Gemological **ABSTRACTS**

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COLORED STONES AND ORGANIC MATERIALS

Alexandrite effect. A. V. Vasiliev. *Gemological Bulletin*, No. 8, 2003, pp. 28–38 [in Russian with short English abstract].

A specially designed computer-controlled spectrometer was used to obtain absorption spectra to study color-change phenomena in minerals. The following samples were studied: chrysoberyl, emerald, corundum, several garnets, fluorite, apatite, stillwellite, and lovchorrite [rinkite]. Using various light sources (i.e., tungsten, mercury, direct sunlight, scattered daylight, D65 fluorescent lamp, and "equal energy source E"), characteristics of hue, tone, and saturation were evaluated and integrated into an analysis of the influence of spectral light distribution on color perception. Particular attention was paid to crystal orientation in the anisotropic minerals.

Rubies from Myanmar, Cambodia, and Tanzania, as well as blue sapphires from the Ural Mountains (Russia), showed particularly significant color differences between daylight and the other sources. Spessartine-grossular garnets from Tanzania showed a distinct color change, comparable to alexandrite from the Urals. Much less color change was seen in samples of spessartine-grossular from Sri Lanka and pyrope from Yakutia. Fluorite from an emerald mine in the Urals showed a noticeable change. A "reverse" alexandrite effect (i.e., blue rather than red in tungsten illumination) was observed in grossular from Noril'sk (Siberia). Technical explanations for all of these observations are given. In the case of apatite, stillwellite, and lovchorrite, which contain rare-earth elements, color change was seen only when they were compared in daylight and with a mercury lamp.

BMS

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Features of chemical composition and optical properties of peridot. A. A. Zolotaryov, A. K. Buiko, A. A. Buiko, and N. O. Ovchinnikov, *Gemological Bulletin*, No. 10, 2003, pp. 14–20 [in Russian with short English abstract].

The properties of 28 faceted gem-quality peridots from China, Egypt, Pakistan, Russia, Tanzania, and the U.S. were determined. Electron-microprobe analyses showed that all the samples were predominantly forsterite (Mg_2SiO_4) with 5–15 mol.% fayalite (Fe_2SiO_4). Peridots from Pakistan and Tanzania had lower Fe contents, whereas those from Russia and the U.S. had higher Fe contents. Variations in Fe affected the colors and R.I. values. Trace elements (e.g., Ni, Mn, and Ca) had a negligible effect on these properties.

The main hues varied between yellowish green and orange-yellow. The yellow component was correlated to Fe. A good correlation was found between Fe content and the highest refractive index (n_γ), which ranged between 1.680 and 1.698. Peridots from Pakistan (lower Fe contents) were optically positive, whereas those from Russia and the U.S. (higher Fe contents) were optically negative. The birefringence was at least 0.017; this is a distinguishing characteristic and enables peridot to be separated from sinhalite ($MgAlBO_4$, birefringence 0.008), which otherwise has optical properties very similar to peridot. *BMS*

High-pressure, metasomatic rocks along the Motagua fault zone, Guatemala. G. E. Harlow, V. B. Sisson, H. G. Avé Lallemant, S. S. Sorensen, and R. Seitz, *Ofioliti*, Vol. 28, No. 2, 2003, pp. 115–120.

The Motagua fault zone in central Guatemala forms the present boundary between the North American and Caribbean plates, and is the world's second most important source of jadeite (after Myanmar). It consists of two major subparallel faults, the San Augustín and the Cabañas, where high-pressure/low-temperature rocks occur. Jadeite is hosted by sheared serpentinite bodies, primarily on both the northern and southern sides of the Cabañas fault. However, there are distinct mineralogical differences in the jadeite belts on either side of the fault. Late-stage alteration, grain-boundary alteration, and albitization are present in jadeites from the northern side of the fault, whereas these features have not been documented in jadeites from the more recently discovered southern bodies. Further, jadeites from some areas of the southern belt are more translucent and darker colored (in addition, some are blue) than their northern counterparts.

