Lab-grown YAG - the new simulant for diamond and precious stones

Introduction –

- **‘LifeGem Diamonds Limited’ is pleased to introduce cut & polished gemstones made from the second generation mono-crystal optic YAG (Yttrium Aluminium Garnet), sourced from Europe.**

- **YAG is a much better simulant for diamond and for precious stones, due to its high hardness and transparency. It has a strong dispersion with brilliant diamond-like shining. YAG has a cubic structure of natural garnet.**

- **YAG is a man-made gemstone that has been around for more than 50 years now. The first generation YAG used mineral oxides such as chromium, titanium, manganese, iron, etc., for coloring. The second generation YAG is doped with rare earth elements, with brilliant colours. It is lab-created in a large factory in Europe using advanced equipments, which takes more than 1 month to grow.**

- **It took the European manufacturer 40 years to develop the technology of doping permanent rare earth colours into YAG, which is only one of its kind in the entire world.**

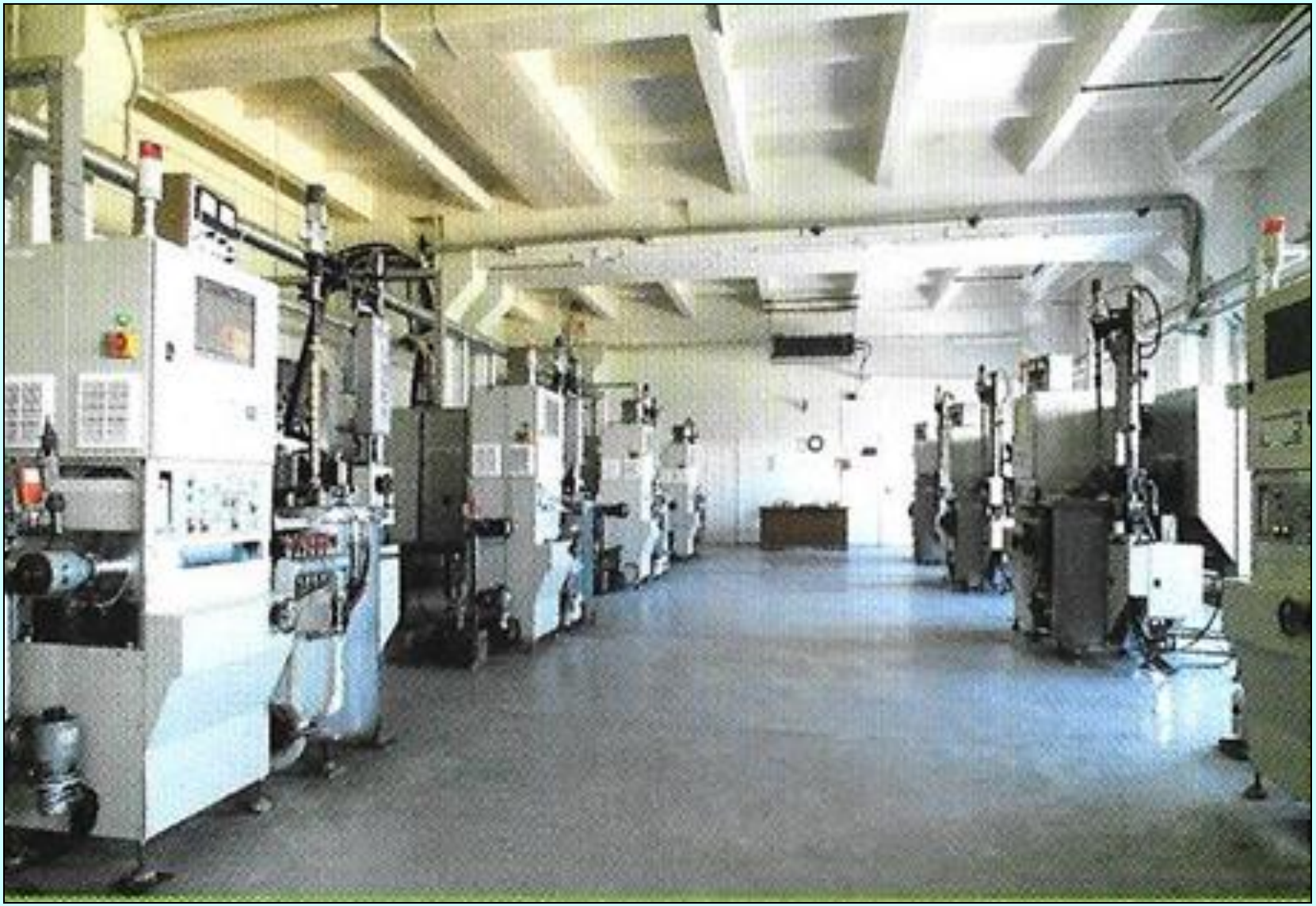
- **The European YAG is grown and cooled in a low-stress environment, with highly controlled thermal-gradient. Hence, the gemstones have high optical quality and high purity. They are unique and defect-free.**

