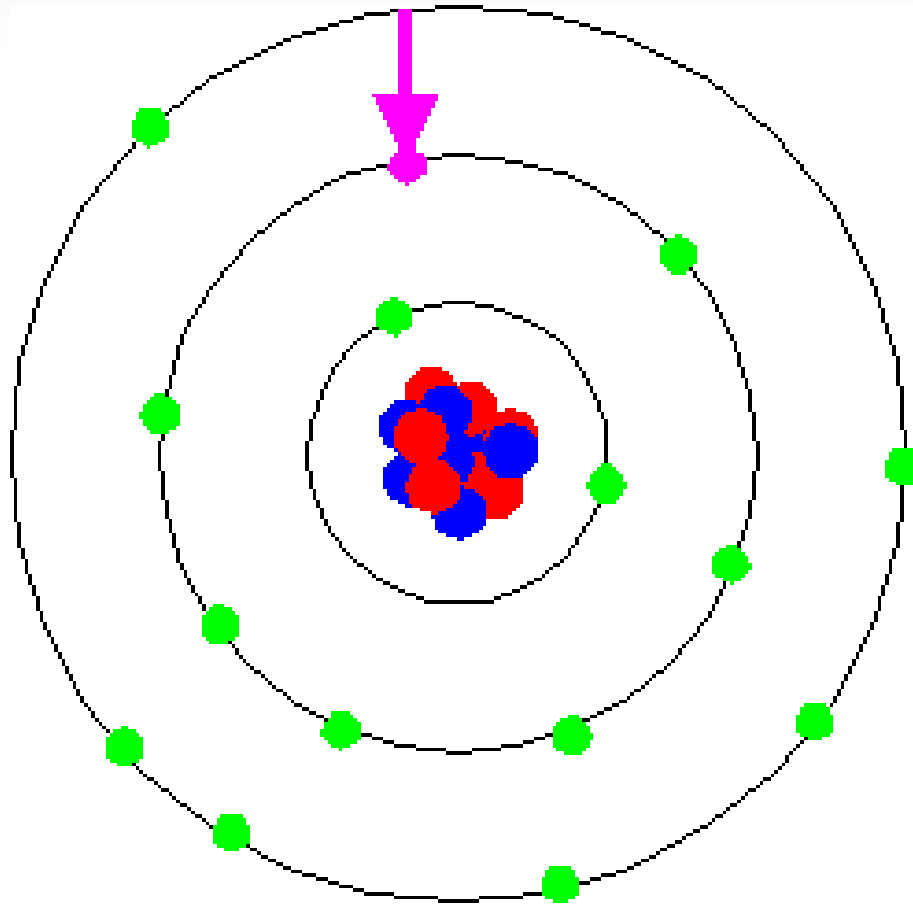


XRF is the method for:

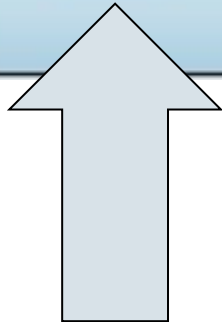
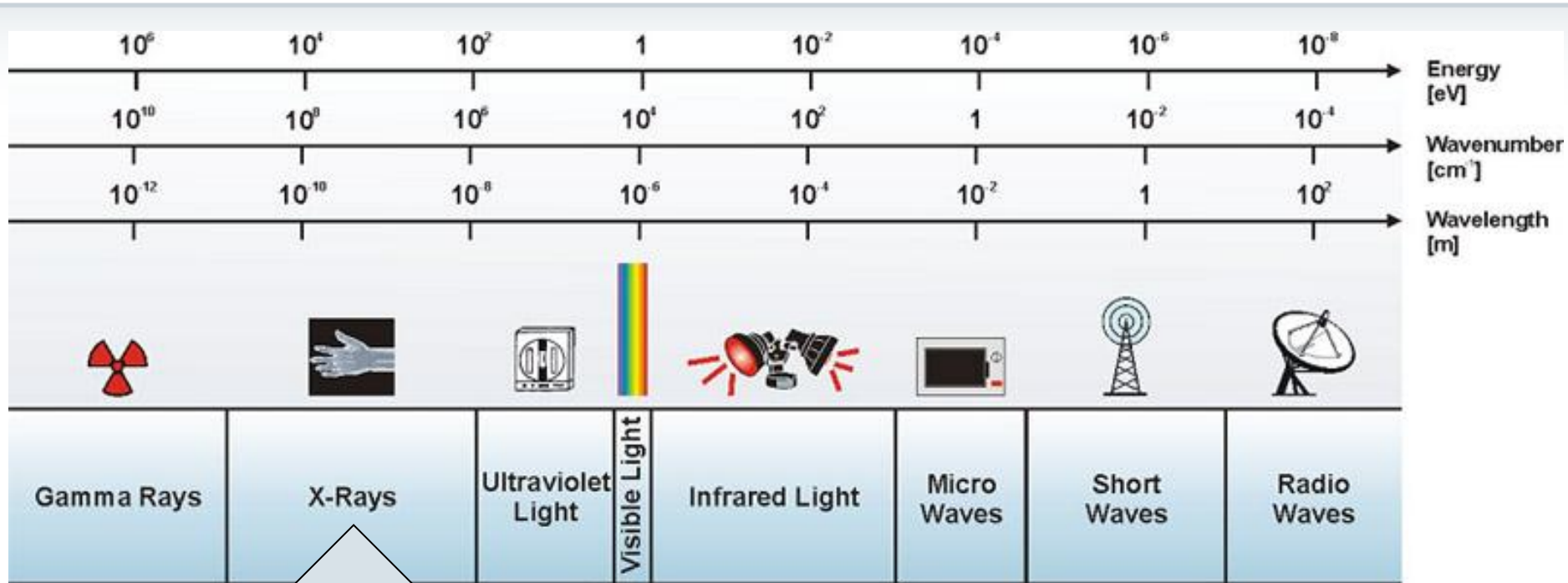
doing qualitative and quantitative analysis of elemental composition by excitation of atoms and detection of their characteristic X-rays

H																	He	
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Ac																
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No			

