MMTC-PAMP: Introduction of Master Alloy

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MMTC PAMP INDIA PVT. LTD.

29TH July 2022

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  - Properties of metal used for making master alloys
  - Major defects and remediation plan
  - Feedback from Customers related to Trees Casting
- Gold – Critical for good quality products

MMTC-PAMP India Pvt. Ltd. Introduction

A one-stop solution for Precious Metals

ONE-STOP SHOP FOR JEWELLERS

1 **Bullion**

Our products are tradable across the world and deliverable on global commodity exchanges

2 **Scrap Refining**

- 45 minute hassle free exchange of scrap metal
- Transparent process

3 **Minted Gold and Silver products**

Exquisite range of coins, bars, collectibles and customized products

4 **Master Alloys**

Developing a comprehensive range of master alloys to be used for the manufacture of jewellery.

PARTNERING WITH INDUSTRY

1 **Simplifying purchase of gold for consumers**

Gold accumulation plan

Enabling customers to purchase and accumulate gold for as low as Rs. 1. Anytime anywhere (365 days 24 x 7)

2 **Gold Monetisation scheme**

- Critical enabler of GMS ecosystem
- Refining and certifying purity for the customers
- Providing surety of quality as the only LBMA Good Delivery refinery in India

3 **Industrials**

- Separate business vertical
- Providing products and solutions for Industrial customers of precious metals

80 MN+
CUSTOMERS

16 TONNES
SCRAP

$12 Mn
INVESTMENT IN NEW PLANT

$1 Mn
PROFIT IN TRADING

12
RETAIL CENTRES

500+
EMPLOYEES

ANNUAL INSTALLED REFINING CAPACITY OF
300T
GOLD &
600T
SILVER

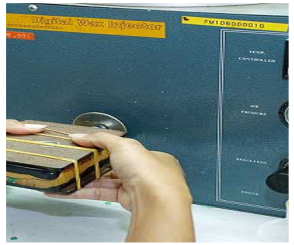
Jewellery Manufacturing – Casting - Handmade

Investment Casting or Lost Wax casting

Master Pattern

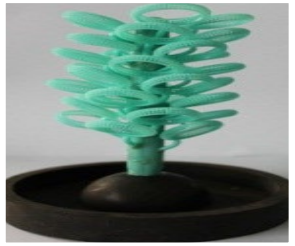
Vulcanization of rubber

Separating of rubber Mold

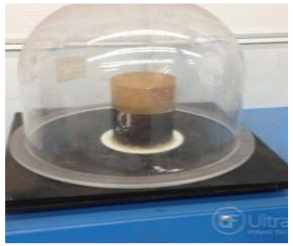


Wax Injecting

Wax Pattern

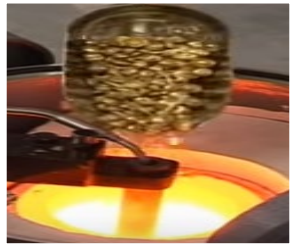


Wax Tree



Mold Filled with Investment

Burnout



Charging Gold + Master Alloy

Vacuum Casting

Disintegrating Investment Powder

Finishing

Investment Casting And Handmade Process

Investment Casting Process

1. Master Pattern
2. Vulcanization of Rubber
3. Separating of Rubber Mold
4. Wax injecting
5. Wax Pattern
6. Wax Tree
7. Mold Filling with Investment
8. Burnout
9. Charging Gold + Master Alloy
10. Vaccum Casting
11. Disintegrating Investment Powder
12. Finishing

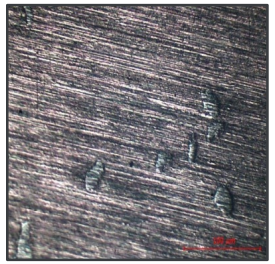
Major Casting Defect

1. Porosity

- Si & Zn Combination helps to reduce it
- Proper sprue location or its design can reduce it significantly

2. Hard spot

- Over use of Silicon and Zinc may lead to Hard Spot also
- Gold Should be free from Fe & Ir Group



3. Cracking

- High Si in Alloy causes Cracking
- Gold and Alloy should be Free From Pb, Se & Te