YAG - a lab-grown semi-precious gemstone -

- **Yttrium aluminum garnets (YAG) are the structural analogues of expensive natural garnets, but excel them in hardness, transparency and dimension of flawless zone. They cut and polish like natural garnets and are quite pretty.**

- **The mechanical and chemical stability of YAG is similar to that of sapphire. YAG is not birefringent and this particular feature is important for natural appearance.**

- **YAG is stable and resistant to acids and alkalis, as well as UV rays, hot water, perfumes, etc. Due to its high hardness, it is scratch-proof and meant for daily wear. Its faceted surface does not chip out during the rough use. YAG's useful life is 50-100 years.**



Growing YAG in the most modern factory

YAG in different colours

YAG – a diamond simulant –

- **Due to strong dispersion, YAG crystals create a diamond play-of-color. They are colorless when grown without additives, but doping with rare earth elements is enough to give them a wide spectrum of colors, including vibrant hues.**

- **For instance, when doped with neodymium or erbium, they get pink or purple shades; and when doped with cerium, they get yellow shades.**

- **YAG has a great clarity, brilliance, luster and sparkle; it is flawless with no visible inclusions, blemishes or scratches. It has a bright luster approaching that of a diamond (sub-adamantine luster). Due to its high hardness, YAG takes excellent polish, displays some fire and is regarded as a man-made diamond simulant.**

- **YAG is also a perfect simulant for precious gemstones like Emerald, Ruby and Sapphire.**

Comparative table for physical and optical properties of YAG, with other jewellery materials –

Parameters	Cubic zirconia*	European YAG	Diamond	Emerald	Ruby & Sapphire
Description	Artificial, & obtained on a large-scale by skull melting process, prone to abrasion and scratches	Lab-grown semi-precious stone, highly resistant to abrasion and scratches	Mined or lab-grown, precious, abrasion-proof and scratch-proof	Precious stone	Precious stones
Mineral	Zirconium oxide	Yttrium Aluminium Garnet	Carbon	Beryl	Corundum

Parameters	Cubic zirconia*	European YAG	Diamond	Emerald	Ruby & Sapphire
Chemical formula	ZrO_2 +10-35%Y_2O_3	$Y_3Al_5O_{12}$	C	$Be_3Al_2(SiO_3)6$	Al_2O_3:Cr
Moh's hardness	7.5-8.0	8.5	10.0	8.0	9.0
Absolute hardness	150-200	300	1,600	200	400
Specific gravity (density in grams / cm^3)	6.0 (heavy and unsuitable for light-weight jewellery)	4.55	3.52	2.63 – 2.75	3.97-4.05
Dispersion (light- effects or fire)	0.060 (shines too much and looks cheap)	0.028 (shines similar to diamond)	0.044	0.014	0.018

Parameters	Cubic zirconia*	European YAG	Diamond	Emerald	Ruby & Sapphire
Refractive index (sparkle or brilliance)	2.09-2.18	1.83	2.42	1.56-1.60	1.76-1.78
Heat resistance (when wax casting with metals at above 800^0C)	No (the colour changes, leading to the destruction of stone)	Yes (heat resistant up to $1,400^0$C & melting temperature $1,950^0$C)	No	No	Yes
Birefringence** (clarity) ($N_0 - N_e$)	0.430-0.500 (very high)	Absent	Absent	0.004-0.007 (slight)	0.008 (slight)

