SHIMADZU

Application News

Energy Dispersive X-Ray Fluorescence Spectroscopy

Determining Gemstone Authenticity and Precious Metal Purities by Energy Dispersive X-Ray Fluorescence Spectroscopy

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Gemstones have been known to undergo various manipulations to enhance their perceived quality. As technology advances, confirming the authenticity of gemstones becomes more and more difficult, creating a large demand for a non-destructive, time-efficient method of determining the composition of gemstones and precious metals. One such method is Energy Dispersive X-Ray Fluorescence (EDXRF) spectroscopy, a technique that enables a user to quickly and easily differentiate between a true stone and a fraud or determine if any chemical enhancements have been made. In addition to stones, precious metals can be analyzed and quantified to identify their purities. This method allows for non-destructive analysis of gemstones and precious metals to avoid the purchase of fraudulent goods.

For this application a Shimadzu EDX-720 with an Rh-lined X-Ray tube was used to analyze gemstones of varying quality and precious metals at different purities. Analysis of a true diamond should result in no elements found, as Carbon is the sole component [Figure 1]. The analysis of a cubic zirconium diamond should show peaks of zirconium (Symbol: Zr) along with other elements used as filler [Figure 2]. By comparing the two spectra, it is easy to see which stone is authentic and which stone is not or if any impurities were added to enhance the perceived quality of the stones.