The authors propose that the Guatemalan jadeites crystallized from seawater-like fluids derived from a subducting plate that entered into a serpentinizing peridotite body. The jadeite formed at temperatures of 100–400°C and pressures of 5–11 kbar. Because jadeites (and associated high-pressure/low-temperature rocks) in the two belts show different mineral assemblages with distinctive properties, the Motagua fault zone may record two collisional events. Alternatively, these two belts may represent different structural levels of one subduction complex. *KSM*

Problem in Chinese fresh-water pearl industry and countermeasure. J. Zhao and R. Yang, *Journal of Gems and Gemmology*, Vol. 5, No. 4, 2003, pp. 42–45 [in Chinese with English abstract].

China is both the world's largest producer and largest exporter of freshwater cultured pearls. However, compared to the late 1990s, much of the industry is facing problems of decreasing quality and falling prices, which threaten to hinder further development. Reasons for these problems include the following: (1) There are no controls on production, (2) technological advances to improve cultivation and the quality of production have not been implemented, and (3) water quality in some of the most important growing areas is afflicted by pollution (i.e., excessive amounts of nutrients, toxic materials, and suspended matter).

Possible solutions to these challenges are offered: (1) Scientific management and state regulation of production should be implemented; (2) the industry should be reorganized with the consolidation of small operations into larger, more efficient companies and cooperatives; (3) research aimed at improving all aspects of the industry should be encouraged and more specialists trained; (4) laws to reduce pollution and improve the growth environment for the pearl-producing mollusks should be enacted and enforced; and (5) brand names for Chinese cultured pearls on the international markets should be developed to help add value. *TL*

TPR, EPR and UV-Vis studies of Ni(II) speciation in chrysoprase. Z. Sojka, S. Witkowski, W. Zabiński, K. Dyrek, and E. Bidzińska, *Neues Jahrbuch für Mineralogie, Monatshefte*, No. 1, 2004, pp. 11–25.

TPR (temperature programmed reduction), EPR (electron paramagnetic resonance), and ultraviolet-visible spectroscopic methods were used to study the local environment (i.e., lattice sites) in which nickel ions (the green chromophore) occur in chrysoprase from three localities: Szklary, Lower Silesia, Poland ("apple" green, 1.71 wt.% Ni); Marlborough Creek, Australia ("emerald" green, 0.98 wt.% Ni); and an unknown African locality (dark green, 4.38 wt.% Ni). The authors demonstrated that nickel is present in two different forms: It is predominantly dispersed into 2:1 phyllosilicates (similar to Ni-talc), and less commonly it is found as extra-framework species adsorbed onto the surface of the chalcedony. *RAH*

DIAMONDS

Electron microscopy analysis of debris produced during diamond polishing. F. M. van Bouwelen, J. E. Field, and L. M. Brown, *Philosophical Magazine*, Vol. 83, No. 7, 2003, pp. 839–855.

Diamond's hardness is anisotropic, and therefore it shows different polishing rates according to crystallographic direction. Historically, diamond polishing was explained in terms of microcleavage along octahedral planes, as tiny irregularities on a diamond's surface contact the scaife. However, various investigations conducted in the 1990s of the details of polished diamond surfaces found no evidence for this hypothesis. Other studies have attempted to examine the debris from polishing, but they were marred by the difficulties in obtaining pristine samples.

The present authors collected polishing debris on a small copper screen coated with a SiO film, hung slightly above the scaife and about 2 cm behind the diamond being polished. The debris ejected from various diamond faces and from different polishing directions was examined both visually and chemically.

High-resolution electron microscopy showed abundant amorphous carbon in the debris taken from all polishing directions. Patches of graphite also were found in the debris. In the sequence of samples from softer to harder direction, the ratio of graphite to amorphous carbon decreased. However, attempts to polish the octahedral planes themselves produced debris with relatively large sheets of graphite and angular fragments of diamond (but no cleavage fragments).