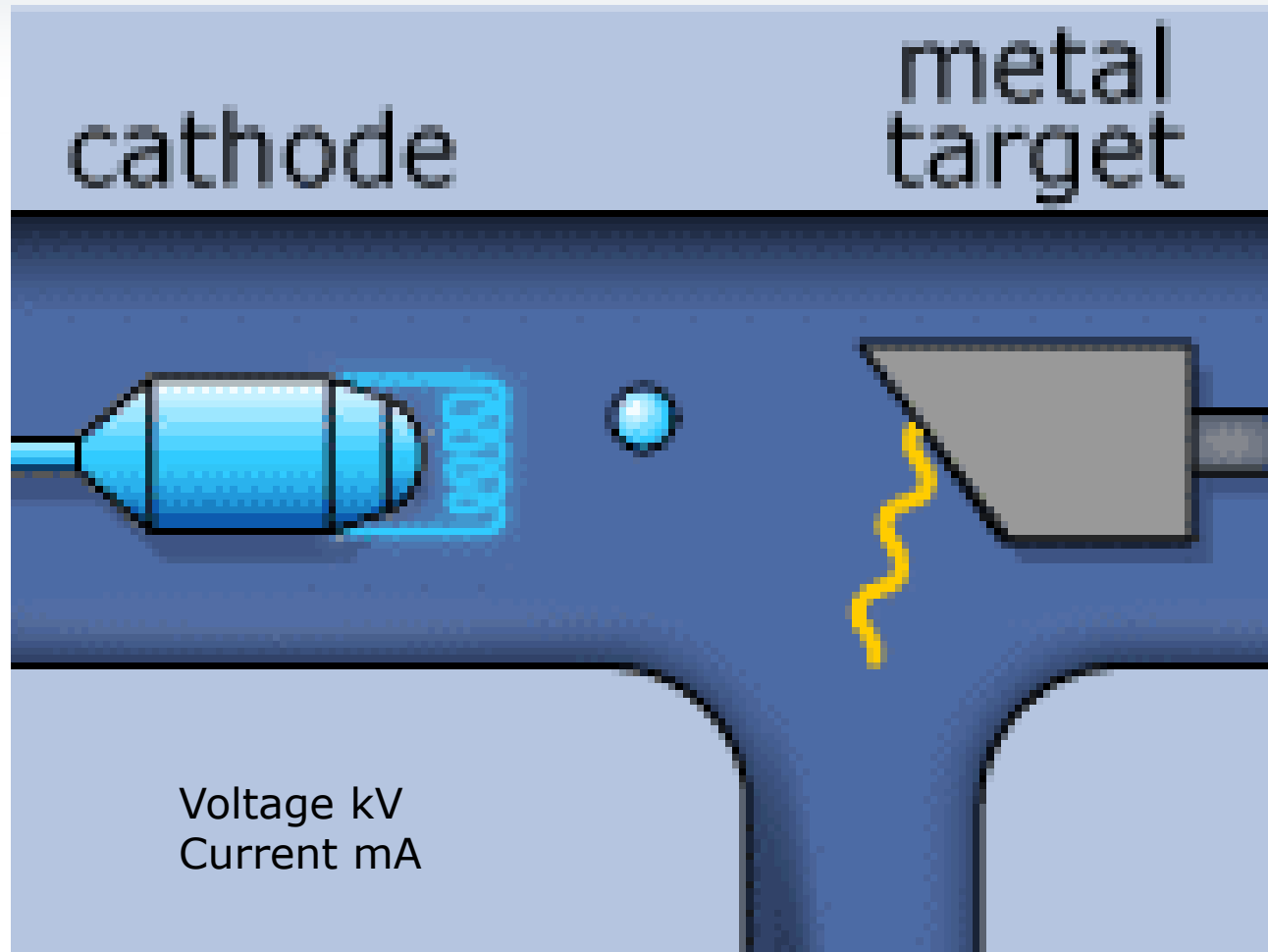
How Characteristic X-rays are Generated in an Atom



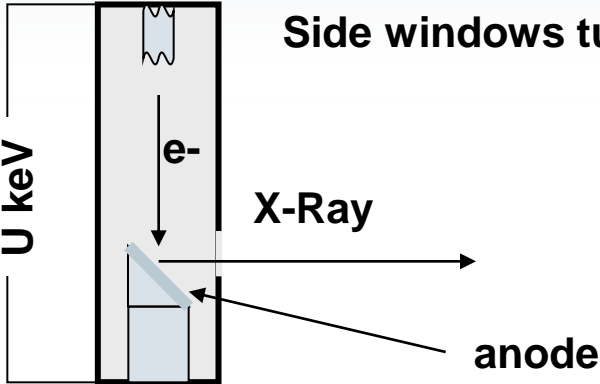
Where X-rays Fit Into the Energy Spectrum



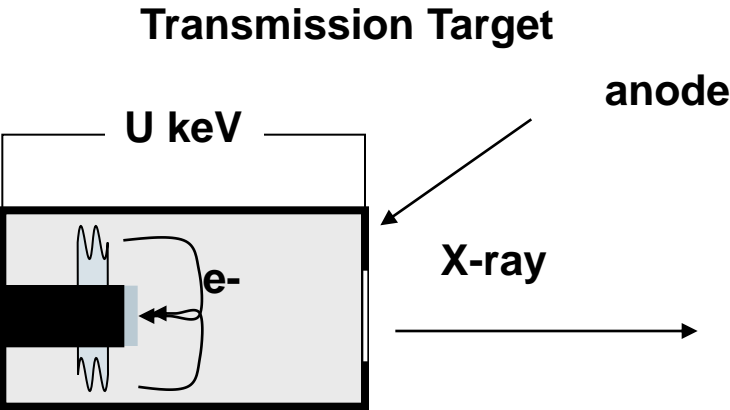
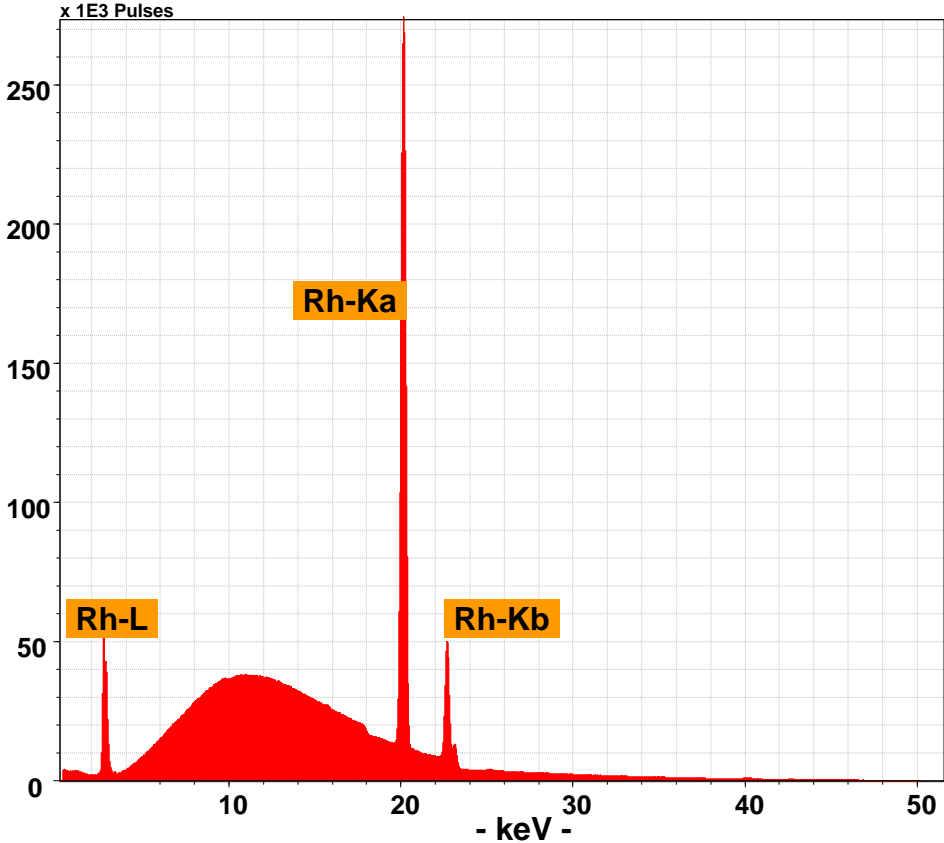
Generation of X-rays in an X-ray Tube



X-ray Production on Demand



Spectrum (Rh Anode)

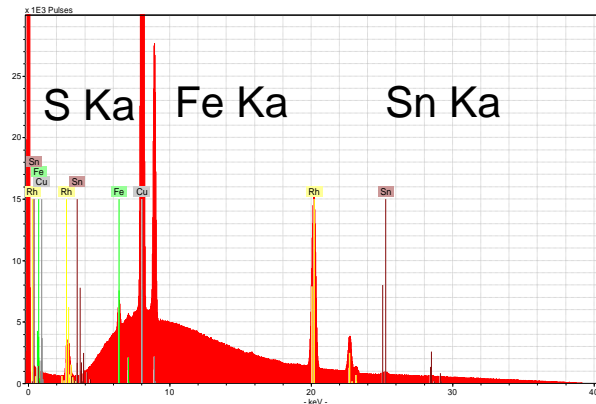
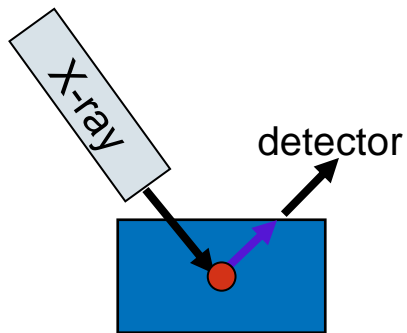


Absorption in the sample and from the sample



absorption: responsible for the information depth.