*** Cubic Zirconia (CZ) is the most popular material for simulated gem stones, as it has high refractive index, good hardness & wide colour scale. It is also very cheap. But, over the years, CZ became 'boring' to the customers. More and more people now consider it to be bad for its unnatural gloss (as Europeans say it 'impudently shines'). Now-a-days, CZ is regarded as a costume gemstone, meant for single use.**

**** Birefringence or double refraction is the difference between high and low refractive indexes in gemstones. Diamond is well-known as singly refractive, and very few gemstones including**

YAG have this property. Gemstones with high birefringence display two or three colours, depending on the viewing angle. They have the effects of fuzzy, out-of-focus appearance, creating a blurred double vision effect (if the stone is faceted, the facets on the opposite side of the viewer will appear to be doubled). Most plastics also have birefringence effects.

Images showing birefringence in cubic zirconia

- **For jewellery applications, we offer cut & polished YAG in 10 colours and shades, in the size range from 0.15 carat (3 mm), up to 40 carats (20 mm). The available colours are –**

➢ Blue	➢ Yellow
➢ Dark green	➢ Amber
➢ Light green	➢ White
➢ Pink	➢ Topaz Sky blue
➢ Beige	➢ Topaz Swiss blue

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Classification of Gems & Jewelry ornamental stones

Classification	Gems				
Hardness Classification	I order				
Name of the material	Diamond	Moissanite	Sapphire / Ruby	Alexandrite	YAG
Chemical formula	C	SiC	Al_2O_3	$Al_2B_eO_4$	$Y_3Al_5O_{12}$
Mohs hardness	10.0	9.5	9.0	8.5	8.5
Material density,g/cm^3	3.47-3.55	3.21	3.95-4.00	3.50-3.84	4.56
Refractive index	2.417-2.419	2.654-2.967	1.766-1.774	1.744-1.758	1.833
Dispersion	0.044	0.104	0.018	0.015	0.028
Birefringence	No	Yes	Yes	Yes	No
Resistance, temperature>800^{0}C	No	Yes	Yes	Yes	Yes

Classification	Gems					
Hardness Classification	II order					
Name of the material	Spinel	Topaz	Emerald / Aquamarine	Tourmaline	Zircon	Fianit
Chemical formula	$MgAl_2O_4$	$Al_2[SiO_4](f,OH)_2$	$Be_3Al_2Si_6O_{18}$	$Na(Li,Al)_3Al_6[(OH)_4](BO_3)3Si_6O_{18}$	$ZrSiO_4$	ZrO_2
Mohs hardness	8.0	8.0	8.0	7.5	7.5	7.5
Material density,g/cm^3	3.57-3.72	3.49-3.57	2.67-2.71	3.02-3.26	4.60-4.70	6.5-10
Refractive index	1.71-1.76	1.606-1.638	1.577-1.583	1.61-1.652	1.81-2.024	2.15-2.25
Dispersion	0.026	0.014	0.014	0.017	0.039	0.06
Birefringence	No	Yes	Yes	Yes	Yes	Yes
Resistance, temperature>800^{0}C	No	No	No	No	No	No

Classification	Gems		
Hardness Classification	III order		
Name of the material	Amethyst	Citrine	Garnet
Chemical formula	SiO_2	SiO_2	(R^2+)3 (R^3+)2 $[SiO_4]3$
Mohs hardness	7.0	7.0	7.0
Material density,g/cm^3	2.36-2.65	2.65	3.47-3.83
Refractive index	1.543-1.554	1.544	1.73-1.90
Dispersion	0.013	0.013	0.022
Birefringence	Yes	Yes	Yes
Resistance, temperature>800^{0}C	No	No	No

Classification	Jewelry-ornamental stones				
Hardness Classification	I order			II order	
Name of the material	OTC	Rhinestone	Swarovski stones	Quartz	Agate
Chemical formula	SiO_2:Al_2O_3	SiO_2	SiO_2	SiO_2	SiO_2
Mohs hardness	7.0	7.0	7.0	7.0	6.5
Material density, g/cm^3	3.2-3.4	2.6	2.6	2.6	2.6
Refractive index	1.65-1.70	1.544	1.544	1.544	1.544
Dispersion	0.015	0.013	0.013	0.013	0.013
Birefringence	Yes	Yes	Yes	Yes	Yes
Resistance, Temperature > 800^0C	Yes	No	No	No	No