Electron-energy-loss spectroscopy enabled the authors to characterize the debris chemically and to calculate a bulk density of 1.9 g/cm^3 for the debris from the softer directions, 2.2 g/cm^3 for debris from a harder direction along the cubic plane, and 2.3 g/cm^3 (the density of graphite) for debris from the octahedral plane. High-energy-loss spectra indicated the presence of a form of amorphous carbon. The spectra revealed no nitrogen, but oxygen was present at 2–4 atom%, with more oxygen in the debris from softer directions. Assuming only carbon and oxygen in the debris, the authors calculated an sp^2-to-sp^3 ratio (the ratio of graphite bonds to diamond bonds) that indicates graphite constitutes 80–100% of the debris for all samples except those from the octahedral plane.

Rather than microcleavage, the authors concluded that the pressure of polishing transforms the surficial layer of diamond to graphite, which is then readily removed. Studies by other researchers of the anisotropic distribution of compressive stress during diamond polishing along different directions also support this conclusion. Last, the authors use this conclusion to explain why a layer of black powder is created when preparing a new scaife. *Ilene Reinitz*

FISH—State-of-the-art technology in final diamond recovery. L. du Plessis and M. Sewawa, *Journal of the South African Institute of Mining and Metallurgy*, Vol. 103, No. 9, 2003, pp. 557–562.

This process-engineering article reviews diamond recovery technology recently employed at Debswana's Jwaneng mine in Botswana. FISH, or Fully Integrated Sort House, has improved three key areas of final diamond recovery: sorting efficiency, availability of production information (turn-around time), and security. FISH, in combination with CARP (or Completely Automated Recovery Plant), was jointly installed at the Jwaneng recovery plant (called "Aquarium") in late 2000.

Through the integration of several commercially proven technologies, the FISH process streamlines feed preparation and the sorting, cleaning, and packing of recovered diamonds. Sorting efficiency improvements were realized by introducing X-ray and laser (Raman spectroscopy) equipment. In turn, decommissioning the maintenance-intensive grease belts improved turn-around times. The new equipment allows "hands-off" operation and maintenance (i.e., human hands do not touch diamonds or diamond concentrate), thus improving product security.

The article also discusses lessons learned from the implementation of these new technologies, such as personnel issues, data collection, and operational feedback. For example, an increase in the number of technical staff was required to cope with the new equipment demands, yet overall operational costs dropped due to efficiencies gained in other areas. Interestingly, Debswana concluded that the successful integration of various technologies proved to be more innovative than the individual technologies themselves. *KAM*

On grading the asymmetry of a round brilliant-cut diamond. S. B. Sivovolenko, Yu. B. Shelementyev, and G. Holloway, *Gemological Bulletin*, No. 9, 2003, pp. 18–25 [in Russian with short English abstract].

Symmetry in round brilliant cut diamonds is evaluated differently in Russia, Belgium, and the U.S. This article summarizes and compares characteristics of the symmetry-evaluation methods used in these countries, with particular emphasis on the cause, effect, and importance of asymmetry. Asymmetry is explained as the degree of mutual deviation from the ideal of the table and pavilion axes. Based on a computer-generated 3D model, a new method for grading asymmetry in round brilliant diamonds is proposed. The article is critical of some aspects of the HRD and GIA methods, particularly where certain deviations from the "ideal" are designated as "important" or "unimportant." The authors maintain that it is more correct to separate the deviations into two categories: (1) those that influence optical properties, and (2) those that simply reflect the skill of a cutter—that is, they are easily visible but not very significant. *BMS*

Options for selling rough. J. Chapman, *Rough Diamond Review*, No. 2, 2003, pp. 16–18.

