CHIMIA 49 (1995) Nr. 5 (Mai)

Conclusions

The characterisation of the 'red spots' has therefore confirmed gold's high resistance to corrosion, whereas silver has once again shown that, though it belongs to the well-known class of precious metals, in certain conditions it tends to modify its oxidization status. However, we can observe that the packaging material normally used as envelopes has no influence at all on the formation of the spots. Nor does the use of PVC, which could release free chlorine, determine the appearance of the defect; nevertheless its substitution is to be hoped for from an ecological point of view.

As for the presence of metallic silver on the surface of gold bars it seems obvious that the best solution is to adopt two completely separated working lines so as to avoid any crossover contamination. Thorough cleaning of the machines used could be an economic alternative, even if, in this case, it would be impossible to eliminate every kind of pollution.

Of course these procedures entail a considerable financial outlay on the part of the considered to be negligible, it is worth while evaluating carefully which is the most suitable way to be able to present to the customers a product without any imperfection from all points of view.

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Valcambi SA

Fiorenzo Arbini*

Profile

Valcambi SA was founded in 1961 and became a fully owned subsidiary of 'Credit Suisse Zürich' in 1980. The premises are located in Balerna, in the southern part of Switzerland. The company counts 230 employees.

Valcambi SA is active in the field of industrial processing of precious metals, namely gold, silver, platinum, and palladium. The company holds all the relevant Swiss licences issued by the Central Federal Office of Precious Metals control in Bern to exercise the trading, melting, and assaying of precious metals. Its operations are under the constant supervision of the abovementioned federal office. All analyses for the determination of the content of the various precious metals are carried out by certified assayers.

Valcambi SA figures on the 'Good Delivery List' for gold and silver and is one of the authorised smelters and assayers of the 'London Bullion Market' and 'London Silver Market'. *Valcambi SA* is also registered in the 'London-Zurich Good Delivery List' for platinum and palladium.

The company's main activities are the following:

- ***Refining of gold, silver, platinum, and palladium:*** material originating from mines or recycling is refined by electrolytic or chemical processes to precious metals with a high degree of fineness.
- ***Recycling:*** recovery of precious metals from scrap originating from the jewellery, dental, electronic, and galvanic industries.
- ***Semi-finished products:*** refined precious metals and their alloys in various compositions are processed to become semi-finished products for the jewellery, watch, and electronic industries.
- ***Dental alloys:*** under the registered trade name of '*Valcambi* Dental', a range of high grade dental alloys are produced and sold.
- ***Watch cases and bracelets in gold and platinum:*** because of the important technological development in this field, *Valcambi SA* has gained a fair share of the Swiss market in this production.
- ***Coins, medals, and ingots:*** legal tender coins of various alloys, standard bars of gold, silver, platinum, and palladium, ingots weighing from 1 to 1000 g are produced by the company.
- ***Laser jewellery in gold and platinum:*** The designer jewellery engraved and decorated with progressive laser technology at *Valcambi SA* was designated 'Best of 1992' in Italy. *Valcambi SA* cooperates in the Brite Euram II Project 5721 with research centres and industries in Germany, Belgium, and Italy. The purpose of this European project is to develop a new laser technology with specialised equipment which can largely satisfy the needs of the precious metals industry for advanced production systems.

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CH–6828 Balerna

Gold Alloys in Jewellery and in Watch Cases

For its beauty and durability, as well as for its long term value, *Gold* has been esteemed as a jewellery metal. Pure gold is easy to work, has a bright pleasing colour, remains tarnish free indefinitely and is non-allergenic and biocompatible, but its use for the manufacture of jewellery is rather limited by its softness. Especially watch cases are impossible to make due to the low mechanical properties. For this reason, it is common to improve the mechanical properties of pure gold by alloying it with other metals.

For centuries the most important gold alloys used in jewellery fabrication have been the coloured gold alloys based on the ternary Au–Ag–Cu system. The colours range from gold yellow to silver-white to copper-red, depending on the ratio of silver to copper. Additionally, zinc is commonly added to these alloys to deoxidize, lighten the colour, decrease the hardness and lower the melting point.

White gold alloys contain nickel or palladium as decolourisers, as well as small quantities of copper, silver or zinc to meet the various properties required by the jewellery and the user. At the beginning of the 20th century they were developed as a substitute for expensive platinum jewellery, but in the last years, the demand for white gold alloys has fallen in favour of coloured gold and platinum.