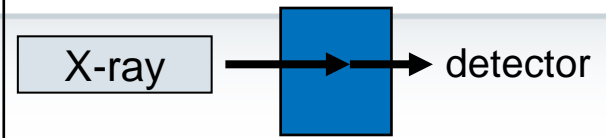
“depth from which a photon produced within the sample can leave the sample and reach the detector”



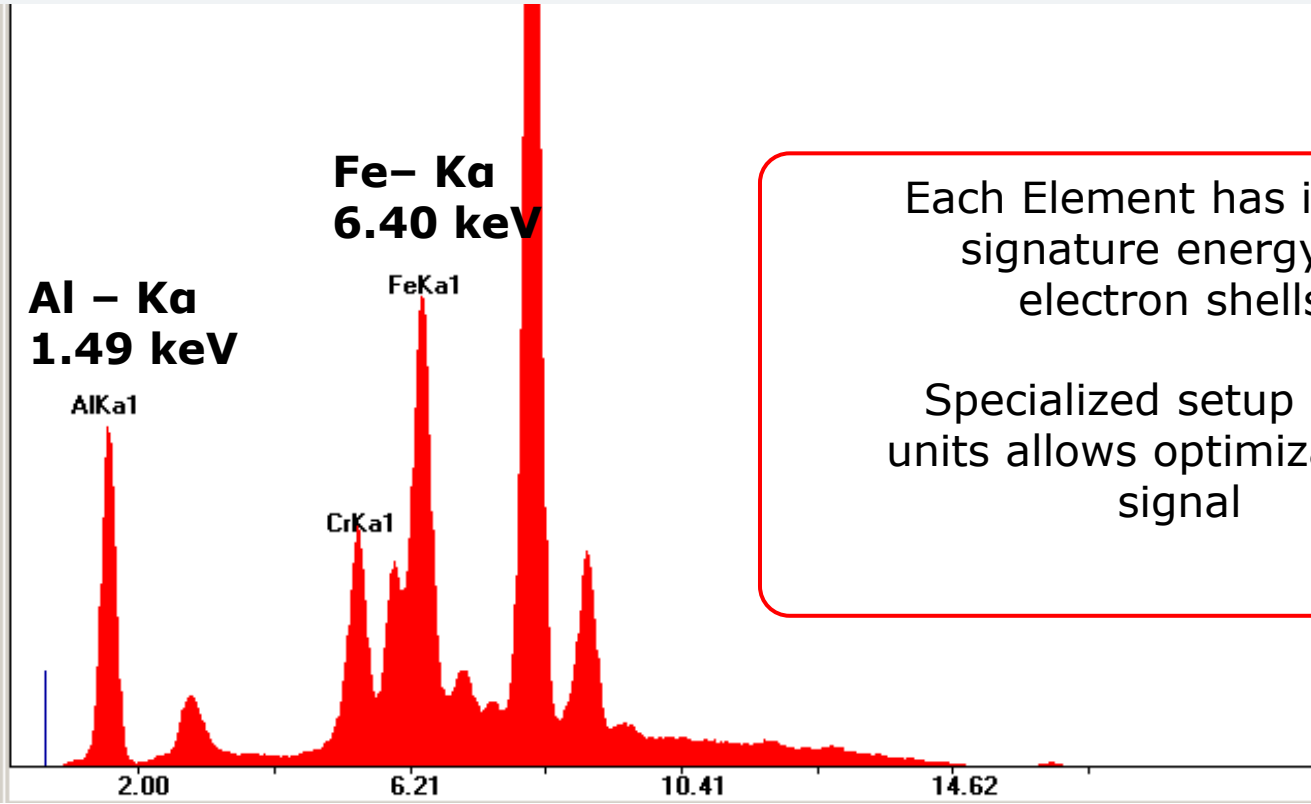
wood (45°)
polypropylene
S Ka 45 μm
Fe Ka 1200 μm
Sn Ka 29000 μm

ceramic (45°)
SiO₂
S Ka 3 μm
Fe Ka 50 μm
Sn Ka 2600 μm

metal (45°)
Cu
S Ka 0.5 μm
Fe Ka 8 μm
Sn Ka 45 μm



Example of XRF Spectrum



Each Element has its own signature energy for electron shells.

Specialized setup of the units allows optimization of signal

X-ray energy tells you **WHAT** element it came from

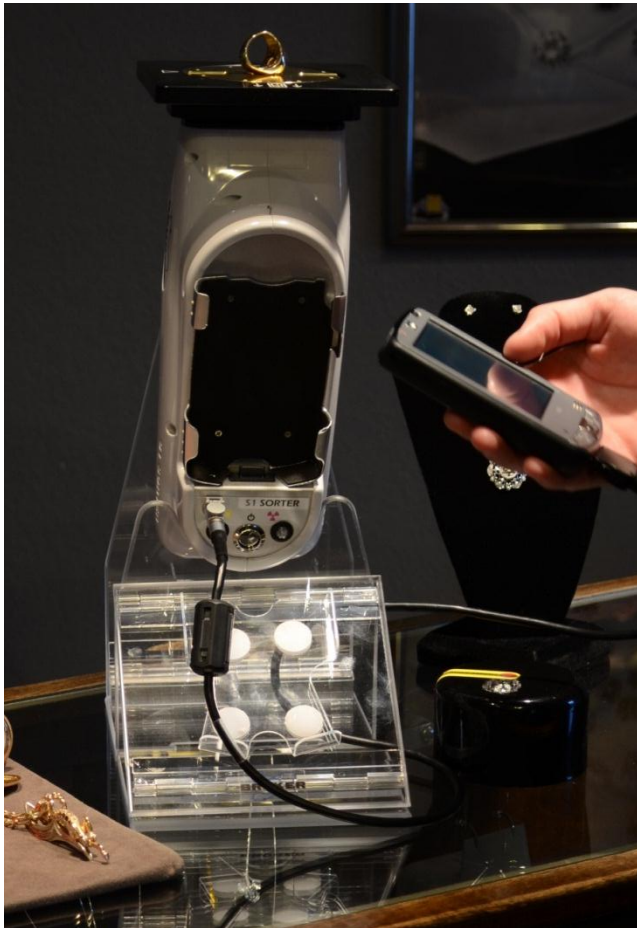
Number of X-rays tells you **HOW** much is present

Instrumentation (handheld)