In an industry where rough diamond producers have unique production profiles and monthly outputs, the successful sale of rough requires careful consideration. No longer is De Beers virtually the sole buying organization, as in decades past. Today, several avenues are available to primary producers. Sellers of (legitimate) rough may use diamond bourses or exchanges, find contract buyers, enter into investor-dealer arrangements, use tendering agents or brokers, or establish a sales office. Some caveats for these options are given, such as the care required in assembling parcels that will appeal to purchasers, as well as the necessity of well-defined contractual obligations regarding contract sales and investors. The article recommends that experts be consulted in many cases, such as for valuation purposes, product presentation, advice on local demand and governmental regulations, and marketing. Although optimizing sales of rough is complex, current high demand places producers in a position of strength, which can be exploited with an appreciation of the advantages and shortcomings of various selling practices. *DMK*

The preservation of alluvial diamond deposits in abandoned meanders of the middle-Orange River. P. G. Gresse, *Journal of the South African Institute of Mining and Metallurgy*, Vol. 103, No. 9, 2003, pp. 535–538.

The Orange River has transported diamonds eroded from kimberlites and intermediate secondary sources in South Africa's interior and deposited them within gravel terraces along much of its length. These terraces are typically preserved at distinct elevations above the current river level, but were not recognized during most of the 20th century as they were capped by younger sediments. Within the past four years, some of these terraces have been successfully mined, particularly along the "mid-Orange River" section between Douglas and Prieska in South Africa's Northern Cape Province.

Each terrace has a characteristic diamond content and age. For example, the most consistent diamondiferous paleodeposit is located 60–90 m above the current river level and was formed in the mid-Miocene (~8 million years ago). Each time the river cut more deeply into the valley as a result of sea-level or other changes, it would partially rework the previous cycle's gravel deposits, including its diamonds. The diamond content of any one gravel terrace is dependent on the amount of diamonds introduced from upstream by the paleoriver, the number of reworked diamonds from the previous cycle's gravels, and the amount of dilution material present. Data on the internal structure and morphology of these deposits are obtained through drilling and high-resolution aeromagnetic surveys, the latter being particularly effective in delineating those terraces that contain a large amount of iron (originally sourced from banded iron formations in the area). A high iron content correlates with a higher diamond content; apparently, the added density of the iron-bearing gravels enhanced the trapping mechanism for diamonds. *KAM*

Revival of the Skeleton Coast. R. Baxter-Brown, *Rough Diamond Review*, No. 3, 2003, pp. 27–30.

The Skeleton Coast, a narrow, 800-km-long stretch of desert bordering the Atlantic Ocean in northern Namibia, encompasses rugged terrain lacking in infrastructure; it is an inhospitable environment for diamond exploration. Rusting pieces of machinery and prospecting pits from exploration between 1943 and 1971 are reminders of failed ventures. Urged to open the Skeleton Coast for exploration once again, the government of Namibia granted the first diamond prospecting licenses for the region in recent times in 1999. Exploration activities were delayed until 2001 due to environmental concerns. Since then, some successful ventures have been launched in the area, and ore-reserve evaluation programs have identified several potentially profitable areas.

The origin of the Skeleton Coast diamonds is problematic. Various possibilities have been proposed, but the most favored is that the diamonds originated in kimberlites in Angola and were brought to the Skeleton Coast by south-flowing Angolan rivers starting in late Tertiary time. *MT*

Selection of plant for diamond ore concentration. T. Mason, *Rough Diamond Review*, No. 2, 2003, pp. 33–38.

One of the most important steps in diamond mining is the concentration of diamonds, along with other heavy minerals, from the kimberlite or alluvial ore prior to routing the concentrate to an X-ray sorter or grease-table separator. The goal is to minimize the volume of material that must be processed during the final recovery stage. The techniques of primary concentration are based on density, and their principle of operation is called "densimetric separation." Dense-medium separators such as HM (heavy-medium) cyclones, jigs, and pans are described, and their efficacy is discussed. Although cyclones are very efficient, a more economic concentration of diamondiferous ore can be attained by using them in conjunction with simpler devices such as jigs, pans, and shakers. The author recommends that diamond mining projects use densimetric ore profiles to develop effective and efficient plant designs. *DMK*

INSTRUMENTS AND TECHNIQUES

Aplicações de microscopia eletrônica de varredura (MEV) e sistema de energia dispersiva (EDS) no estudo de gemas: Exemplos Brasileiros [The application of scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS) to gem research: Brazilian examples]. L. da C. Duarte, P. L. Juchem, G. M. Pulz, T. M. M. Brum, N. Chodur, A. Liccardo, A. C. Fischer, and R. B. Acauan, *Pesquisas em Geociências*, Vol. 30, No. 2, 2003, pp. 3–15 [in Portuguese with English abstract].

