INAMORI SYNTHETIC CAT'S-EYE ALEXANDRITE

By Robert E. Kane

The world's first commercially available synthetic cat's-eye alexandrite chrysoberyl is now being manufactured and marketed by the Kyocera Corporation in Kyoto, Japan. Kyocera markets synthetic gemstones in the United States under the trade name "Inamori Created." This article reports on a detailed gemological examination of this new synthetic cat's-eye alexandrite. Although most of the gemological properties of this new synthetic overlap those of natural cat's-eye alexandrite, it can be identified by its unique internal characteristics and its unusual fluorescence to short-wave ultraviolet radiation.

In late January 1987, the Inamori Jewelry Division of Kyocera International, Inc., San Diego, California, gave GIA two synthetic cat's-eye alexandrite chrysoberyls for study. Kyocera reported that these two oval double cabochons (3.27 and 3.31 ct) were representative of the new synthetic cat's-eye alexandrite being manufactured and cut in their highly automated synthetics facility in Kyoto, Japan. (figure 1).

This new synthetic cat's-eye alexandrite was first marketed in Japan set in jewelry in early September 1986, and has just been released in the United States as loose stones as well as in jewelry. As of June 1987, Kyocera had produced only 250 ct of this material for jewelry purposes. The stones currently available range in weight from slightly under 1 ct to 7.5 ct (K. Takada, pers. comm., 1987). They are marketed in the U.S. under the trade name "Inamori Created," as are Kyocera's other synthetic gems. In preparing this article, a total of 13 cabochon-cut Inamori synthetic cat's-eye alexandrites, ranging in weight from 1.04 to 3.31 ct, were subjected to several gemological tests, including detailed microscopic study. The results are reported below. A brief history of chrysoberyl synthesis is also provided.

HISTORY OF CHRYSOBERYL SYNTHESIS

Alexandrite is the color-change variety of chrysoberyl, the beryllium aluminate, $BeAl_2O_4$, with an impurity of Cr^{3+}. A conspicuous change of color from an intense bluish green to a deep "raspberry" (purplish) red is the most desirable for alexandrite. The flux growth of nonphenomenal chrysoberyl dates back to the latter half of the 19th century. From 1845 on, Ebelman used borate fluxes to synthesize very small crystals of chrysoberyl. Later Deville and Caron, and Hautefeuille and Perrey, also reported similar success with chrysoberyl synthesis (Nassau, 1980). Nassau also noted that in recent years experiments have been conducted with the more common lithium molybdate and lead oxide–lead fluoride–boron oxide flux combinations, but only small crystals have been produced. He also cites reports of the use of the Verneuil process to synthesize chrysoberyl or alexandrite-crystal boules.

Synthetic chrysoberyl containing only chromium as a trace element, usually at the 0.05% level or less (which results in pale color and a very weak alexandrite effect), provides a useful laser crystal. Laser rods up to 2.5 cm in diameter and 15 cm long (1 in. × 6 in.) are being grown by the Czochralski pulling technique at the Allied Chemical Corp. of Morris Township, New Jersey (Morris and Cline, 1976). Faceted stones cut from synthetic alexandrite grown by the Czochralski method at Allied Signal Corp. (formerly Allied Chemical) are now commercially available in the trade. The hydrothermal growth of synthetic chrysoberyl, but apparently not of alexandrite, has been reported in a series of Czechoslovakian patents by D. Rykl and J. Bauer (Nassau, 1980).

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Faceted synthetic alexandrite has been produced and marketed sporadically since 1973 by Creative Crystals of San Ramon, California, under the trade name Alexandria-Created Alexandrite (Cline and Patterson, 1975). Although both flux and melt techniques are covered in this patent, the inclusions present in the synthetic alexandrite commercially available from Creative Crystals indicate that this material is definitely flux-grown. In 1974, Creative Crystals experimentally synthesized cat's-eye chrysoberyl (not alexandrite) by the flux method; however, this product was never placed on the market (D. Patterson, pers. comm., 1987).

Faceted synthetic alexandrite has been commercially available from Kyocera International since 1975 (K. Takada, pers. comm., 1987). This material does not show any characteristics of flux growth and is probably grown by a melt process, specifically the Czochralski pulling method. Confirmation of this is provided by a U.S. patent assigned to Kyoto Ceramic Co. by Machida and Yoshihara (1980), in which the primary emphasis is a description of synthesizing alexandrite by a direct melting method: the Czochralski (rotational pull-up) technique.