- Around 1.4 kg weighing instrument, easy to transport

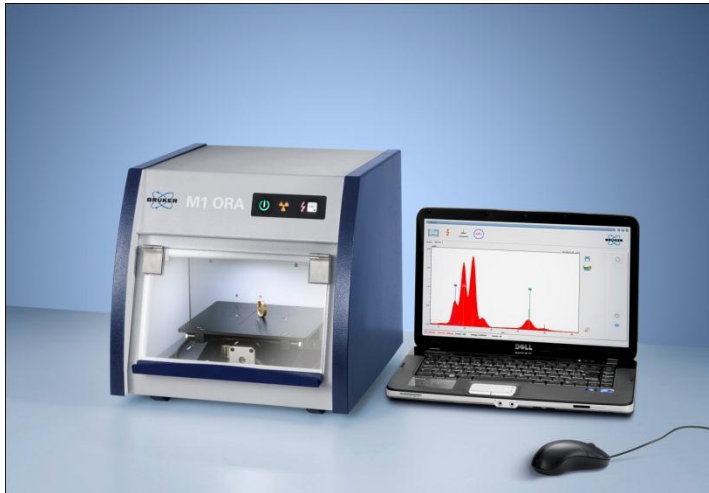
Handheld or stationary use



Micro-XRF benchtop units



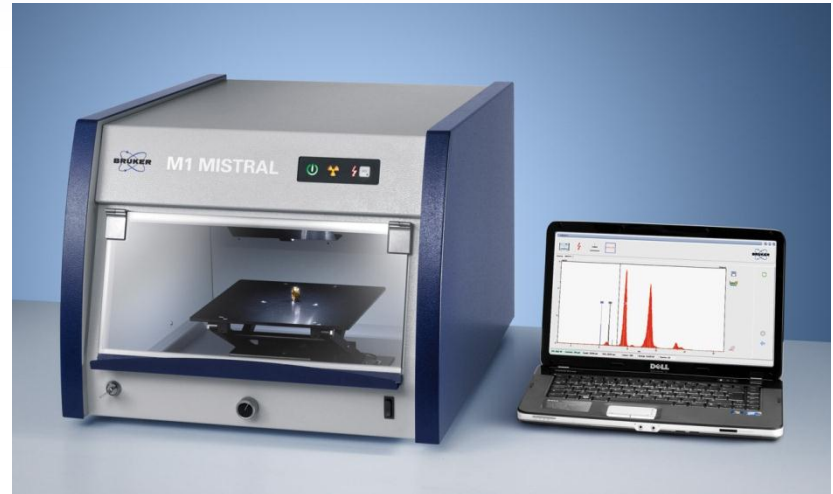
M1 Ora



Small unit for jewelry analysis

- Measurement on air.
- Spot size down to 0.1 mm.
- Measurement from top
- Quantification standard based, standardless, coating thickness

M1 Mistral^{SDD}



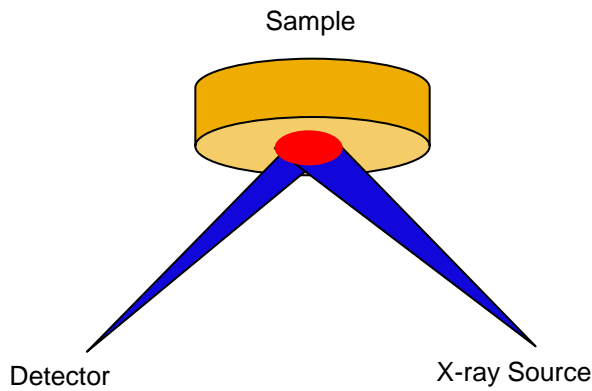
Larger unit for unknowns, platings

HH-XRF vs Micro-XRF

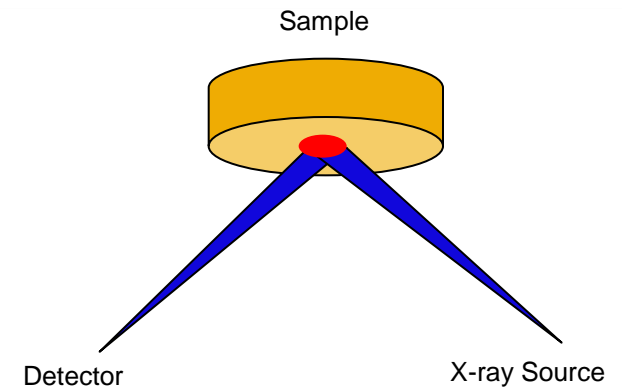
Beam Size Comparison



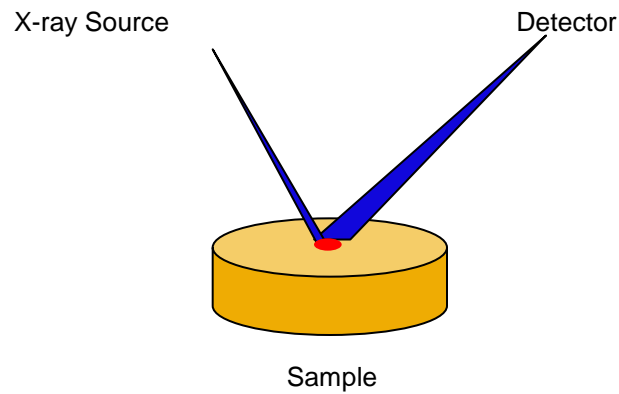
S1 SORTER ($\sim 6\text{mm}^2$)



S1 TITAN ($3 \times 2\text{mm}$)



M1 Ora / Mistral ($\sim 0.07\text{mm}^2$)



Use of HH-XRF for precious metal identification and quantification



- HH-XRF can be used to identify the "GRADE" of the metal as well as the KARAT reading
- More importantly it can determine the concentrations of the all elements in the object.
 - This allows to detect elements such as Ir and Ru which cannot be detected by the fire assay for settlement analysis
 - Unusual alloys such as dental alloys (containing Hg)
 - Palladium jewelry can be distinguished from Pt
 - XRF is useful also for silver alloys which vary much more nationally than other precious metals



Courtesy 123 Precious Metal Refining, LLC

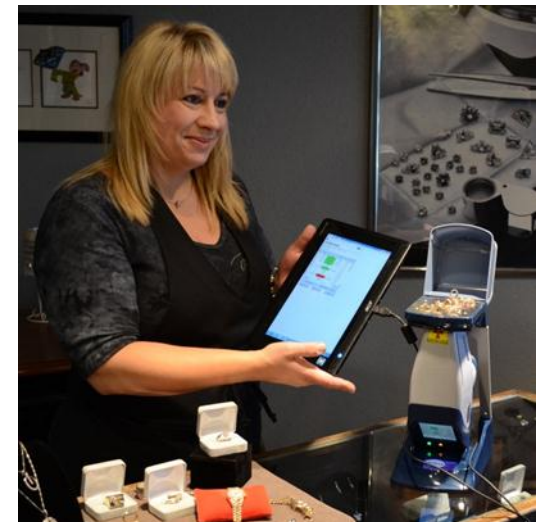
Gold Accuracy and repeatability



S1 TITAN		Stdev absolut (1s) for 10 measurements				
Grade	Content	Au	RelStdevAu	Ag	Cu	
22 karat	91.60%	0.06%	0.06%	0.04%	0.05%	
18 karat	75.20%	0.11%	0.15%	0.08%	0.03%	
13 karat	53.80%	0.10%	0.19%	0.08%	0.07%	
10 karat	41.50%	0.10%	0.23%	0.07%	0.07%	

NOTE: you need to balance speed with precision. Average over the sample does not necessarily be a better analysis

Small objects not covering the spot are normalized to 100% using Bruker's unique small sample intensity scaling which includes full FP matrix correction.



Size and power does not matter! The layer is defined by the sample!