The inclusions in several Brazilian gems were studied using SEM and EDS techniques. Emeralds from Campos Verdes, Goiás State, were found to contain inclusions of talc, dolomite, chromite, pyrite, magnetite, and sylvite (KCl; in fluid inclusions). The emeralds are color zoned, with outer green regions that are richer in Cr^{3+} than the inner near-colorless zones. Amethysts from Rio Grande do Sul State contain needle-like inclusions of goethite, rather than cacoxenite and rutile as suggested previously. Agate and quartz geodes from the same state contain pyrolusite and hollandite. The "silk" effect in corundum from Barra Velhe (Santa Caterina State) is due to inclusions of diaspore, while asterism in this corundum is attributed to needle-like channels. Rounded zircons are common inclusions in corundum from various localities in Minas Gerais State, and some have sillimanite and/or kyanite inclusions that suggest a metamorphic origin.

RAH

The detection of colour-enhanced and synthetic gem diamonds by optical spectroscopy. A. T. Collins, *Diamond and Related Materials*, Vol. 12, No. 10–11, 2003, pp. 1976–1983.

More than five decades of fundamental research on the optical properties of defects in diamond provide the basis for today's gem-testing laboratories to assess gem-quality diamonds. In the majority of cases, spectroscopic analysis enables the determination of the origin of color—natural or treated—as well as the differentiation of synthetic from natural. This paper is a compendium of benchmark optical properties that define these separations.

It begins with an overview of the specific defects—nitrogen, boron, and plastic deformation—responsible for the various natural and treated colors seen in diamond. It then reviews the primary optical characteristics resulting from radiation damage and subsequent annealing, as well as HPHT processing. Concluding paragraphs detail the distinguishing defect properties of both near-colorless and colored HPHT-grown synthetic diamonds. *SW*

In situ mobile subaquatic archaeometry evaluated by non-destructive Raman microscopy of gemstones lying under impure waters. D. C. Smith, *Spectrochimica Acta Part A*, Vol. 59, No. 10, 2003, pp. 2353–2369.

Laboratory simulation experiments were conducted to determine the feasibility of identifying cultural heritage objects at an underwater archaeological site with a mobile Raman microspectroscopy (MRM) system. Three gem materials (zircon, amazonite, and sodalite) were placed under different kinds of pure and impure waters (the latter representing waters containing dissolved or suspended organic or inorganic material that might typically be found at an underwater site). The optical objective of the Raman microscope was immersed in the water to eliminate the normal aerial pathway of the laser beam between the objective and the item being analyzed.

Raman spectral band intensities were found to be stronger than, similar to, or weaker than spectra for the same gem minerals recorded in air. Nevertheless, diagnostic bands could be recognized in the spectra recorded for samples in the pure and impure waters, although some of the inherent problems presented by Raman analysis (e.g., fluorescence) remained. A number of technological, scientific, and archaeological considerations for *in situ* MRM analysis of objects underwater are discussed, and it is concluded that subaquatic archaeometry by MRM could be a viable technique at certain sites. On-site experiments to authenticate this new approach have not yet been conducted. *JES*

Rank correlation of laser-induced breakdown spectroscopic data for the identification of alloys used in jewelry manufacture. A. Jurado-López and M. D. Luque de Castro, *Spectrochimica Acta Part B*, Vol. 58, No. 7, 2003, pp. 1291–1299.