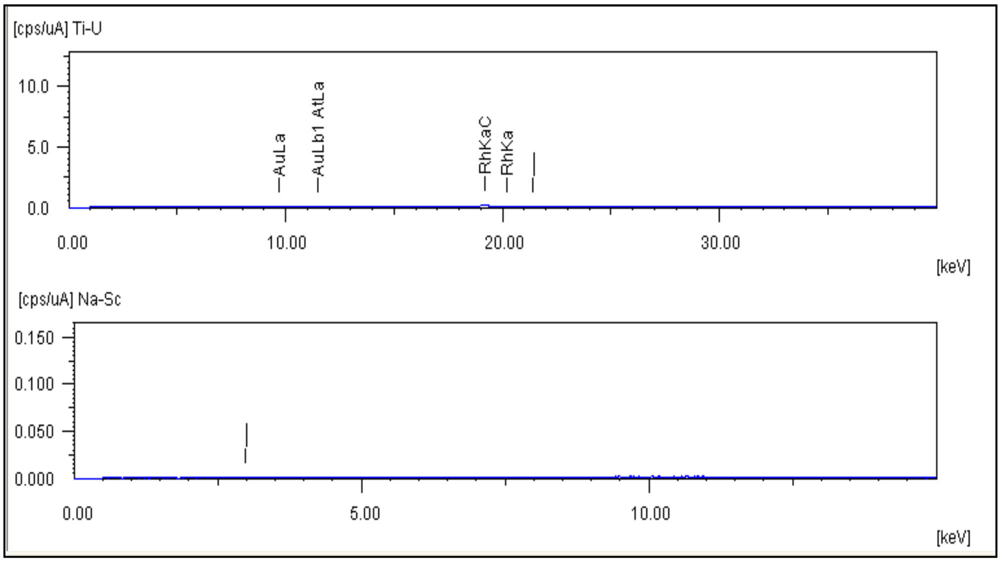


Figure 1: EDX analysis of a diamond in a gold setting

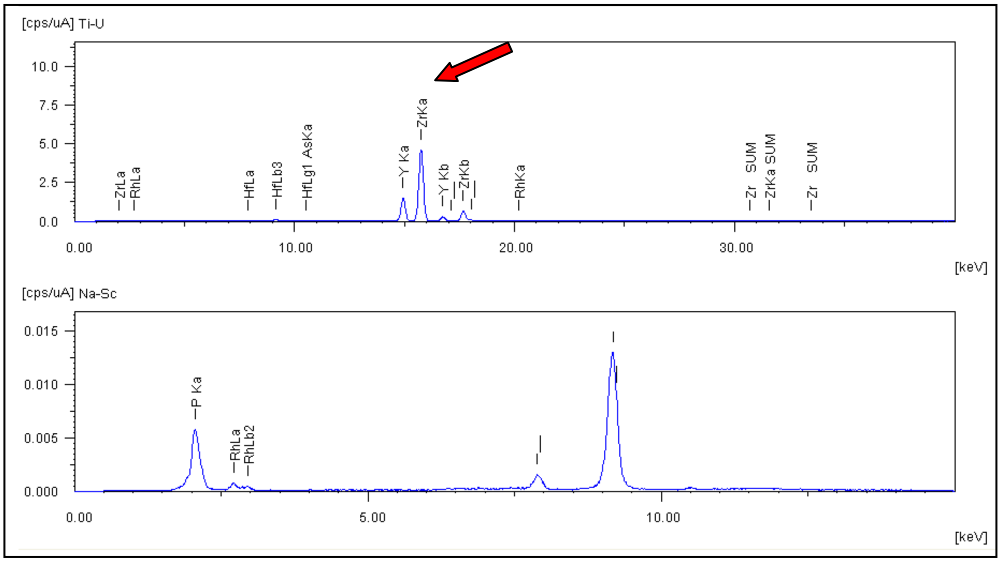
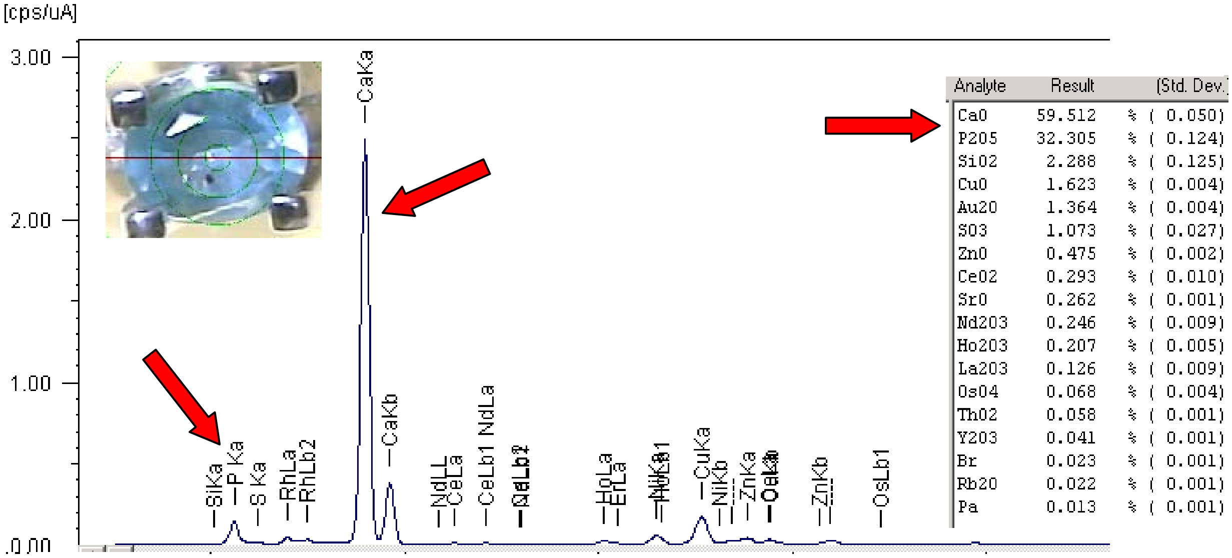