On July 15, 1983, *Women's Wear Daily* reported that the Sumitomo Cement Company's central research laboratory, based in Funabashi City, Japan, had succeeded in synthesizing cat's-eye alexandrite. Sumitomo filed for worldwide patents for synthesizing this material with a melt method that uses the floating-zone technique (K. Takada, pers. comm., 1987). The growth process is followed by spontaneous cooling to room temperature and a special heat-treatment process.

In September 1983, independent of Sumitomo, Kyocera began experimentation on the synthesis of cat's-eye alexandrite (K. Takada, pers. comm., 1987). This research led to the eventual commercial marketing of this new synthetic. In a U.S. patent by Uji and Nakata (1986) assigned to the Kyocera Corp., the synthesis of single-crystal cat's-eye chrysoberyl (not alexandrite) is described. The primary emphasis of the patent is on several examples whereby the Czochralski method is used. The patent also mentions two different examples of synthesizing an "olive-green" and a brown cat's-eye chrysoberyl (not alexandrite) by means of a lithium molybdate flux. However, information contained in this patent, in addition to the fact that the Inamori synthetic cat's-eye alexandrites do not show any microscopic characteristics of flux growth, leads to the conclusion that this new product is grown by the Czochralski method.

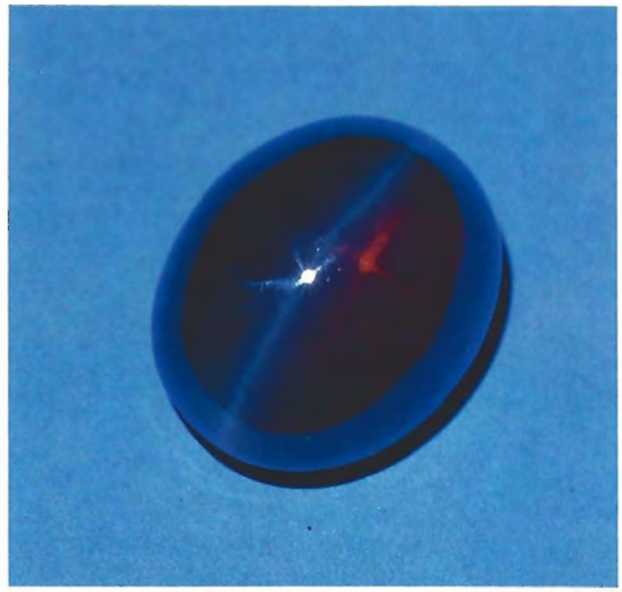


Figure 1. This Inamori synthetic cat's-eye alexandrite appears dark purple-red in incandescent light. Photo © Tino Hammid.

GEMOLOGICAL PROPERTIES

Thirteen cabochon-cut Inamori synthetic cat's-eye alexandrites were closely examined and submitted to a variety of gemological tests. The results are reported below and summarized in table 1.

Visual Appearance. A distinct color change was observed in all of the samples in fluorescent illumination (or natural sunlight) as compared to incandescent illumination. When the stones were viewed with a single overhead light source, a broad eye of moderate intensity was noted in each. When viewed with a Verilux fluorescent light source, the synthetic cat's-eye alexandrites appear dark grayish green with a slightly purplish overtone. The eye exhibits a slightly greenish white-blue color. There is an overall dull, "oily" appearance. When viewed with an incandescent light source (figure 1), the same stones changed to a dark purple-red with a bluish white eye, again with an overall dull, "oily" appearance. This "oily" appearance affected the transparency slightly in both types of illumination. When viewed with the unaided eye and overhead illumination, as well as with transmitted illumination, these synthetics appeared to be completely free of inclusions.

TABLE 1. The gemological properties of the Inamori synthetic cat's-eye alexandrites.

Properties that overlap those of natural cat's-eye alexandrites	
Color	Moderate to distinct color change from dark grayish green, with a slight purplish overtone, and a slightly greenish white-blue eye under fluorescent lighting; to a dark purple-red, with a bluish white eye when viewed with incandescent light
Visual appearance to the unaided eye	Transparent with an overall hazy, "oily" appearance in both lighting conditions; no inclusions are visible to the unaided eye
Refractive index	Spot readings of 1.745–1.755
Trichroism	Strongly distinct colors of purple-red, brownish orange, and gray-green
Color filter reaction	Bright red
Specific gravity	3.73 ± 0.02; estimated with heavy liquids
Absorption spectrum[a] (400–700 nm)	Absorption lines at 680.5, 678.5, 665, 655, 645, 472, and sometimes at 468 nm (very weak); broad absorption blocking out all of the violet and some of the blue, and portions of the yellow-green to orange areas of the visible spectrum. Spectrum will vary depending on viewing position and which rays are isolated.
Key identifying properties	
Fluorescence	
Long-wave	Moderate red (overlaps natural, *not diagnostic)*
Short-wave	Weak, opaque, chalky yellow fluorescence that appears to be confined near the surface; careful examination reveals an underlying weak red-orange fluorescence.
Inclusions	Parallel, straight-appearing and undulating color-zoned growth features; and nondescript white-appearing, minute particles specifically oriented in parallel planes (visible only with fiber-optic illumination), which give rise to the chatoyancy. With the iris diaphragm partially closed (over darkfield illumination at 25×) to create a shadowing effect, the unevenly spaced parallel growth features become more evident and reveal themselves as undulating rather than straight.