Laser-induced breakdown spectrometry (LIBS) is a minimally destructive, rapid, reliable, and relatively inexpensive spectroscopic technique. This article describes the application of LIBS to the multi-element analysis of 32 alloys that are widely used in jewelry manufacture; 25 were chosen as library standards, and the remaining seven were used as samples. The alloys were divided into two groups: one for gold alloys used in jewelry manufacturing and the other for low-melting welding points. Each alloy was subjected to five laser shots to obtain a representative spectrum. The Spearman rank correlation coefficients of the spectra were compared to the library standards by mean of ranks from 1 to 1024 (the latter representing the most intense pixel in a given spectrum). The maximum rank was obtained when the composition of the alloy was similar to that of the standard.

Cu and Zn were detected in all the alloys, whereas Ag was found in most of them. Ni was found only in white gold; Ir was common (~12–30 wt.%) in most of the alloys used for welding points. Although Cd is currently not permitted in jewelry because of its toxicity, this element was detected in one of the welding point alloys.

In addition to its usefulness in the jewelry trade, LIBS has great potential for a wide range of industrial applications, especially in the mining and chemical processing industries. *KSM*

Spectra of gem materials. G. Pearson, *Australian Gemmologist*, Vol. 21, No. 12, 2003, pp. 478–485.

Discrepancies are commonly observed in the spectra of gem materials seen with a hand spectroscope and those obtained with a UV-Vis spectrophotometer. This raises questions about the visibility, in hand-held spectroscopes, of absorption features that have been long-recognized as characteristic of many gems, such as sapphire and peridot. By defining and illustrating the "relative luminous efficiency" curve, which represents the sensitivity of human vision across the visible wavelength range, the author concludes that some of the instrumentally derived absorption spectra presented in many gemology texts cannot be seen with a hand-held spectroscope. *RAH*

The using of luminescence in gemology. B. S. Gorobets, O. V. Kononov, A. A. Rogojine, and T. D. Kvitko, *Gemological Bulletin*, No. 10, 2003, pp. 34–56 [in Russian with short English abstract].

This comprehensive review of the applications of luminescence methods in gemology contains five tables, 52 figures with spectra of minerals (including their synthetic analogues and simulants), and 11 color photos. General topics include a discussion of luminescence types (e.g., cathodo- and thermoluminescence) and the nature of luminosity—with special attention paid to the effects of Fe, Cu, and radiation defects. The techniques and instruments used for obtaining luminescence spectra also are described. Recommendations are given for the visual observation of thermal and UV luminescence in diamonds and emeralds, and methods are provided by which their synthetic counterparts can be distinguished.

Future work by the authors will be directed toward creating an extensive database for natural and treated gems, compiling specific instructions for using luminescence to distinguish natural from synthetic gems, and establishing a research center in Russia dedicated to developing methods and instrumentation for luminescent determinations of gems and related materials. *BMS*

JEWELRY RETAILING

The role of branding in the diamond industry. A. Murray, *Rough Diamond Review*, No. 3, 2003, pp. 34, 37–38.

With its "Diamonds are Forever" campaign, De Beers has provided sustained global guidance since the 1940s. Although diamonds had been highly revered for generations, they did not become a mass consumer product until De Beers promoted them. As new producers and corporate players have entered the diamond market in recent years, the consumer's choice has increasingly been influenced by branding. The initial brands, usually based on particular cuts of polished diamonds (e.g., the Quadrillion and Ideal cut), have increased consumer confidence and given diamonds an added prestige that makes them popular and sought after. Another brand dimension is provided by country of origin (e.g., Australia or Canada) or specific mines in those countries (e.g., Argyle or Ekati, respectively). These can summon strong, sometimes patriotic feelings from customers. Positioning also plays an important role in diamond branding, as having a corporate identity can help a company in various commercial ways as well as distinguish it from other players.