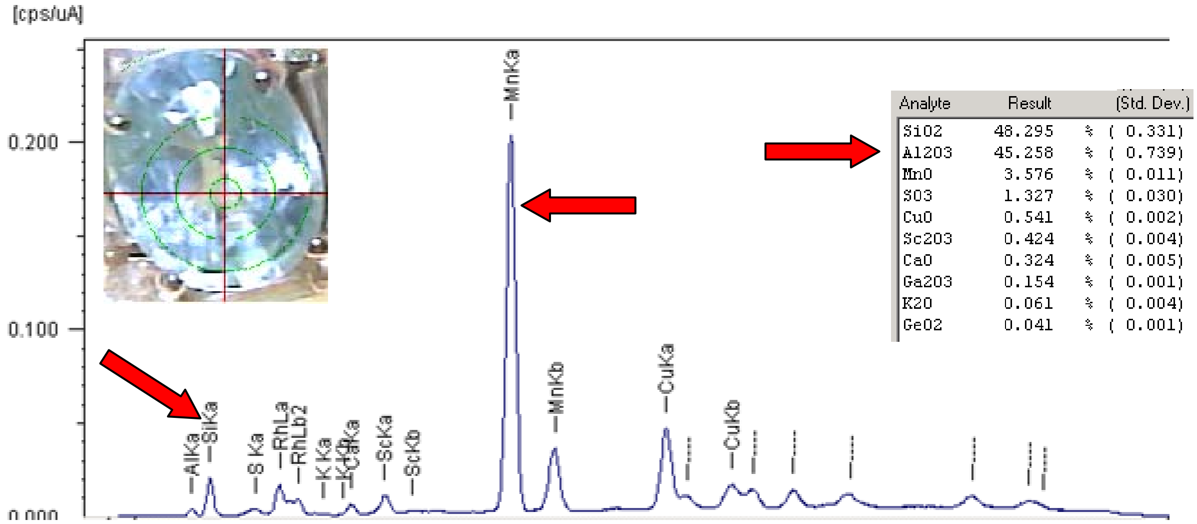
Figure 2: EDX analysis of a cubic zirconium 'diamond' in a gold setting

Analysis of an Apatite stone and a Tourmaline stone revealed how two seemingly identical stones can be mistaken for one another. The Apatite stone spectrum [Figure 3] revealed a composition of Calcium Oxide (Symbol: CaO) and Phosphorous Pentoxide (Symbol: P_2O_5), compounds not naturally found in the more expensive Tourmaline group. The Tourmaline gemstone spectrum [Figure 4] enables the user to further classify the stone into its specific mineral group [Table 1]. Comparing the two spectra, the more expensive gemstone, Tourmaline, shows a Manganese (Symbol: Mn) peak where the less expensive gemstone, Apatite, does not.



Analyte	Result		(Std. Dev.
CaO	59.512	%	(0.050)
P2O5	32.305	%	(0.124)
SiO2	2.288	%	(0.125)
CuO	1.623	%	(0.004)
Au2O	1.364	%	(0.004)
SO3	1.073	%	(0.027)
ZnO	0.475	%	(0.002)
CeO2	0.293	%	(0.010)
SrO	0.262	%	(0.001)
Nd2O3	0.246	%	(0.009)
Ho2O3	0.207	%	(0.005)
La2O3	0.126	%	(0.009)
OsO4	0.068	%	(0.004)
ThO2	0.058	%	(0.001)
Y2O3	0.041	%	(0.001)
Br	0.023	%	(0.001)
Rb2O	0.022	%	(0.001)
Pa	0.013	%	(0.001)

Figure 3: EDX Analysis of Apatite



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Analyte     Result      (Std. Dev.)
SiO2        48.295   %  ( 0.331)
Al2O3       45.258   %  ( 0.739)
MnO          3.576   %  ( 0.011)
SO3          1.327   %  ( 0.030)
CuO          0.541   %  ( 0.002)
Sc2O3        0.424   %  ( 0.004)
CaO          0.324   %  ( 0.005)
Ga2O3        0.154   %  ( 0.001)
K2O          0.061   %  ( 0.004)
GeO2         0.041   %  ( 0.001)
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Figure 4: EDX Analysis of Tourmaline