4. Rough Surface

- Si helps to improve fluidity during casting and reduces rough surface

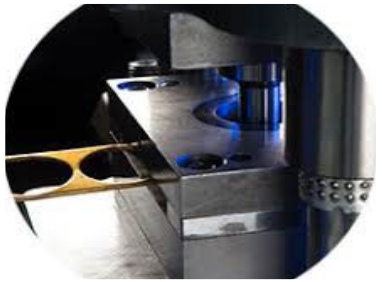
5. Oxide Inclusion

- Oxygen in metal can cause Copper Oxidation & lead to Inclusion
- Excess Zn in alloy can lead to inclusion

Handmade Manufacturing Process

Strip & Rod Casting

Wire Drawing and Strip Rolling



Stamping or Die cutting

Soldering

Setting

Finishing

Investment Casting And Handmade Process

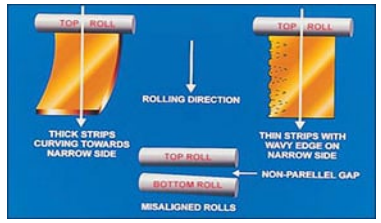
Handmade Process

1. Charging Gold+Master Alloy
2. Strip & Rod Casting
3. Wire Drawing & Strip Rolling
4. Stamping or Die Cutting
5. Soldering
6. Setting
7. Finishing

Major Handmade Defect

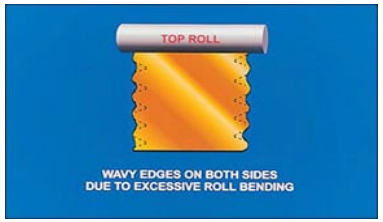
1. Roll Misalignment

- Machine Adjustment



2. Roll bending

- Machine Adjustment

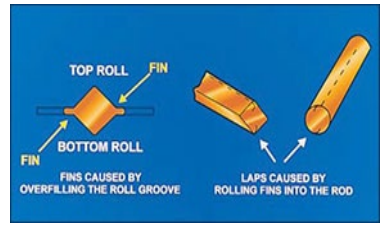


3. Edge cracking

- Higher Oxygen in metal
- Higher Casting temp.
- Si, Pb , Te & Se Should be Zero