[a]*As observed through a hand-held type of spectroscope.*

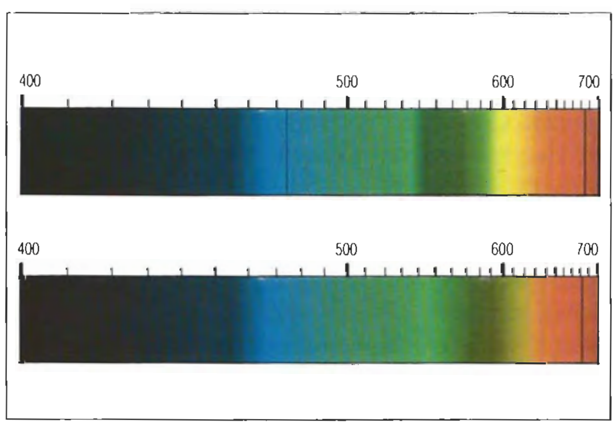
Interestingly, when the cabochons were viewed under a strong, single incandescent light source down the long direction, asterism was observed. The two additional rays were weaker than the chatoyant band. This behavior would not be expected in natural cat's-eye alexandrites.

Physical and Optical Properties. Testing of the Inamori synthetic cat's-eye alexandrites revealed refractive-index values (1.745–1.755, obtained by the spot method), specific-gravity values (3.73 ± 0.02), trichroism (purple-red, brownish orange, and gray-green), and a bright red reaction to the Chelsea color filter that are all essentially consistent with the corresponding properties in natural cat's-eye alexandrite. The spectra observed with a GIA Gem Instruments spectroscope unit are the same as those for alexandrite (natural and synthetic) described in Liddicoat (1981, p. 191) and shown here in figure 2. These features were confirmed by spectrophotometry.

Transmission Luminescence. When the synthetic cat's-eye alexandrites were placed over the strong light source from the opening of the iris diaphragm on the spectroscope unit, they all displayed a very strong greenish white transmission luminescence (in some viewing positions a slight pink cast was seen; see figure 3, left). In fact, the transmission luminescence was so strong that it was visible even in sunlight, or any artificial light. This transmission luminescence is the cause of the overall dull, "oily" appearance seen when the stones are viewed with the unaided eye, as discussed above.

Although natural cat's-eye alexandrites may exhibit a similar transmission, it is generally not as strong and has a slightly different appearance. In contrast, many natural as well as synthetic alexandrites (not chatoyant) will exhibit a strong red transmission (see figure 3, right).

Figure 2. The absorption spectra for Inamori synthetic cat's-eye alexandrite, as observed on a hand-held type of spectroscope at room temperature. The upper drawing shows the spectrum seen in the red direction, and the lower shows the spectrum seen in the green direction. Spectral colors are approximate.



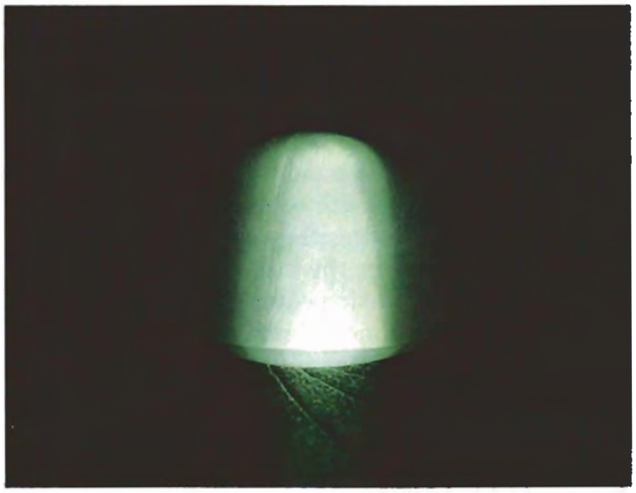


Figure 3. Transmission luminescence as seen over the strong light source from the opening of the iris diaphragm on the spectroscope unit. Left, Inamori synthetic cat's-eye alexandrite; right, natural alexandrite from Brazil. Photos by Shane McClure.

