Formica-made nanogems:

The major alternative to the coloured synthetic crystals and glasses in jewellery

By K. Avakyan, Phd (Geology)
CEO, FORMICA Ltd (Moscow, Russia) and Rough Synthetic Stones Co Ltd (Thailand)

There are about 3,000 known natural minerals on Earth. In contrast, man-made or synthesised (synthetic and created) minerals grown in laboratory or factory conditions numbered only a few hundred. Most synthetic materials do not have natural analogs, but their unique properties were specifically designed for use in optics, electronics and other areas of technology. Only some of them do have essentially the same properties as natural minerals. Both types are successfully used as substitutes to simulate natural gems, but only 20 to 30 of them are important in fine and fashion jewellery.

1. SYNTHETIC CRYSTALS AND MATERIALS. Since high quality natural gemstones are rare and expensive, synthetic gemstones imitating the optical appearance as well as physical and chemical properties of their natural analogs offer jewellers an appreciated alternative. Commonly used synthetic gemstones include moissanite, hydrothermally grown emerald, amethyst, citrine or smokey quartz, as well as alexandrite, spinels and corundums grown either by Czochralski's (pulled) or Verneuil's (flame fusion) methods.

Some laboratory-made gemstones, called simulants, appear very much as natural gems, but their physical and chemical properties are quite different; many of these materials do not have natural analogs. The most widely accepted and implemented simulant worldwide is Cubic Zirconia (CZ), one of the best diamond substitutes. The global production of white (colourless) CZ alone exceeds 200 tonnes per month. Other well-known simulants are Yttrium-Aluminium Garnet (YAG) and Gadolinium-Gallium Garnet (GGG) and others.

One of the divisions of the FORMICA Group of Companies (main office in Moscow, Russia), located in Thailand, are manufacturing Special Colour CZ imitating coloured diamonds (Chocolate-Brown, Blue, Ice-Blue, Pink, Peach, Canary, Apple-Green) as well as other gems (Emerald, Sapphire, Tanzanite, Blue Topaz, Aquamarine, Colour-Change, Peridot). It is well-established that the major problem in the production of CZ and many other synthetic crystals is the unevenness of colours. The manufacturing process of these materials does not allow for

1. Nano Emerald; 2. Nano Sapphire; 3. Nano Peridot; 4. Nano Garnet; 5. Nano Swiss Blue; 6. Nano Citrine

Table 1: Refractive Index (RI) and Specific Gravity (SG) comparison of Formica Nanogems (hardness is 7-7.5) with natural counterparts

Formica Nanogems	RI	SG (g/cm3)	Natural Gemstone	RI	SG (g/cm3)	Hardness
Nano Emerald	1.62-1.63	3.02-3.09	Emerald	1.577-1.590	2.720	7.5-8.0
Nano Sapphire	1.61-1.62	3.07-3.15	Sapphire	1.762-1.770	4.000	9
Nano Blue Topaz	1.620	3.07-3.08	Topaz	1.619-1.627	3.530	8
Nano Peridot	1.622	3.110	Peridot	1.654-1.690	3.340	6.5-7.0
Nano Garnet	1.63-1.64	3.11-3.14	Garnet	1.700-1.890	7.0-7.5	7.0-7.5
Nano Citrine	1.61-1.63	3.00-3.07	Quartz	1.544-1.553	2.660	7
Nano Smokey	1.622	3.060	Quartz	1.544-1.553	2.660	7
Nano Spinel Pink	1.618	3.050	Spinel	1.712-1.725	3.600	8
Nano Spinel Blue	1.628	3.140	Spinel	1.712-1.725	3.600	8
Nano Spinel Black	1.625	3.000	Spinel	1.712-1.725	3.600	8

Full catalogue of all produced colours, shades and varieties (transparent, translucent and opaque) can be found in Table 2.

maintaining uniform dispersion of the additives in the melt (or solution) which could result in slight variations of pigment concentrations in the batch and, therefore, variations in colour shades when the melt starts to crystallize. The most common materials with unevenness of colour are Green, Blue and Brown CZ, synthetic Blue Sapphire, as well as Green and Blue YAG.

Developing a high-quality product for mass-production jewellery requires significant effort in order to consistently produce materials within a narrow range of colours. This, undoubtedly, impacts manufacturing costs due to a lower yield from a starting batch and careful colour selection processes. Therefore, companies that produce synthetic stones for jewellery are looking for viable alternative materials.

2. GLASSES. In fine and low-cost fashion jewellery, the facetted stone or chaton of choice is usually made of colourless or coloured glasses rather than of gems. Although glasses are quite uniform in colour they are inferior to the synthetic minerals which have a higher refractive index, more brilliance, extreme hardness, higher density and most importantly, a superior thermal shock resistance. The latter is especially important in the high temperature wax casting cycle during jewellery manufacturing since materials prone to a thermal shock (rapid heating and cooling) and colour degradation due to oxidation of colouring agents at high temperatures in air cannot be used.

3. GLASS-CERAMICS. Along with the synthetic minerals and glasses, so-called hybrid materials are successfully used in high-precision optics and other fields of science and technology. These materials optimally combine the valuable properties inherent in crystals and glasses. The breakthrough materials, known as transparent glass-ceramics, incorporate the properties of both glasses and crystalline materials, which are not typical for glasses or crystals alone. The uniformly coloured transparent glass-ceramic materials have been proven to be quite hard and, at the same time, to replicate the optical characteristics of some of the most widely used gemstones. The analog of the glass-ceramics in nature is Obsidian – an effusive volcanic rock composed mainly of natural volcanic glass with abundant nucleation crystals (crystallites) and microlites.