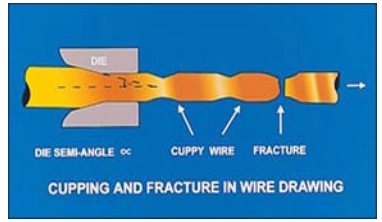
4. Fins and laps

- Improper Metal feeding



5. Drawing

- Improper annealing
- Boron as grain refiner

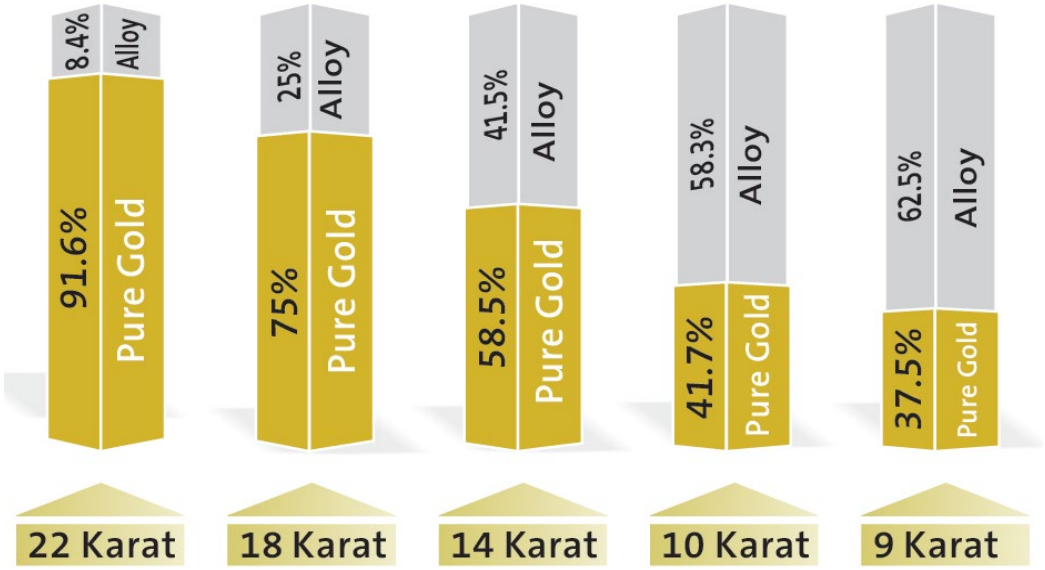


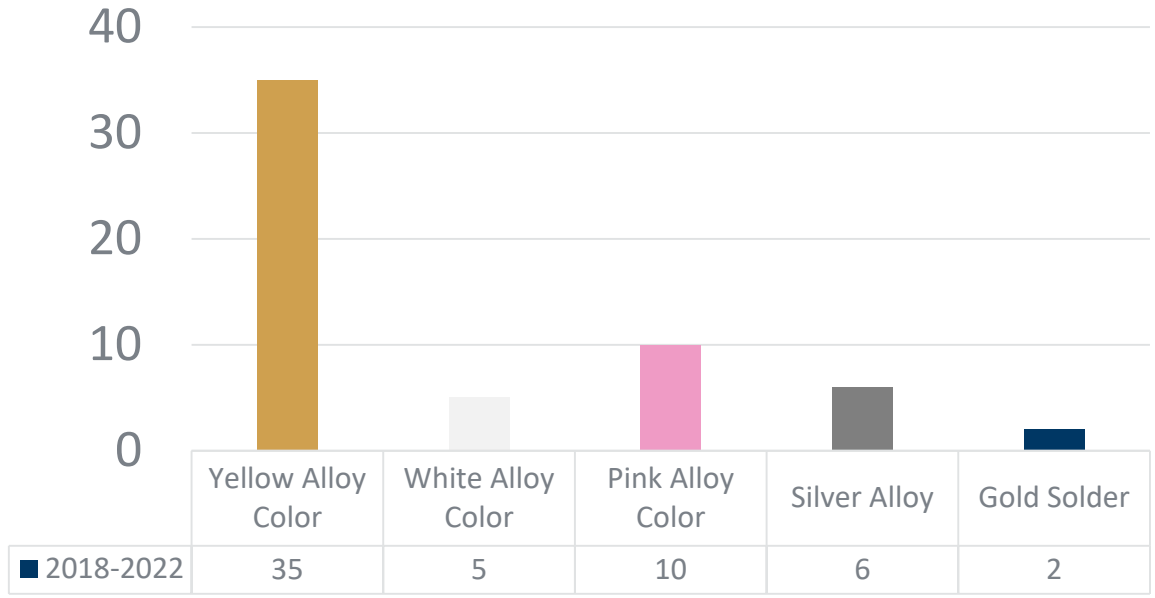
Master Alloy

What is Master Alloy

- Traditionally Jewelry is manufactured by casting in open / closed (Inert) system or handcrafting using strips or rods.
- In all the above operation, 24 karat Gold is converted to lower karatage i.e. 22kt, 18kt , 14kt , 10kt & 9kt by addition of elements like silver , copper, Zinc , other metals in small quantity which act as deoxidizer and grain refiner in the alloy. The alloyed metal used is known as **Master Alloy.**
- Master Alloys are available to produce gold of variety colors e.g. Yellow Gold , White Gold , Rose Gold , Green gold etc.

Gold Karat System





Range of Master Alloy in MMTC-PAMP

9K-22K YELLOW GOLD CASTING ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY001	Rich Yellow	9-14K	Casting	23.00	Good Luster, High Reusability
SWY014	Bright Yellow	9-22K	All purpose	11.50	Economical, Good Shine
SWY040	Std. Yellow	9-22K	All purpose	13.00	Good Luster, Good Workability
SWY037	Rich Yellow	9-18K	Mechanical	19.75	High Performance, Good Shine

14K-18K YELLOW GOLD CASTING ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY002	Yellow	14K	Casting	20.50	Good Luster & Reusability
SWY002	Rich Yellow	18K	Casting	20.50	Good Luster & Reusability

18K YELLOW GOLD CASTING & MECHANICAL ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY003	Deep Yellow	18K	Casting	44.50	High Performance & Luster
SWY034	Deep Yellow	18K	Casting	47.00	Reusability, Good Shine
SWY039	Rich Yellow	18K	Casting	51.00	Excellent Workability & Shine,
SWY007	Std. Yellow	18K	Mechanical	33.00	Recom. for Bangels, Good Shine