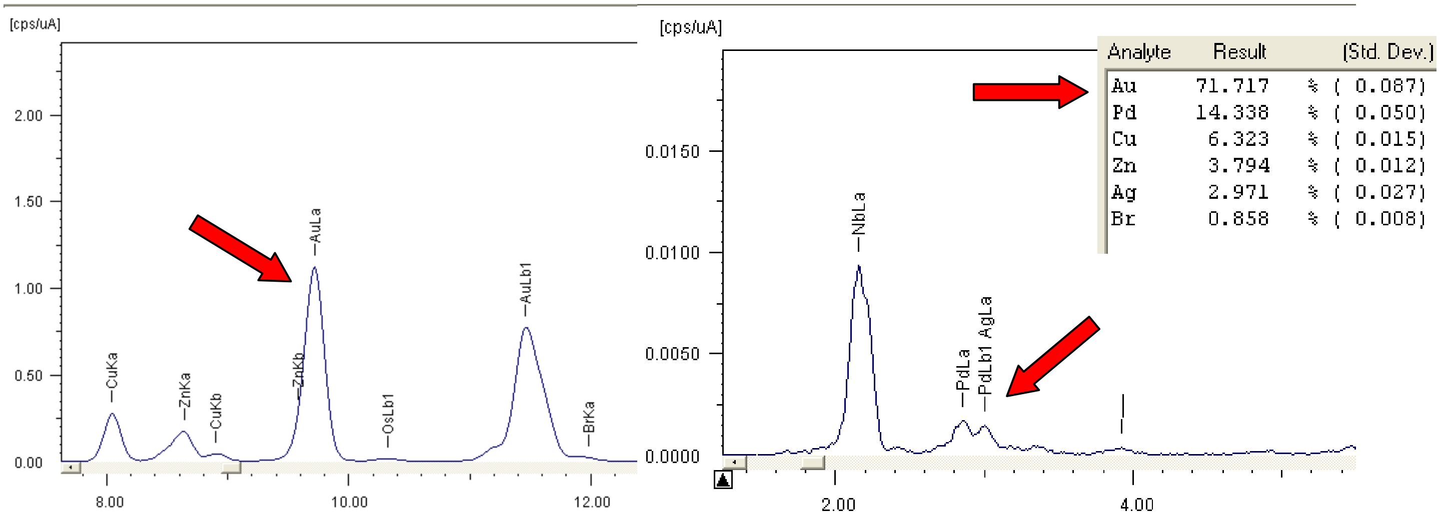
Buergerite	$NaFe^{3+}_3Al_6Si_6O_{18}(BO_3)_3O_3F$	Magnesiofoitite	$(Mg_2Al)Al_6Si_6O_{18}(BO_3)_3(OH)_4$
Chromdravite	$NaMg_3Cr_6Si_6O_{18}(BO_3)_3(OH)_4$	Olenite	$NaAl_3Al_6Si_6O_{18}(BO_3)_3O_3OH$
Dravite	$NaMg_3Al_6Si_6O_{18}(BO_3)_3(OH)_4$	Povondraite	$NaFe^{3+}_3(Fe^{3+}_4Mg_2)Si_6O_{18}(BO_3)_3(OH)_3O$
Elbaite	$Na(Li_{1.5},Al_{1.5})Al_6Si_6O_{18}(BO_3)_3(OH)_4$	Rossmanite	$(LiAl_2)Al_6Si_6O_{18}(BO_3)_3(OH)_4$
Feruvite	$CaFe^{2+}_3(MgAl_5)Si_6O_{18}(BO_3)_3(OH)_4$	Schorl	$NaFe^{2+}_3Al_6Si_6O_{18}(BO_3)_3(OH)_4$
Foitite	$(Fe^{2+}_2Al)Al_6Si_6O_{18}(BO_3)_3(OH)_4$	Uvite	$CaMg_3(MgAl_5)Si_6O_{18}(BO_3)_3(OH)_3F$
Liddicoatite	$Ca(Li_2Al)Al_6Si_6O_{18}(BO_3)_3(OH)_3F$	Vanadiumdravite	$NaMg_3V_6Si_6O_{18}(BO_3)_3(OH)_4$