Branding and positioning require commitment, as their benefits pay off over the long run; results take at least a year or two to become evident. The long-term view is consistent with the soul of the diamond industry, which has always been about building and maintaining relationships, as well as establishing values. *MT*

SYNTHETICS AND SIMULANTS

Effect of HPHT annealing on the photoluminescence of synthetic diamonds grown in the Fe–Ni–C system. A. Yelisseyev, S. Lawson, I. Sildos, A. Osvet, V. Nadolinny, B. Feigelson, J. M. Baker, M. Newton, and O. Yuryeva, *Diamond and Related Materials*, Vol. 12, No. 12, 2003, pp. 2147–2168.

Absorption and photoluminescence (PL) spectra were employed to characterize the effects of HPHT annealing on synthetic diamond crystals containing high concentrations of nitrogen and nickel impurities. Twenty synthetic diamond crystals were grown from an Fe-Ni-C system at 1,600 K and 5.5 GPa in a split-sphere type apparatus. Some of the crystals were subsequently annealed for 4 hours at either 1,950 K or 2,200 K. Additional samples used for comparison included crystals grown in a Ni-free (Fe-C) system as well as several Yakutian diamonds with relatively high Ni concentrations for natural stones.

Numerous narrow lines were observed in the PL spectra of the synthetic diamonds containing nickel and nitrogen impurities. More than 20 vibronic systems were identified, some for the first time, and their responses before and after annealing were recorded. Based on analysis of these data, the authors proffer the following main groups for characterizing these systems:

I. Systems existing in as-grown synthetic diamonds that decrease in intensity with annealing at 1,950 K
II. Systems that appear after annealing at 1,950 K and then decrease in intensity or disappear with annealing at 2,200 K
III. Systems that appear after annealing at 1,950 K and do not decrease in intensity with annealing at 2,200 K

Group I systems are identified by individual impurity ions such as negatively charged substitutional nickel. Group II systems relate to a nickel ion in a di-vacancy position and intermediate nickel-nitrogen complexes containing single nitrogen atoms. Group III systems correlate with more complicated nickel-nitrogen complexes comprising at least two nitrogen atoms surrounding the nickel. *SW*

Optical properties of synthetic diamond single crystals. A. V. Mudryi, T. P. Larionova, I. A. Shakin, G. A. Gusakov, G. A. Dubrov, and V. V. Tikhonov, *Semiconductors*, Vol. 38, No. 5, 2004, pp. 520–523.

Synthetic diamond crystals (4–7 mm in diameter) with potential for use in precision scientific instruments were grown by the thermal gradient method (Ni-Fe-C system; 1,750–1,800 K; 5.4–5.5 GPa) and subsequently subjected to HPHT treatment (2,000–2,200 K and 6.0–6.5 GPa for 3–24 hours). The untreated crystals were yellow-green and exhibited a prominent S3 band at 496.7 nm in their cryogenic PL spectra. The HPHT-treated synthetic diamonds had a pale green color and displayed the S3 band in addition to three S2 bands at 523.3, 489.1, and 477.8 nm (i.e., A, B, and C defects, respectively, of S2). Although the S2 bands were found occasionally in untreated samples, their intensities increased by factors of 5–10, and the overall luminescence of the synthetic diamonds increased by factors of 3–5, after HPHT treatment. The increase in luminescence is attributed to a redistribution of Ni and N impurities within the synthetic diamonds during treatment and a corresponding change in bodycolor. Luminescence excitation spectra further indicated that S2 (A) and S2 (B) are independent features related to different defects. IR absorption spectra of the same samples show that HPHT treatment resulted in aggregation of >90% of the C defects (single substitutional N) into A defects and the near-complete annealing of Me-X centers (Me = metal solvent; X may be carbon and/or nitrogen). PL and IR data confirmed that HPHT treatment resulted in significant reconfiguration of the defects in the synthetic diamond lattice.

Christopher M. Breeding

Properties and diagnostics of natural and synthetic malachite. T. V. Chernenko and E. P. Melnikov, *Gemological Bulletin*, No. 8 (pp. 11–27) and No. 9 (pp. 31–35), 2003 [in Russian with short English abstracts].