18K -22K YELLOW GOLD CASTING & MECHANICAL ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY023	Yellow	18K	Casting	26.00	Good Luster, Good Fluidity
	Deep Yellow	22K	Casting	26.00	Good Luster, Good Fluidity
SWY023A	Yellow	18K	Casting	26.00	High Performance, Low Loss
	Deep Yellow	22K	Casting	26.00	High Performance, Low Loss
SWY028	Greenish Yellow	18K	Casting	65.10	Resuability, Tarnish Resistant
	Greenish Yellow	22K	Casting	65.10	Resuability, Tarnish Resistant
SWY029	Greenish Yellow	18K	Casting	64.00	Hard with good surface luster
	Greenish Yellow	22K	Casting	64.00	Hard with good surface luster
SWY031	Reddish Yellow	18K	Casting	17.00	Economical , High Reusability
	Reddish Yellow	22K	Casting	17.00	Economical , High Reusability
SWY033B	Light Yellow	18K	Casting	2.00	Good shine, Economical
	Deep Yellow	22K	Casting	2.00	Good shine, Economical
SWY009	Reddish Yellow	18K	Mechanical	16.00	Economical, Good Shine
	Reddish Yellow	22K	Mechanical	16.00	Economical, Good Shine
SWY019	Yellow	18K	Mechanical	20.00	High Performance, Good Shine
	Rich Yellow	22K	Mechanical	20.00	High Performance, Good Shine
SWY004	Yellow	18K	All purpose	39.00	High Performance & Reusability
	Deep Yellow	22K	All purpose	39.00	High Performance & Reusability
SWY004B	Yellow	18K	All purpose	39.00	High Performance, Low Loss
	Deep Yellow	22K	All purpose	39.00	High Performance, Low Loss

22K YELLOW GOLD CASTING & MECHANICAL ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY005	Deep Yellow	22K	Casting	34.00	Good Performance & Reusability

22K YELLOW GOLD CASTING & MECHANICAL ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWY013	Reddish Yellow	22K	Casting	8.50	Good for Filigiri Work & Shine
SWY027	Rich Yellow	22K	Casting	6.10	Hard alloy, Good Shine
SWY033	Reddish Yellow	22K	Casting	2.00	Low Silver, High Fluidity
SWY006	Deep Yellow	22K	Mechanical	40.00	Good Luster, High Reusability
SWY015	Reddish Yellow	22K	Mechanical	4.00	Economical, Good for Stamping
SWY016	Reddish Yellow	22K	All purpose	10.00	Hard, High Surface Luster
SWY018	Rich Yellow	22K	Mechanical	18.00	Good for Stamping ,Wire
SWY017	Reddish Yellow	22K	All purpose	5.00	Good for Stamping, Strip & Wire

14K-18K WHITE GOLD CASTING & MECHANICAL ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWW001	Std. White	18K	Casting	4.00	High Fluidity, Stone-in-Place
SWW002	Std. White	14K	Casting	15.00	Stone-in-Place, Good Whiteness
SWW003	Off-White	14-18K	Casting	10.00	Low Nickel, High Reusability

9K-18K WHITE GOLD CASTING ALLOY

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWW006	Std. White	9-18K	Casting	1.00	Low silver, Soft Workability

9K-21K PINK GOLD CASTING & MECHANICAL

CODE	COLOR	KT*	APPLICATION	Ag%	SPECIAL COMMENTS
SWP013	Deep Pink	18K	All purpose	4.15	High Reusability & Workability
SWP003	Pink	9-14K	Casting	9.00	Medium Silver, User Friendly
SWP004	Light Pink	9-14K	Casting	15.00	High Silver, Low De-ox
SWP005	Pink	9-14K	Casting	6.50	Suitable for Stone in Place
SWP005B	Light Pink	9-18K	Casting	6.50	High Reusability & Workability
SWP001	Deep Pink	9-14K	All purpose	4.50	Excellent Workability, Low Silver
SWP002	Pink	9-14K	All purpose	6.00	Low Silver, European 5N Color
SWP011	Light Pink	18-21K	All purpose	18.00	Good for Sheet, Wire, High Silver
SWP012	Pink	9-14K	Casting	10.00	User Friendly, Good Reusability
SWP012B	Pink	9-18K	Casting	10.00	Good Workability & Reusability

925" STERLING SILVER ALLOY

CODE	COLOR	PURITY**	APPLICATION	Cu%	SPECIAL COMMENTS
SWS001	Ultra White	925	Casting	61.00	Tarnish Resistant, High De-ox
SWS002	White	925	Casting	67.00	Economical , High Fluidity
SWS003	White	925	Mechanical	92.00	Tarnish Resistant, Good De-ox
SWS004	White	925	Mechanical	93.00	Spring Hard Alloy, Anti Tarnish
SWS005	White	925	Casting	76.00	High Performance & Reusability
SWS007	Super White	925	All Purpose	63.00	High Fluidity & Anti Tarnish, De-ox

MASTER ALLOY

Alloys for Yellow, Pink & White Gold Alloy for Sterling Silver

Application: Gold and Silver Jewellery

Properties: Usage of 999.9+ Silver in alloy reduces casting issue and metal loss.