Table 1: Recognized Minerals in Tourmaline

Precious metal purities can quickly and easily be identified using the quantification method on the EDX-720. The raw metal or piece of jewelry can be analyzed with zero sample prep. A gold (Symbol: Au) quantification analysis found a ring to contain 71.7% gold [Figure 5] with a 14% composition of Palladium (Symbol: Pd). Using the standard percentage of gold to alloy Karat chart [Table 2], the piece can be classified as an 18K gold ring. The quantification analysis of a 14K gold piece confirmed the grading with a gold percentage of 59.013% [Figure 6] along with a 20% composition of Copper (Symbol: Cu).

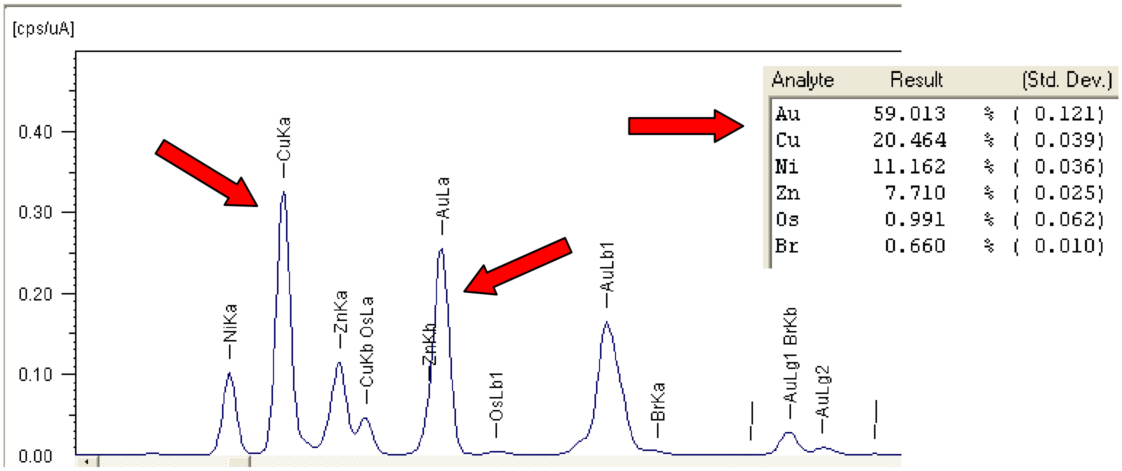
Karat	Parts Gold to Alloy	Percentage	Fineness
10K	10/24	41.67%	417
14K	14/24	58.33%	583
18K	18/24	75.00%	750
22K	22/24	91.66%	917

Table 2: Gold Karat Grading



Analyte	Result	(Std. Dev.)
Au	71.717 %	(0.087)
Pd	14.338 %	(0.050)
Cu	6.323 %	(0.015)
Zn	3.794 %	(0.012)
Ag	2.971 %	(0.027)
Br	0.858 %	(0.008)

Figure 5: EDX Analysis of 18K gold



Analyte	Result	(Std. Dev.)
Au	59.013 %	(0.121)
Cu	20.464 %	(0.039)
Ni	11.162 %	(0.036)
Zn	7.710 %	(0.025)
Os	0.991 %	(0.062)
Br	0.660 %	(0.010)

Figure 6: EDX Analysis of 14K gold

Conclusion

EDXRF is a rapid, non-destructive tool that can easily differentiate quality gemstones and precious metals from stones and metals that are counterfeit or have undergone chemical enhancements. This analysis can be used at any stage of the buying process, from raw materials to a finished product. EDX analysis leaves little room for deception by using both qualitative and quantitative functions that enable every compositional element from Sodium to Uranium to be found.

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