The analytical lines (emissions) from the sample pose some challenges:

- Au Ka1 68.803 KeV K abs (excitation potential) 80.725 KeV
- Au Kb1 77.984 KeV
- Au La **9.713 KeV** L1 abs (excitation potential) 14.535 KeV
- Au Lb **11.442 KeV**
- Au Ly **13.381 KeV**
- Au Ma.. **2.123 KeV** M1 abs 3.148 KeV

Material
Formula: 75.2%Au +24.8% Cu
Density: 15.60 g/cm3

Radiation
Line: Au LB1 Wavelength: 1.0835 Angströms
%Int: 56.6 Energy: 11.44 keV

Absorptions in cm2/g
Photo: 97.8 Compton: 0.059 Rayleigh: 3.50
Total: 101 Depth @90% absorption: 14.6 µm

Buttons: Quit, Apply

Material
Formula: 75.2%Au +24.8% Cu
Density: 15.60 g/cm3

Radiation
Line: Au LA1 Wavelength: 1.2776 Angströms
%Int: 100.0 Energy: 9.705 keV

Absorptions in cm2/g
Photo: 149 Compton: 0.053 Rayleigh: 4.11
Total: 153 Depth @90% absorption: 9.6 µm

Buttons: Quit, Apply

18K gold

The GOLDEN cent



- What happens if we measure a coated sample?
 - If the gold layer is smaller than the layer we analyze (which is governed by physics), we read a mix of base and the gold layer.

- This is a flash gold coating measured to be .25 micron

Thickness diagram for decorative gold plating – Copyright 2004 Metal Arts Specialties

Unit of conversion chart

1 micron = 40 micro inches

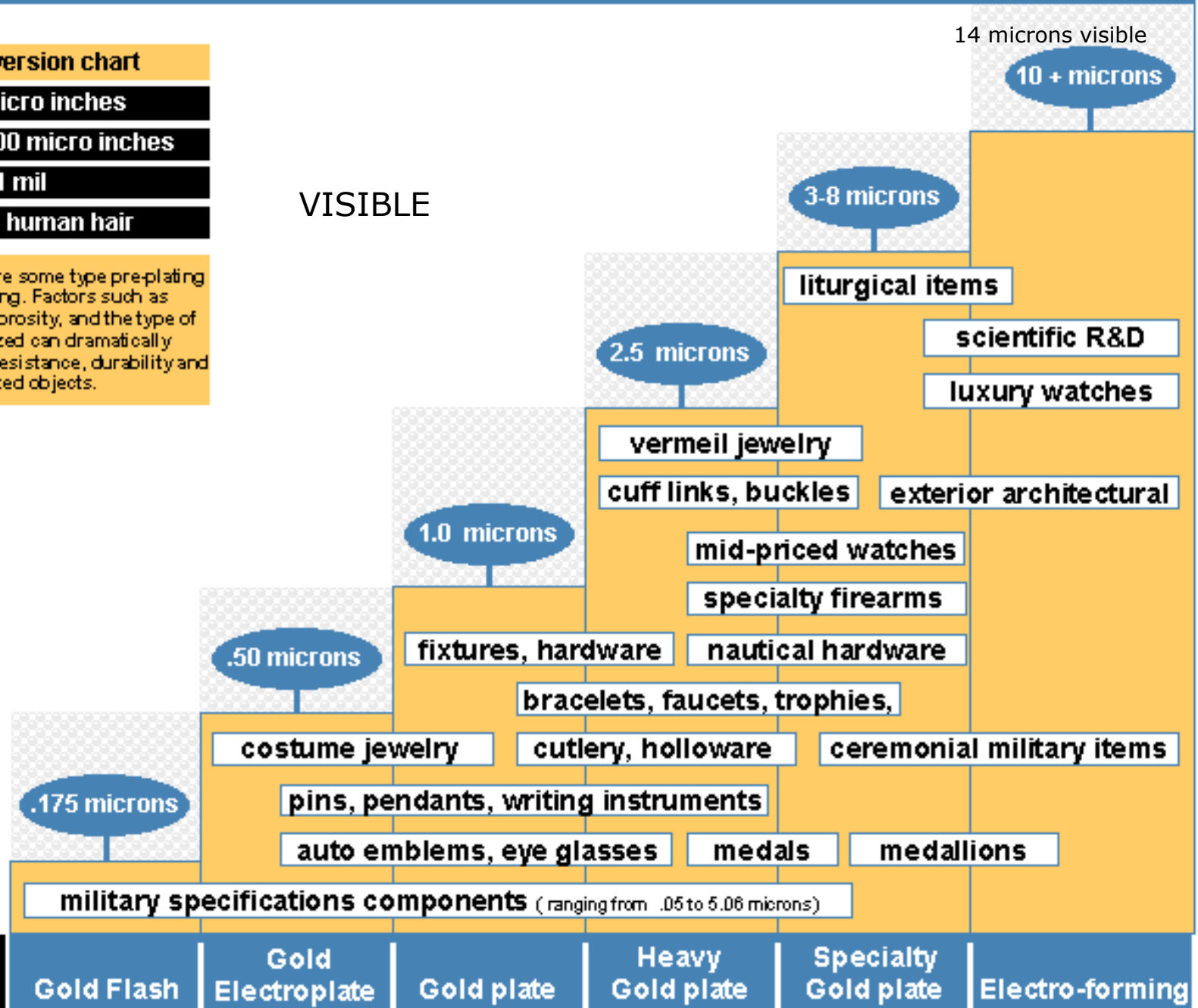
2.5 microns = 100 micro inches

25.5 microns = 1 mil

100 microns = a human hair

Most metals will require some type pre-plating prior to final gold plating. Factors such as surface preparation, porosity, and the type of plating chemistry utilized can dramatically impact the corrosion resistance, durability and brightness of gold plated objects.

VISIBLE



What is plated...

- Decorative gold plating on antique pieces, bathroom fittings or furniture articles is mostly flash gold typically 22-24K and in the range of 0.2-0.5 microns and can be spotted by the "LOW" Karat reading and high "other" metal content (e.g. Pb in brass)
- It is possible that 22K plating has been applied to 18K articles and needs verification "upgrading" the 18K to 19-20K. This is done to upgrade non-HALMARKED materials and to trick acid tests! The plating can be in the range of 2-6 microns and used in jewelry, watch and eyewear industries (requires Ni bonding layer)
 - This can be spotted again by unusual Karat grade and by studying the spectra: the ratio between the Au emission lines will be "off" from its theoretical ratio
 - Measure more spots and look for variations indicating coating
- Hard "electroformed" materials with coating in excess of 14 microns (if Au LB) is measured or 10 microns (for Au La1) appear solid

Faked! Lose 72 K in one deal!



- W coated with thick Au is undetectable by all mentioned techniques!
- One gold dealer discovered that four of the 3-inch-by-1-inch gold bars he bought — worth about \$72,000 retail — were counterfeit (Sept 23rd 2012). He was tricked by the “respectable” markings and correct weight and dimensions.
- Only drilling or most accurate density measurements (by fluid displacement) will help here
- If it sounds too good to be true, it is either stolen or fake!

Be aware of the ORIGINAL , enables to spot the fake!