SILVER ANODE

Min. 999+ Silver Purity

Dimension: Length Max. 600 mm
Width 15 -150 mm
Thickness 1.5-6.0 mm

Application: Electroplating

Properties: Uniform Plating,Con-forms to IS Specs[B413-97a(2017)]

SILVER POWDER

Min. 999.9+ Silver Purity

Dimension: upto 50 Micron Size

Application: Electrical Contact,Solar Paste,Medicines, Plating

Properties: Consistent Quality,High Flowability,Increased Conductivity

STRIPS, WIRES & RODS

Gold: 1. Fine Gold-Min. 999+ Purity
2. Alloyed Gold-9K to 22K Karat
Silver : 1. Fine Silver-Min. 999.9+ Purity
2. Alloyed Silver-Sterling (Min. 93% Purity)

Application: Jewellery,Findings , Accessories

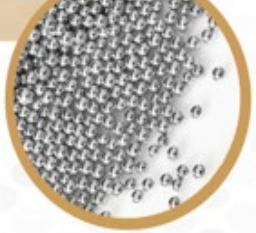
Properties: Uniform Color

SILVER GRAINS

Min. 999.9+ Silver Purity

Application: Jewellery,Bullion

Properties: Uniform Size, Zero Oxidation & Impurity Content as per ASTM[B413-97a(2017)]



Master Alloy Mgf. processes controls bring added advantage to your products

OUR PROCESS

- Manufactured using **99999 Silver** and **premium quality raw material**
- Produced in strictly controlled environment, giving alloy free of **lead, cadmium, or any other noxious elements**
- Stringent quality control parameters