Fluorescence. When the synthetic cat's-eye alexandrites were exposed to long-wave (366 nm) ultraviolet radiation, a moderate red fluorescence was observed. This reaction to long-wave U.V. radiation is also seen in natural cat's-eye alexandrites. When the samples were exposed to short-wave (254 nm) U.V. radiation (in a dark room, with the synthetic stone lying on a black pad raised to within a few inches of the U.V. source), an unusual reaction was observed. The cabochons exhibited a weak, opaque, chalky yellow fluorescence that appears to be confined near the surface. Careful examination revealed an underlying red-orange fluorescence. This unusual reaction to short-wave U.V. radiation would not be expected in a natural cat's-eye alexandrite, and therefore provides the gemologist with an excellent indication that the piece is synthetic.

Microscopic Study. All of the samples were carefully examined with a standard gemological binocular microscope; darkfield, fiber-optic, transmitted, and polarized illumination were all used.

When the cabochons were examined with darkfield illumination, parallel striations were seen oriented perpendicular to the length of the cabochon. However, it was difficult to discern the precise nature of these striations because viewing

Figure 4. With the built-in iris diaphragm on the Gemolite microscope stage partially closed (over darkfield illumination) to create a shadowing effect in this cabochon-cut Inamori synthetic cat's-eye alexandrite, the unevenly spaced parallel growth features become more evident and reveal themselves as undulating rather than straight. Magnified 25×.

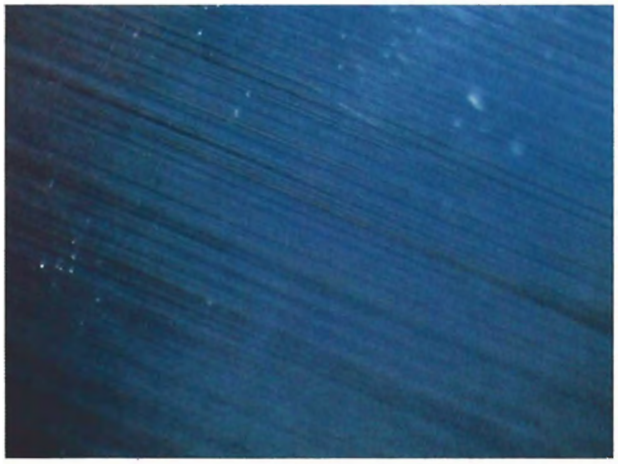


Figure 5. Oblique illumination created with a fiber-optic light unit reveals the nondescript, white-appearing, minute particles—specifically oriented in parallel planes (in association with the undulating striations shown in figure 4)—that give rise to the chatoyancy in this Inamori synthetic cat's-eye alexandrite. The larger white spots are surface features on the stone. Magnified 45×.

was obstructed by the typical "halo" seen in transparent, highly polished double cabochons. Partially closing the built-in iris diaphragm (over darkfield illumination) on the microscope stage, to create a shadowing effect, revealed that the unevenly spaced parallel growth features are undulating rather than straight (see figure 4). Such features would not be expected in natural cat's-eye alexandrites. Fiber-optic illumination revealed nondescript white-appearing minute particles that are specifically oriented in parallel planes (in association with the above-mentioned striations), and give rise to the chatoyancy (figure 5). No other distinctive features were seen with transmitted or polarized illumination. None of the inclusions resembled natural inclusions.

Natural cat's-eye chrysoberyls (non–color change, as well as alexandrite) always contain ultra-fine parallel growth tubes or needles that are oriented very close together and give rise to the cat's-eye effect when the stones are cut *en cabochon*. These inclusions are quite different in appearance from those observed in the Inamori synthetic cat's-eye alexandrites. Natural cat's-eye chrysoberyls also are frequently host to solid crystal inclusions of mica, quartz, apatite, and actinolite as well as other minerals. In addition, two- and three-phase fluid inclusions, containing both water and carbon dioxide, are commonly seen. Also typical of natural cat's-eye chrysoberyls are strong, highly visible growth features; they may be parallel, singular, straight, angular, and irregular. The Inamori synthetic cat's-eye alexandrites examined to date do not contain any of these internal features.

IDENTIFICATION AND CONCLUSION

The Inamori synthetic cat's-eye alexandrites closely resemble their natural counterparts in visual appearance, and most of their physical and optical properties overlap those of natural cat's-eye alexandrites. The key identifying characteristics of the new Inamori synthetic are: (1) the undulating growth features seen with the microscope when shadowing and darkfield illumination are used, and the white particles seen when fiber-optic illumination is used in conjunction with magnification; and (2) the unusual fluorescence seen with short-wave ultraviolet radiation.

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