COINS



1 H Hydrogen 1.01 0.0007																	2 He Helium 4.00 0.0002						
3 Li Lithium 6.94 0.53	4 Be Beryllium 9.01 1.85 K α 0.108																	5 B Boron 10.81 2.34 K α 0.183	6 C Carbon 12.01 2.27 K α 0.277	7 N Nitrogen 14.01 0.001 K α 0.392	8 O Oxygen 16.00 0.001 K α 0.525	9 F Fluorine 19.00 0.001 K α 0.677	10 Ne Neon 20.18 0.0009 K α 0.849
11 Na Sodium 22.99 0.97 K α 1.040	12 Mg Magnesium 24.31 1.74 K α 1.254																	13 Al Aluminium 26.98 2.70 K α 1.486	14 Si Silicon 28.09 2.33 K α 1.740	15 P Phosphorus 30.97 1.82 K α 2.010	16 S Sulfur 32.07 2.07 K α 2.309	17 Cl Chlorine 35.45 0.003 K α 2.622	18 Ar Argon 39.95 0.002 K α 2.958
19 K Potassium 39.10 0.86 K α 3.314	20 Ca Calcium 40.08 1.54 K α 3.692 L α 0.341	21 Sc Scandium 44.96 2.99 K α 4.093 L α 0.395	22 Ti Titanium 47.87 4.54 K α 4.512 L α 0.452	23 V Vanadium 50.94 6.11 K α 4.953 L α 0.510	24 Cr Chromium 52.00 7.15 K α 5.415 L α 0.572	25 Mn Manganese 54.94 7.44 K α 5.900 L α 0.637	26 Fe Iron 55.85 7.87 K α 6.405 L α 0.705	27 Co Cobalt 58.93 8.86 K α 6.931 L α 0.775	28 Ni Nickel 58.69 8.91 K α 7.480 L α 0.849	29 Cu Copper 63.55 8.93 K α 8.046 L α 0.928	30 Zn Zinc 65.38 7.13 K α 8.637 L α 1.012	31 Ga Gallium 69.72 5.91 K α 9.251 L α 1.098	32 Ge Germanium 72.64 5.32 K α 9.886 L α 1.188	33 As Arsenic 74.92 5.78 K α 10.543 L α 1.282	34 Se Selenium 78.96 4.81 K α 11.224 L α 1.379	35 Br Bromine 79.90 3.12 K α 11.924 L α 1.481	36 Kr Krypton 83.80 0.004 K α 12.648 L α 1.585						
37 Rb Rubidium 85.47 1.53 K α 13.396 L α 1.692	38 Sr Strontium 87.62 2.64 K α 14.165 L α 1.806	39 Y Yttrium 88.91 4.47 K α 14.958 L α 1.924	40 Zr Zirconium 91.22 6.51 K α 15.775 L α 2.044	41 Nb Niobium 92.91 8.57 K α 16.615 L α 2.169	42 Mo Molybdenum 95.94 10.22 K α 17.480 L α 2.292	43 Tc Technetium (98) 11.50 K α 18.367 L α 2.423	44 Ru Ruthenium 101.07 12.37 K α 19.279 L α 2.558	45 Rh Rhodium 102.91 12.41 K α 20.216 L α 2.697	46 Pd Palladium 106.42 12.02 K α 21.177 L α 2.838	47 Ag Silver 107.87 10.50 K α 22.163 L α 2.983	48 Cd Cadmium 112.41 8.69 K α 23.173 L α 3.133	49 In Indium 114.82 7.31 K α 24.210 L α 3.286	50 Sn Tin 118.71 7.29 K α 25.271 L α 3.444	51 Sb Antimony 121.76 6.69 K α 26.359 L α 3.604	52 Te Tellurium 127.60 6.23 K α 27.473 L α 3.768	53 I Iodine 126.90 4.93 K α 28.612 L α 3.938	54 Xe Xenon 131.29 0.006 K α 29.775 L α 4.110						
55 Cs Cesium 132.91 1.87 K α 30.973 L α 4.285	56 Ba Barium 137.33 3.59 K α 32.194 L α 4.466	57 La Lanthanum 138.91 6.15 K α 33.442 L α 4.647	72 Hf Hafnium 178.49 13.31 K α 7.899 M α 1.646	73 Ta Tantalum 180.95 16.65 K α 8.146 M α 1.712	74 W Tungsten 183.84 19.25 K α 8.398 M α 1.775	75 Re Rhenium 186.21 21.02 K α 8.652 M α 1.843	76 Os Osmium 190.23 22.61 K α 8.911 M α 1.907	77 Ir Iridium 192.22 22.65 K α 9.175 M α 1.980	78 Pt Platinum 195.08 21.46 K α 9.442 M α 2.050	79 Au Gold 196.97 19.28 K α 9.713 M α 2.123	80 Hg Mercury 200.59 13.53 K α 9.989 M α 2.195	81 Tl Thallium 204.37 11.85 K α 10.269 M α 2.271	82 Pb Lead 207.20 11.34 K α 10.551 M α 2.342	83 Bi Bismuth 208.98 9.81 K α 10.839 M α 2.423	84 Po Polonium (209) 9.32 K α 11.131 M α 2.499	85 At Astatine (210) 7.00 K α 11.427 M α 2.577	86 Rn Radon (222) 0.01 K α 11.727 M α 2.654						
87 Fr Francium (223) 1.87 K α 12.031 M α 2.732	88 Ra Radium (226) 5.50 K α 12.339 M α 2.806	89 Ac Actinium (227) 10.07 K α 12.652 M α 2.900																					

58 Ce Cerium 140.12 6.77 K α 4.839 M α 0.884	59 Pr Praseodymium 140.91 6.77 K α 5.035 M α 0.927	60 Nd Neodymium 144.24 7.01 K α 5.228 M α 0.979	61 Pm Promethium (145) 7.26 K α 5.432 M α 1.023	62 Sm Samarium 150.36 7.52 K α 5.633 M α 1.078	63 Eu Europium 151.96 5.24 K α 5.849 M α 1.131	64 Gd Gadolinium 157.25 7.90 K α 6.053 M α 1.181	65 Tb Terbium 158.93 8.23 K α 6.273 M α 1.240	66 Dy Dysprosium 162.50 8.55 K α 6.498 M α 1.293	67 Ho Holmium 164.93 8.80 K α 6.720 M α 1.348	68 Er Erbium 167.26 9.07 K α 6.949 M α 1.404	69 Tm Thulium 168.93 9.32 K α 7.180 M α 1.462	70 Yb Ytterbium 173.04 6.97 K α 7.416 M α 1.526	71 Lu Lutetium 174.47 9.84 K α 7.655 M α 1.580
90 Th Thorium 232.04 11.72 K α 12.968 M α 2.996	91 Pa Protactinium 231.04 15.37 K α 13.291 M α 3.082	92 U Uranium 238.03 18.95 K α 13.614 M α 3.171	93 Np Neptunium (237) 20.45 K α 13.946 M α 3.250	94 Pu Plutonium (244) 19.84 K α 14.282 M α 3.339	95 Am Americium (243) 13.69 K α 14.620 M α 3.438	96 Cm Curium (247) 13.51 K α 14.949 M α 3.527	97 Bk Berkelium (247) 14.79 K α 15.277 M α 3.626	98 Cf Californium (251) 15.1 K α 15.605 M α 3.725	99 Es Einsteinium (252) 13.5 K α 15.933 M α 3.824	100 Fm Fermium (257) 13.5 K α 16.261 M α 3.923	101 Md Mendelevium (258) 13.5 K α 16.589 M α 4.022	102 No Nobelium (259) 13.5 K α 16.917 M α 4.121	103 Lr Lawrencium (262) 13.5 K α 17.245 M α 4.220

Atomic number

Atomic weight

Density (g/cm³)

Symbol

Element name

Energy (keV)

Spectral line

35 79.90
Br 3.12
Bromine
K α 11.924
L α 1.481

At one point pennies were Cu



CDA110 or CDA172
51 Match 9.0 01-01 01:14
Time 15.0

El	Min	%	Max	+/-
Ni		0.131		0.028
Cu	98.000	99.606	100.000	0.444
Zn		0.263		0.054

A close-up photograph of a US penny coin, showing the profile of Abraham Lincoln and the words "LIBERTY" and "IN GOD WE TRUST". The coin is dark and appears to be made of copper.