YOUR ADVANTAGE

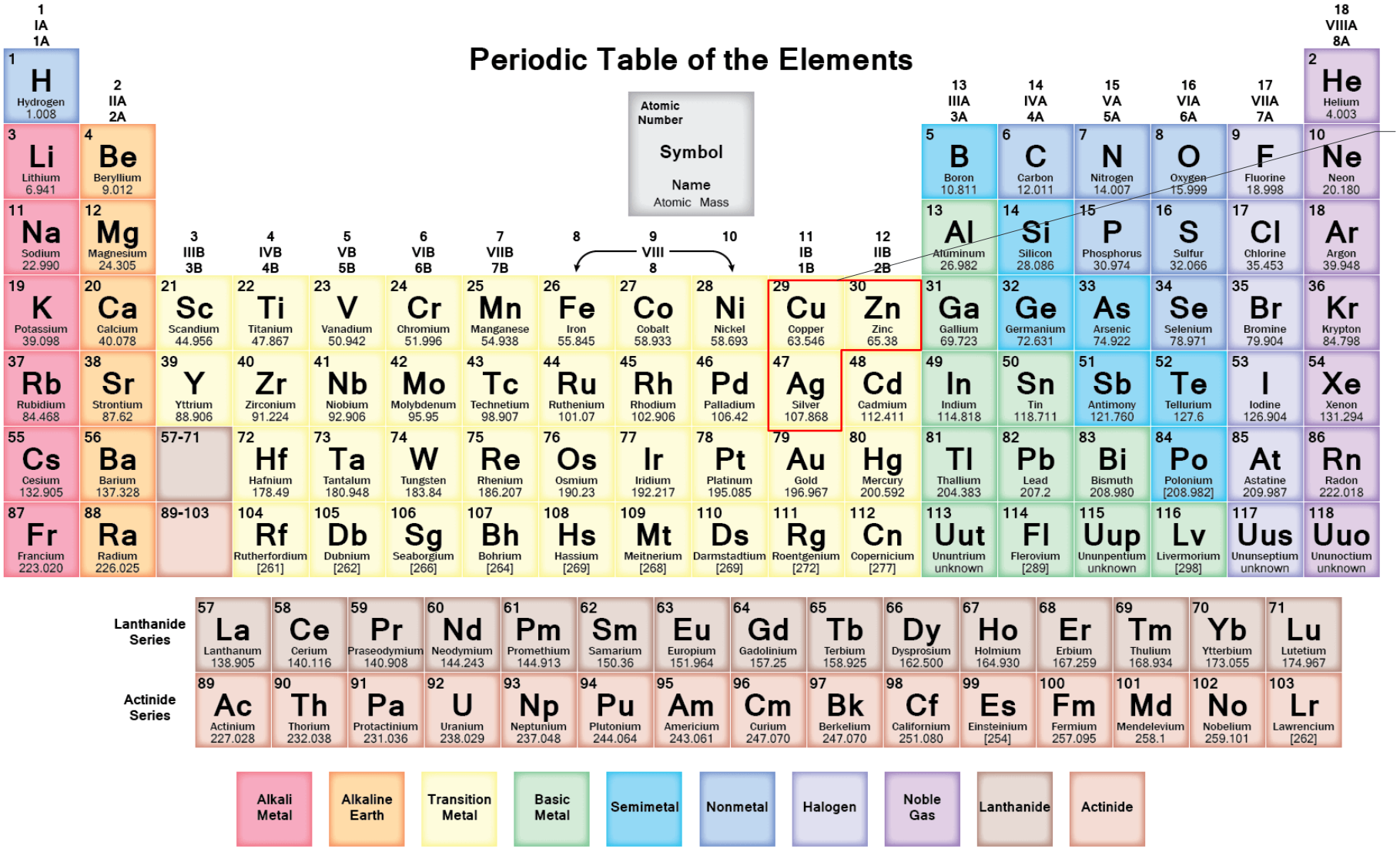
Attain

- High Productivity
- Good luster
- Homogeneity
- Less tarnish
- Minimum gold loss
- Good Hardness & toughness in 22K casting and handmade products

Access 24x7 technical assistance to ascertain and eliminate any issues

Engage continuously with experienced metallurgists and laboratory chemists to develop new products and solutions

Ingredient and properties of ingredient



Elements Role in Alloy

Ag	Silver - provides lustre & used to control the color for a desired appearance
Cu	Copper - increases hardness of the pure gold while still making it ductile for casting. Copper tends to turn gold color pink
Zn	Zinc -Provides more fluidity of the melt , improves cast-ability; It improves tensile strength and improves color too
Si	Silicon-Increases the fluidity of the melt. It decreases the sensitivity that gold alloy has towards oxygen.
Ge	Germanium - acts as an effective de-oxidizer
Ni	Nickel a- bleaching agent and turns yellow gold into white appearance
B	Boron - deoxidiser and perhaps acts as grain refiner too via dispersion hardening
Co	Cobalt - grain refiner which increases hardness due to its dispersion effect
In	Indium - Increases fluidity and ductility ;lowers melting temperature
Ga	Gallium –has hardening effect

General Casting Issue:

General Casting Issue	
Types of Defects	Reason **Contribution of Alloy composition**
Gas Porosity	•Deoxidizer like Silicon in presence of Zinc produces a reciprocating effect to reduce mold-metal interface reaction time during casting by reducing surface tension. •This reduces gas porosity caused by Sulphur dioxide from investment powder $CaSO4 \rightarrow CaO + SO2 + ½O2$; but the balance of Si, Zn in the alloy content is an important criterion else it can lead to inclusion issues. • The other major contributor to gas porosity is unburnt carbon from poor burnout; In alloys with Nickel, it can lead to aggravated gas porosity
Shrinkage Porosity	•Alloys with high Nickel or Cobalt require higher casting temperature which may attribute to this defect •Flask and casting temperature combination needs to be optimized to avoid this •Proper sprue location or its design can reduce it significantly
Inclusion as Hard spots	•Oxygen in used copper and silver may lead to complex Silver copper oxide which will form hard spots •Over use of Silicon and Zinc may lead to oxide too •If Iridium is present in alloy as grain refiner , it may lead to hard spots if the melt is not homogenized at recommended temperature .