This in-depth, well-illustrated two-part article on malachite reviews the history of its use in jewelry and as a decorative stone, the geology of its major deposits, and methods by which it is synthesized. Based on a study of 150 natural and ~20 synthetic malachites, the authors identified textural, structural, chemical, and other differences between the natural and synthetic samples. For example, their densities are distinctive (3.87–3.92 g/cm^3 for natural and 3.61–3.70 g/cm^3 for synthetic). Chemically, natural malachites contain P (due to admixed pseudomalachite), Be, Co, and V that distinguish them from synthetic malachites, which contain Pb, Sn, and Ga (not found in natural samples). Numerous other trace elements may be present in both natural and synthetic malachites, and in some cases these can be correlated to differences in color and texture. Individual crystallites in natural malachites are larger than similar crystallites in the synthetic varieties.

Chemical and temperature parameters are determined for the formation of the two most attractive varieties of natural malachite, with the Russian names "plissovy" (radiating fibers) and "biryuzovy" (light green "turquoise-like"). "Plissovy" forms in gossans over Cu-Fe deposits from solutions with low concentrations of Cu and CO_2 at temperatures of 60–70°C. "Biryuzovy" usually forms in Cu-bearing clays associated with limestones in karst terranes from concentrated solutions at temperatures of 20–50°C. *BMS*

Study on large-sized ruby grown by temperature gradient technique. C. Song, S. Zhou, J. Si, H. Li, G. Zhou, Y. Hang, and J. Xu, *Journal of Synthetic Crystals*, Vol. 32, No. 5, 2003, pp. 423–426 [in Chinese with English abstract].

Large crystals of synthetic ruby (not of gem quality) were grown by the temperature gradient technique from seed plates using Al_2O_3 powders mixed with 0.5–3% Cr_2O_3. Crystallization started at 2,050°C; cooling rates were 0.5–2.5°C/hour. The largest crystal measured 75 mm in diameter, 45 mm long, and weighed 1,076 g. This crystal was dark red in the center and even darker red (almost black) at its edges and bottom. Wave-like growth bands were observed in the top portion, while clouds of minute inclusions were concentrated near the seed plate. The concentration of the inclusions decreased from edge to center and from bottom to top, resulting in a "trumpet"-shaped distribution along the growth direction similar to that found in synthetic Ti-doped sapphire crystals grown by the same technique.

Electron-microprobe analysis showed that the inclusions were mainly uncrystallized Al_2O_3 powder. Gas bubbles or voids also were observed. Microprobe and spectroscopic (visible range) data showed that the Cr^{3+} concentration increased in two directions (i.e., from center to edge and from bottom to top), corresponding to the growth progression. The authors propose that the quality of synthetic ruby crystals produced by this method could be improved by optimizing the cooling rate, purifying the raw materials, and controlling the temperature during growth. *TL*

A Verneuil synthetic ruby showing diverse veil-like 'fingerprints.' J. M. Duroc-Danner, *Journal of Gemmology*, Vol. 28, No. 8, 2003, pp. 483–488.

Today the treatment of gem corundum is of such concern that it tends to overshadow the topic of natural vs. synthetic. This article brings that topic back into the forefront, as its focus is on a 2.06 ct, oval-shaped, flame-fusion synthetic ruby that was discovered in a parcel of natural rubies being checked for country of origin.

This synthetic ruby was treated (i.e., quench-crackled with flux "fingerprints" later induced) to more closely resemble a natural ruby. The fingerprints were similar to those seen frequently in Mong Hsu rubies and could easily fool anyone viewing the stone with a 10× loupe. Only careful observation at higher magnification revealed the telltale signs of the stone's synthetic origin: curved striae and clouds of tiny gas bubbles, both hidden beneath numerous wispy, veil-like, flux-induced fingerprints that varied in their appearance throughout the stone. Also helping to mask the evidence of synthesis were many surface-reaching fractures and straight, heavy polish lines. *WMM*