Collector coins: another area of concern and use of HH-XRF



Silver content:

if it ain't 5 9's, it's not fine silver

Precious Metal Alloys FP 1:26

Ag
236 Time 15.0 Match Qual 10.0
08-31-2012 10:34

El	Min	%	Max	+
Ag	99.000	100.000	100.000	0.7

Spectra Edit Info Back

←Prev Next→

Precious Metal Alloys FP 1:26

No Match
235 Time 15.0 Match Qual 3.5
08-31-2012 10:33

El	Min	%	Max	+/-
Ni		4.190		0.130
Cu		71.200		0.539
Zn		21.900		0.299
Ag		2.680		0.122

Spectra Edit Info Back

←Prev Next→



Fake Morgan vs "boxed" Real Morgan



Precious Metal Alloys FP 1:27

No Match
 238 Time 15.0 Match Qual 0.0
 08-31-2012 10:36

El	Min	%	Max	+/-
Fe		82.600		0.628
Ni		17.400		0.488

Spectra Edit Info Back

←Prev Next→



Precious Metal Alloys FP 1:30

No Match
 258 Time 15.0 Match Qual 0.0
 08-31-2012 11:21

El	Min	%	Max	+/-
Cu		10.140		0.179
Ag		90.280		1.174

Spectra Edit Info Back

←Prev Next→



Diameter: 38.1 millimeters
 Weight: 26.73 grams
 Composition: .900 silver,
 .100 copper Edge: Reeded
 Net Weight: .77344 ounce
 pure silver.

More Morgans




CDA863-Mr

25 Match

Time 20.0

El	Min		
Mn	2.50	5.00	
Ni	0.00	2.10	
Cu	60.00	66.25	
Zn	22.00	23.94	28.00
Zr		0.01	0.00
Nb		0.09	0.01
Mo		0.03	0.01
Ag		1.78	0.05
Sn	0.00	0.00	0.20
Pb	0.00	0.00	0.20




No Match

27 Match 0.0 02-08 08:21

Time 23.0

El	Min	%	Max	+/-
Cu		6.46		0.06
Ag		93.50		
Pb		0.04		



COINs (Mx) reading higher in Ag? Instrument issue?



COINs (Mx) reading higher in Ag? Instrument issue?



Also this Australian (1946) coins reads strangely high



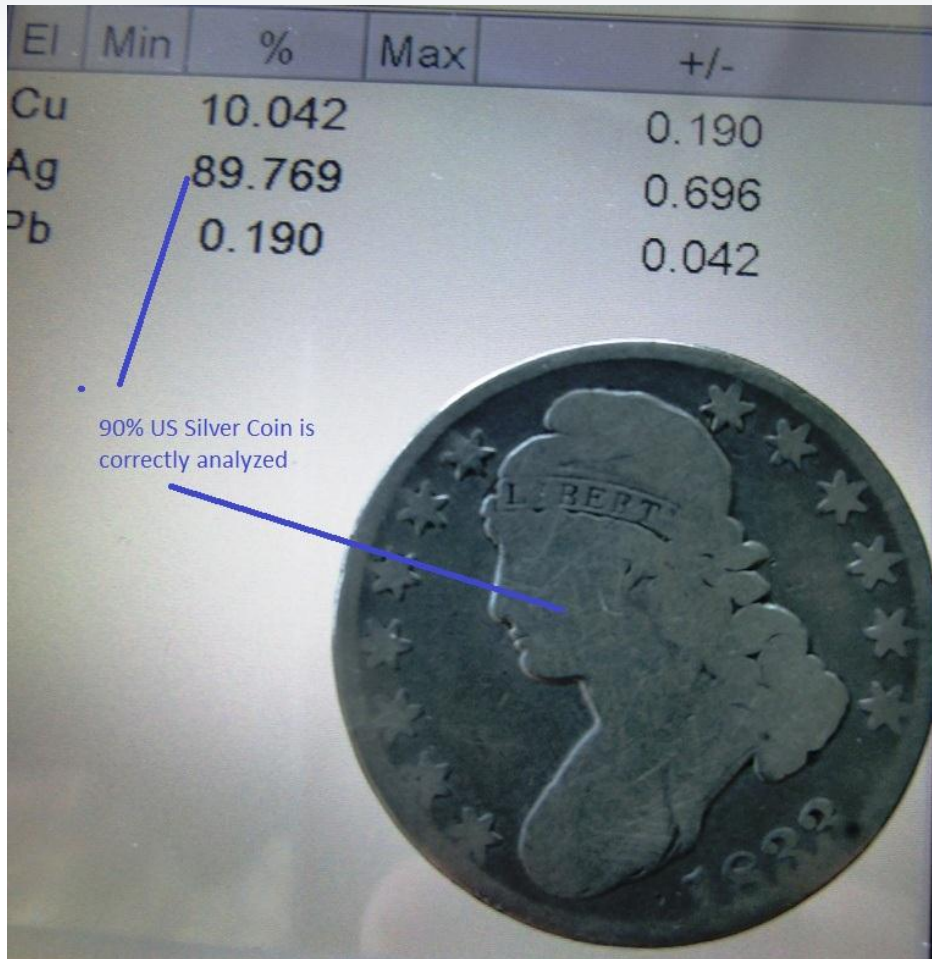
El	Min	%	Max	+/-
Ni		4.195		0.140
Cu		30.504		0.312
Zn		4.840		0.124
Ag		60.460		0.560

1946 Shilling was 50.0% silver, 40% copper, 5% nickel, 5% zinc

Measures Ag as 10% high

A close-up photograph of a 1946 Australian Shilling coin. The coin is silver-colored and features a profile portrait of a man with a beard. The word "AUSTRALIA" is embossed at the top, and "SHILLING 1946" is embossed at the bottom. Two stars are positioned on either side of the portrait. The coin is placed over a digital display showing a table of elemental analysis data.