The proportion of precious metal in an alloy is officially expressed in terms of parts per thousand by weight of alloy. However, the older carat system for gold is still widely used, with one carat representing 1/24 of the total metal, so that 18 ct is equivalent to a fineness of 750 and 14 ct to a fineness of 585. The fineness levels of

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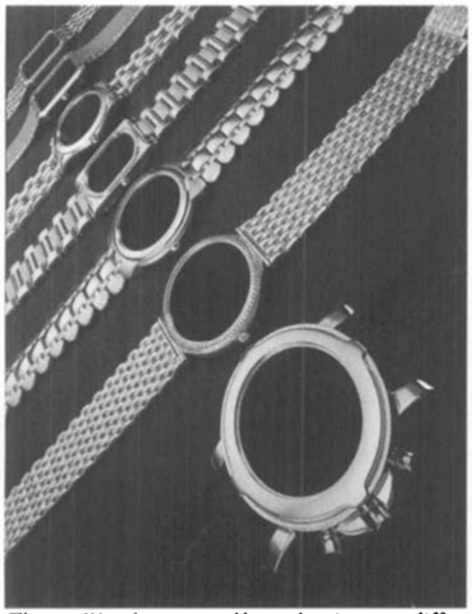

Figure. *Watch cases and bracelets in many different precious metal alloys*

916, 750, 585, and 375 (equivalent to 22, 18, 14, and 9 carat) are recommended by the International Organisation for Standardisation (ISO 9202 – Jewellery, Fineness of precious metal alloys). In most countries a definite number of grades of fineness is permitted by law. In Switzerland, the minimum fineness 916, 750, 585 are officially acknowledged.

To standardise colours and to obtain a reliable basis for visual comparison, the Swiss organisation Normes Industrielles de l'Horologerie Suisse has established a series of standard 18 and 14 ct gold alloys, the colours of which are designated by the numbers 1N (14 ct) 2N, 3N, 4N, and 5N (NIHS 03–50, 1961). DIN Organisation accepted these standards, but defined the colours independently of the material by using spectrographic methods to measure certain optical values; tone, saturation level and darkness. Furthermore, DIN has standardised two additional colours designated 0N (green-yellow) and 8N (white).

Gold-Titanium Alloy

Recently, an alloy of very high caratage, almost equal to fine gold (99% minimum) in its value and pleasant appearance, but with sufficiently improved hardness and wear resistance was developed for the production of jewellery. *Valcambi* applied its knowledge of the use of these alloys for the production of watch cases and jewellery. The composition of the alloy depends on the jewellery to be manufactured but the gold fineness level is minimum 99%. The solubility of Ti in gold falls from 1.2 wt.% at 800° to 0.4 wt.% at 400°. The alloy therefore becomes solutionized at 800° and on cooling from this temperature to 400° it hardens significantly, because of the relatively high volume of the compound $TiAu_4$ in which the titanium separates. Production of the alloy must be carried out in a vacuum in an induction furnace back filled to at least 1 torr with pure argon; suitable crucible materials are alumina and zirconia.

The gold is melted and heated to 1300° and a titanium block or rods (powder should not be used as the surface oxide-nitride layers makes them hard to dissolve) with purity at least 99.7% dropped into the melt; a flash of light accompanies the dissolution process. The molten alloy is then cast into a copper mould in the chamber and the casting cooled before air is introduced.

Titanium reacts with both oxygen and nitrogen at elevated temperatures, but the tarnish developed on the surface can be removed by dipping the casting into a 10% solution of potassium pyrosulfate ($K_2S_2O_7$) in water, drying, and then heating until the residual $K_2S_2O_7$ melts. A tarnish free alloy is obtained after quenching and washing off the residue in water.

Cold working increase the hardness of the alloy from a value of 75 HV to 110–120 HV following 40% cold working. Furthermore, a minimum of 50% cold work hardening should be effected. Not only does this give grain refinement, but it also allows greater hardness to be attained in subsequent age-hardening steps at lower temperature. For purpose of comparison, the 18 carat 3N alloy necessitates intermediate annealing steps when it is used for watch cases production; 990 gold-titanium does not require such annealing. However, the alloy can be solutionized by holding at 700° for 30 min and then cooling down as rapidly as possible in water.

Following watch cases production, hardening for 1 h at 500° gives the alloys a hardness of 160 HV. The hardest material (180 HV) is obtained after 100 h at 400°, but this is too long to be applicated in practice.

The *Table* allows comparison of the colours, compositions, hardness, yield strength and percentage elongation to fracture of pure gold, some standard 14, 18, and 22 ct alloys and 990 gold-titanium alloy in three starting states: cold worked (C), annealed (S), and hardened (H) (* = not hardened).

Table

Metal or alloy	Composition	Colour	Melting range	Hardness HV1			0.2% Yield Str. – MPa			Elongation [%]
			[°C]	C	S	H	C	S	H	S
Pure Gold	Au 999,9	Yellow	1063	80	30	*	220	37	*	43
990 Au-Ti	**Au990 Ti10**	**Yellow**	**1072**	**105**	**75**	**160**	**320**	**75**	**400**	**35**
22ct	Au917 Ag41 Cu41	Yellow	980–1000	160	75	*	470	110	*	42
18ct, 2N	Au750 Ag190 Cu60	Pale-Yellow	895–920	215	125	140	680	280	360	35
18ct, 3N	Au750 Ag125 Cu125	Yellow	885–900	230	145	230	630	330	620	40
18ct, 4N	Au750 Ag90 Cu160	Pink	880–895	245	140	215	760	330	700	40
18ct, 5N	Au750 Ag45 Cu205	Red	890–900	250	155	265	800	340	500	40
14ct, 1N	Au585 Ag260 Cu140	Pale-Yellow	830–845	275	145	250	750	370	700	30
14ct, 2N~	Au585 Ag200 Cu200	Pale-Yellow	825–835	300	160	255	940	470	690	38