FORMICA Ltd is the first company in the world that has developed and now produces a new group of glass-ceramic materials intended for use in the jewellery industry with unique physical and optical properties (see Table 1): hardness = 7 – 7.5; Refractive Index = 1.61 – 1.64; density = 3.0 – 3.3 g/cm^3; melting temperature 1600 to 1750°C; lustre and colour is maximally close to many natural minerals; homogeneous and even colour. We call this new transparent, opal and opaque-coloured nanocrystalline material as Formica Nanogems. This new synthetic material derives its name from the nanosized (~10^{-7} cm) crystals of Spinel, Gahnite, Sapphirine, Garnet, and Quartz (to name only a few) homogeneously distributed in the amorphous matrix. Nanogems chemically are the high-temperature aluminosilicates, and their physical properties vary depending on composition, concentration and sizes of the nanocrystals so that a variety of colours and colour saturations can be produced. They are stable to oxidations and do not show any colour degradation at temperature up to 1600°C. This

Table 2. Formica Nanogems production catalogue

No.	Name and Colour	Hues and Shades
01. Transparent Colours		
01.01.01	Nano Emerald	Very Dark
01.01.02		Dark
01.01.03		Medium
01.01.04		Light
01.02.01	Nano Sapphire	Very Dark
01.02.02		Dark
01.03.01	Nano Sapphire (Violet)	Very Dark
01.03.02		Dark
01.04.01	Nano Spinel Blue	Dark
01.05.01	Nano Topaz Swiss Blue	Dark
01.05.02		Medium
01.05.03	Nano Topaz Sky Blue	Medium
01.05.04		Light
01.06.01	Nano Citrine	Very Dark
01.06.02		Dark
01.06.03		Medium
01.06.04		Light
01.07.01	Nano Garnet Orange-Red	Medium
01.08.01	Nano Peridot	Medium
01.09.01	Nano Spinel Pink	Medium
01.10.01	Nano Smokey	Yellowish
01.11.01	Nano Grey (Night Blue)	Very Dark
01.11.02		Dark
02. Opaques and Translucent Colours		
02.01.01	Nano Spinel Black	Opaque
02.02.01	Nano Aqua Blue	Dark
02.02.02		Medium
02.03.01	Nano Turquoise	Medium
02.04.01	Nano Opal Blue Sapphire	Dark
02.05.01	Nano Opal Blue Spinel	Dark
02.06.01	Nano Opal Blue colour	Dark
02.06.02		Medium
02.06.03		Light
02.07.01	Nano Opal Honey colour	Dark
02.07.02		Medium
02.08.01	Nano Opal Yellow-White	Light
02.09.01	Nano Opal Pink	Light
02.10.01	Nano Opaque Beige-Cream	Medium
02.10.02		Light

along with high-thermal shock resistance makes FORMICA-made Nanogems ideal for use in wax casting technology.

Currently, FORMICA manufactures transparent Nanogems that completely imitate the colours, brightness, hardness and density of gemstones such as emerald, sapphire, tanzanite, blue-spinel; "sky," "swiss" and "London blue" topaz; peridot; yellow and golden citrine; red garnet; pink and black spinel; and grey and smokey quartz. The photographs (Photos #1-6) of various facetted coloured Nanogems clearly show their most remarkable optical similarity to the natural gemstones.

The most amazing is the resemblance of Emerald-Green Nanogems to natural Emeralds. They are indistinguishable in colour, lustre and reflectivity, and are very similar in density and hardness. Due to its very affordable price, this material is a serious alternative to Hydrothermal Emerald, Green CZ, Green YAG, Green Corundum and others.

Peridot, Sky, Swiss and London Blue coloured Nanogems are also very similar to the natural Peridot and Blue Topaz in colour, refractive index, lustre and density. With these advantages, they can successfully compete with CZ, Hydrothermal Quartz and Synthetic Spinel.

Nanogems in Sapphire-Blue colour are not identical to their natural counterpart in hardness, density and refractive index, but they are similar in colour and lustre. Considering the high cost of the synthetic Sapphire grown by the Verneuil method, the Sapphire Blue Nanogems are in demand by many jewellery manufacturers.

Many coloured materials produced by FORMICA are offered in different variations of colour saturation: Very Dark, Dark, Medium and Light. The darker varieties are used for producing smaller-sized stones, while the lighter selections are used for larger ones; this enables a manufacturer to maintain the same hue of colour saturation throughout variations in sizes and shapes.

Most colours are also offered not only in their most popular transparent form, but also in a translucent (opaline) variation as well as in opaque: Black, Beige-Cream, Turquoise, Aqua Blue, Blue Opal, Honey, Yellow-White, Pink, etc.

The optical similarity to natural gemstones is so profound that one can call Nanogems as "Nano Emerald," "Nano Sapphire," "Nano Topaz," etc. While the nanocrystals of the Nanogems represent naturally occurring minerals, the complete composition of the matrix with the incorporated crystals differs from the natural gemstones. Despite this, Nanogems offer many advantages compared to the currently available market alternatives that make it more attractive to jewellery producers. The growing success of this high-quality material among jewellery manufacturers has given many people worldwide an opportunity to enjoy the simulated beauty of many different gemstones at a fraction of the cost of a genuine stone.

Nanogems are at the cutting edge for imitating natural gemstones. It is time for Nanogems!