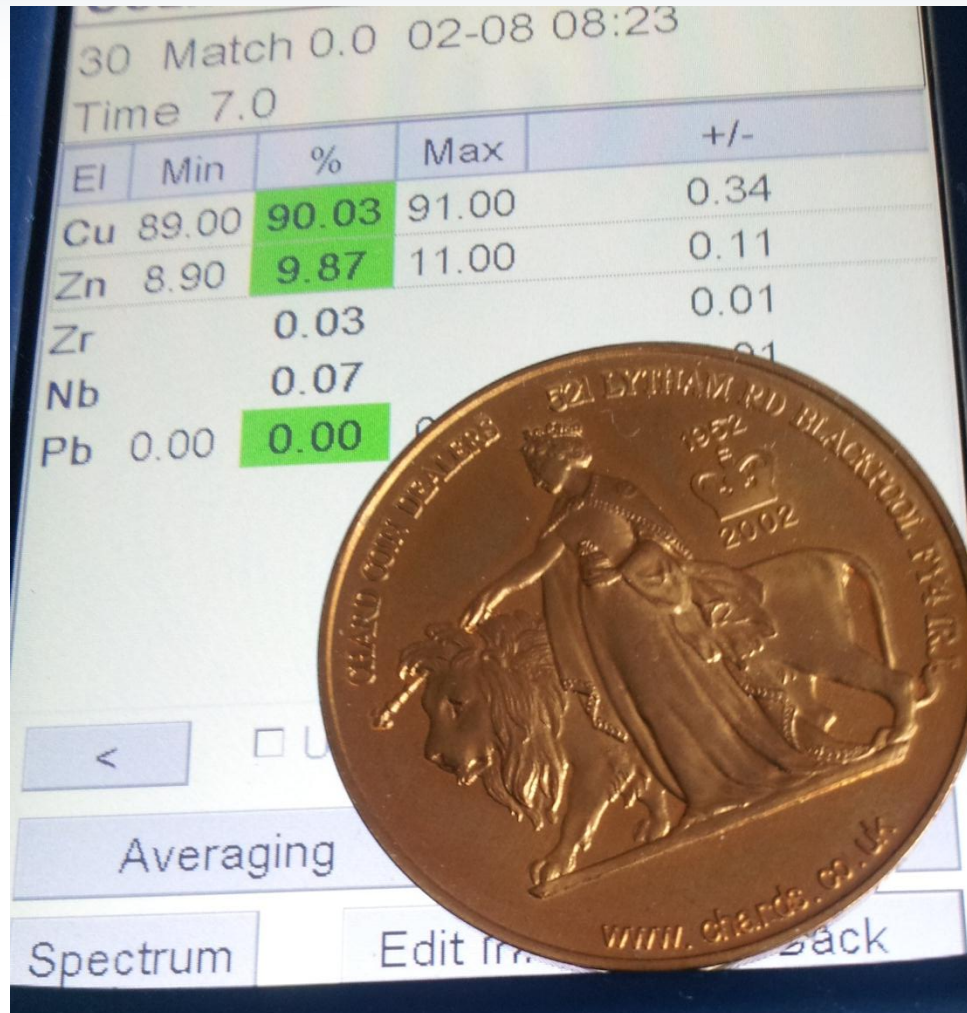
US coin read correct



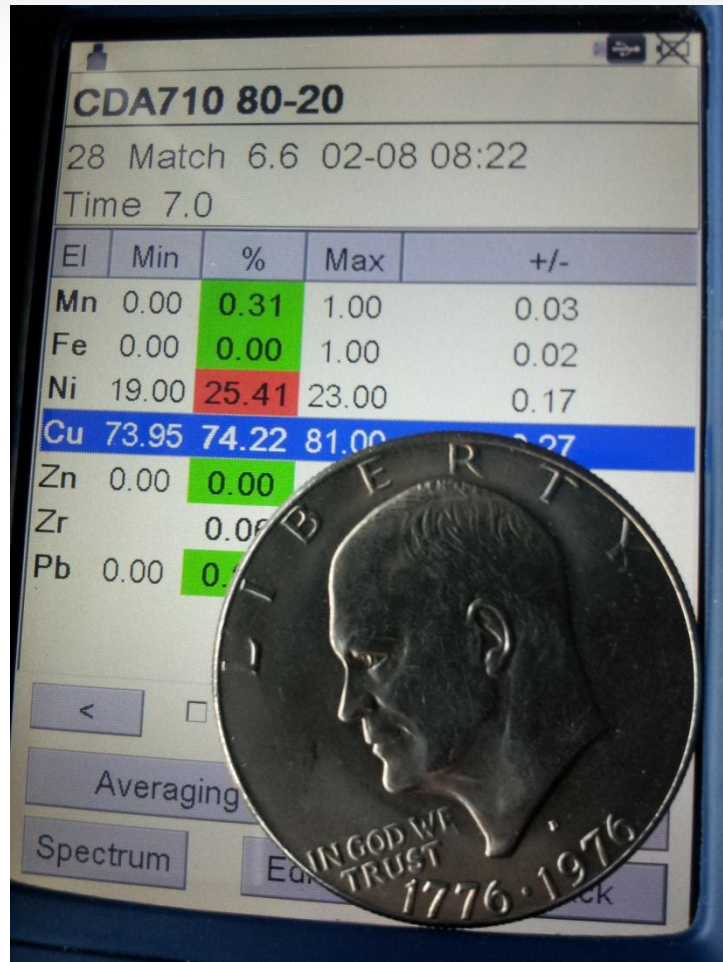
What happened here

- Once we “removed” the surface layer of some of those coins and measured again, we got the correct / expected concentration
- The coins were ACID washed, removing the Cu and Zn
 - Due to analyzed layer, we read Ag “higher” since it is depleted in the removed elements

HM Pb-free coins



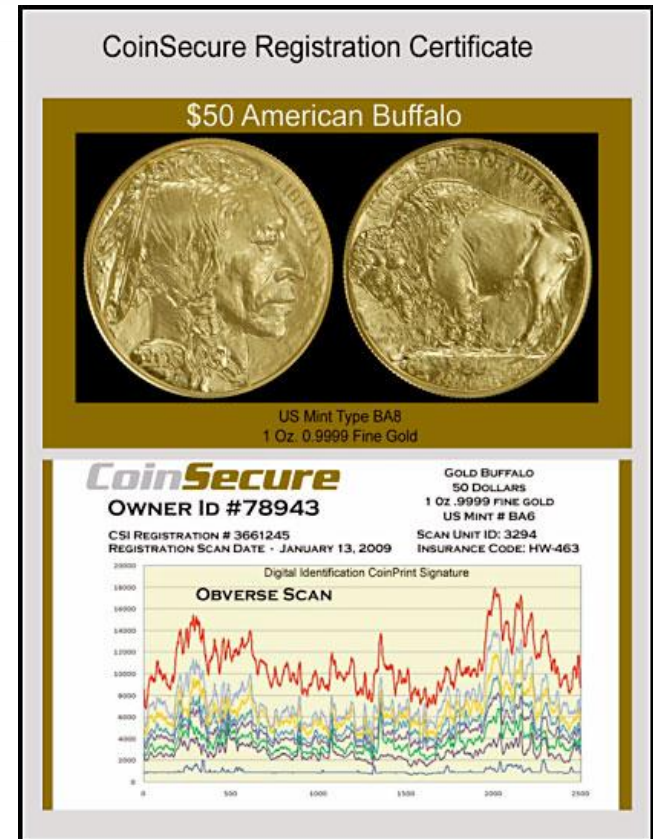
Coated: Ni layer



XRF is only one fingerprint



- The **CP16 CoinAnalyzer™** -- a desktop coin identification system, can find unique characteristics within seemingly identical coins and record these characteristics as a file to serialize the coin. ***This gives each coin an individual identity that is permanently linked to the physical coin attributes.***
- In less than 5 seconds, the CP16 can analyze a coin, finding the unique characteristics of that coin and storing them in a **CoinPrint™ ID file** similar to a fingerprint file. An individualized **serial number** is added to this identification record.



Conclusion



- HH-XRF and the smaller spot size micro-XRF are great tools for the larger scale buyer of precious metal scrap or "... buy gold" establishments as they are for any refiner
- With pricing of well below \$20K USD, HH-XRF allows for more conclusive and accurate ID, which will result in higher margins, paying for the analyzer possible in just a few deals!
 - Recall our 4-Karat difference and the ability to spot older jewelry...
- Investigating the raw data (spectral fingerprint) enables to spot plating as long as the analyzed layer is thicker than the plating. Using the "tramp" elements such as Cu and Ni enable to spot them as well, BUT the HH-XRF is NOT the tool to unequivocally test and measure layers.
- Micro-XRF is designed for layer analysis but is limited by the same physics
- One technique alone is not enough to counter today's counterfeiters, which take advantage of the high prices and eBay-based trades
- Authenticated coins (boxes) from trusted companies are enabling peace of mind and creating value for buyer, seller and collector

Q&A



Any Questions?

Please type any questions you may have for our speakers in the [Q&A panel](#) and click Send.

Thank you!