General Casting Issue:

General Casting Issue	
Types of Defects	**Reason** **Contribution of Alloy composition**
Oxide Inclusion	•The copper used in alloy making should be oxygen free and the oxygen content should be less than 10 ppm. •Moreover, the silver used in alloy should have oxygen less than 50 ppm to avoid oxide formation in casting stage. Oxygen in silver leads to copper oxide inclusions, mostly as a silver/copper oxide eutectic. •Following may happen due to this: - a. The inclusions cause hard spots as found during polishing b. Gas pores are created due to unstable oxide dissociation at solidification. c. Bubbles and pores are formed when copper oxide containing silver is annealed in a reducing atmosphere
Cracking	•Imbalance between Cu : Si ratio can lead to Si segregation at grain boundary; • leading to cracking during casting; so the addition of Si is crucial and specially in which form is it added •Use of Iridium in alloys can form clusters leading to cracking during mechanical work
Roughness and oxidation	•Small zinc additions in alloy reduce the reaction with the investment and, in this way, reduce gas porosity too. Probably, the formation of a dense layer of zinc oxide at the surface of the solidifying melt prevents the interaction of the melt with the investment •This reduces surface roughness and may help in reducing gold loss during pre-polish . •The Jewellery surface is more lustrous and free from surface oxidation

Customer case study

Customer	I	2	3
Jewelry Manufactured	Studded 14k & 18k casting (diamonds)	CNC bangles 22K	93 Sterling Silver
Previously Using Alloy	Competitor	Copper and silver	Competitor
MMTC-PAMP Alloy used	SWY002 & SWY004	SWY017B	SWS002
Problem Faced	Microporosity	Low Lustre, Hardness in bangle	Low Hardness & low Reusability
Solution	In first interaction changed sprue loaction and design	In first interaction, we studied his requirements of hardness & lustre	In first interaction, we understood his requirement of hardness & reusability; did hardness testing of present sample under Vickers .
	Developed SWY002 with Si as Deoxidiser and with Silver content to meet his price expectation; colour was not acceptable	Developed SWY017B with cobalt and boron for grain refining and deoxidising; silver was kept low in order to meet his price expectation;	Developed SWS002 with higher hardness ;yet there was issue in reusability such as cracking
	Changed Copper silver ratio within same price range and supplied new sample	Hardness was still required	Increased Silicon solubility by adjusting Copper Silicon ratio to reduce cracking and increased Zinc slightly to compensate for oxidation
	wanted more lustre; added Germanium and submitted new sample within two working days	We changed the copper content in order to increase solid solution hardening and supplied new sample in 3 working days	Formulation was acceptable with customer
	The formulation was successful and now commercial conversion to 10kgs per month	Acceptable for customer ; commercial conversion to 10kgs per month	commercial conversion to 90-100kgs per month

What are the disadvantages of Locally refined Gold

Impurities leading to poor finish and higher rejection

Chemical method if not controlled will add impurities to the Metal

Element	MMTC-PAMP Bullion			Indian Refiners			
	999.9 (Sponge)	999 (Conversion)	995 (Conversion)	Refiner 1	Refiner 2	Refiner 3	Refiner 4
Gold (Au) ‰	999.96	999.08	995.08	994.92	995.05	995.05	995.00
Silver (Ag) **(ppm)**	29	900	4903	4747.6	4791	4584	4872
Palladium (Pd)					5	38	35.5
Platinum (Pt)						11	
Aluminium (Al)					2		
Antimony (Sb)				5.5			
Arsenic (As)				6			
Copper (Cu)	11.6	14.9	13.2	161.4	98	40	14
Iron (Fe)				42	15		27
Lead (Pb)						11.5	42
Manganese (Mn)						2	
Silicon (Si)					3	4	
Tin (Sn)				89.5	15		5.8
Tellurium (Te)					5	14	3.7
Zinc (Zn)				20.8			

PRODUCT COMPARISON

WE STAND OUT

MMTC PAMP ALLOY

18 Y Cast tree with MMTC -PAMP gold free from impurities

Smooth, oxidation free 18 K pink gold strip casted with MMTC-PAMP gold having no impurity

LOCAL ALLOY

Poor 18 Y tree casted using locally refined gold with high impurity

18 K Strip with local gold having oxidized surface finish due to high impurity content

PRODUCT COMPARISON

WE STAND OUT

MMTC PAMP ALLOY

22 K Finished ring from MMTC-PAMP gold having high lustre and finish

Bullion bar with MMTC-PAMP gold

LOCAL ALLOY

22 K ring from local gold having broken shank due to impurities

Slags on bullion bar with local gold

Feedback from Customers related to Trees Casting

Casting Tree From MMTC-PAMP Gold & Alloy

Casting Tree From Local Gold

Casting Tree photos Shared by Customer Using MMTC-PAMP Alloy

SWY001-14K

SWY004-22K

SWY003-18K

SWY034-18K

SWY014-22K

THANK YOU