

## REFERENCES

- Abdukadyrova, I.Kh. 1997. Effect of neutron irradiation on optical spectra of sapphire crystals. *Inorg. Mater.*, **249** : 128–132.
- Aoki, Y., N.T. My, S. Yamamoto, and H. Naramoto. 1996. Luminescence of sapphire and ruby induced by He and Ar ion irradiation. *Nucl. Instr. and Meth.*, **B114** : 276–280.
- Atichart, W. et al. 2010. Report (20 Dec. 2005 – 30 Apr. 2010); (*Project*) raw gem' origin data and identification of geographic origin. Gem Testing Laboratory, Gem and Jewelry Institute of Thailand. [In Thai].
- Atkins, P.W., T.L. Overton, J.P. Rourke, M.T. Weller, and F.A. Armstrong. 2010. *Shriver and Atkins' Inorganic Chemistry*. 5th ed. New York : W.H. Freeman and Company.
- Averback, R.S., and P. Bellon. 2010. Fundamental concepts of ion-beam processing. *J. Appl. Phys.*, **116** : 3–5.
- Burns, B.G. 1993. *Mineralogical applications of crystal field theory*. Cambridge : Cambridge University Press.
- Calligaro, T., J.P. Poirot, and G. Querré. 1999. Trace element fingerprinting of jewellery rubies by external beam PIXE. *Nucl. Instr. Meth.*, **B150** : 628–634.

- Calvo del Castillo, H., J.L. Ruvalcaba, and T. Calderón. 2007. Some new trends in the ionoluminescence of minerals. *Anal Bioanal Chem.*, **387** : 869–870.
- Campbell, J.L., and J.A. Maxwell. 2005. *GUPIXWIN* [computer software], Version 2.1 rev 360. University of Guelph, Ontario, Canada.
- Carter, G., and J.S. Colligon. 1968. *Ion bombardment of solids*. London : Heinemann Education Books, Ltd.
- Chaiwong, C., L.D. Yu, K. Schinarakis, and T. Vilaithong. 2005. Optical property modification of ruby and sapphire by N-ion implantation. *Surf. Sci.*, **196** : 108–112.
- Chanthaphun, C. 2008. *Treatment of Tourmaline from Africa by using irradiation technique*, M.S. Independent Study, Chiang Mai University. [In Thai].
- Clark, J. 2000. ELECTRON AFFINITY [Online]. Available: <http://www.chemguide.co.uk/atoms/properties/eas.html> [2012, September 1].
- Emmeth, J.L. et al. 2003. Beryllium diffusion of ruby and sapphire. *Gems&Gemology.*, (winter 2003) : 89–90.
- Emmeth, J.L., and T.R. Douthit. 1993. Heat treating the sapphires of Rock Creek, Montana, *Gems&Gemology.*, (winter 1993) : 260–264.
- Facska, S. 2012. “Ion irradiation of Ge: from sponge-like structure to periodic pattern formation”. *18<sup>th</sup> IBMM conference, Qingdao P.R. China, 2-7 September 2012*. Presentation data.

- Fox, M. 2001. *Optical properties of solids*. New York : Oxford University Press.
- Guan, P., D.R. McKenzie, and B.A. Paithorpe. 2006. Patterns of energy dissipation in 3D fcc lattices after ion impact. *J. Phys. Condens. Matter.*, **9** : 5015.
- Hamblin, W.K., and E.H. Christiansen. 2000. *Earth's dynamic system*. 10<sup>th</sup> edition. the USA. : Prentice Hall, p.695.
- Hitachi High Technologies America, Inc. 2012. UV-Visible-NIR Spectrophotometers U-4100 UV-Vis-NIR [Online]. Available: <http://www.hitachihta.com/products/life-sciences-chemical-analysis/uv-visible-spectrophotometers/uv-visible-nir-spectrophotome> [2012, August 10].
- Hlaing, U.T. 1993. Mong Hsu ruby update. *Aust. Gemmol.*, **18** : 157.
- Intarasiri, S. 2010. *Correlation on corundum color grading and spectra of IL & PIXE spectrosocpy*. Chiang Mai University, Institute for science and technology research and development.
- Intarasiri, S., D. Bootkul, L.D. Yu, T. Kamwanna, S. Singkarat, and T. Vilaithong. 2009. Gemological modification of local natural gemstones by ion beams. *Surf. Sci.*, **203** : 2788–2792.
- Johansson, S.A.E., J.L. Campbell, and K.G. Malmqvist. 1995. *Particle-Induced X-ray Emission Spectrometry (PIXE)*. New York : John Wiley & Sons, Inc.
- Kamwanna, T. 2008. *Developments of ion beam analysis techniques for micro and nanoscale materials*, Ph. D thesis, Chiang Mai University.

Kamwanna, T., U. Tippawan, S. Intarasiri, and S. Singkarat. 2010. The combined PIXE and IL investigations of gemstones. *Thai J. Phys.*, **6** : 232 – 236.

Kitbutrawat, P. 2006. *Heat treatment for some green sapphire from Attapeu of Laos*, B.S. report, Chulalongkorn University.

Kittel, C. 2005. *Introduction to solid state physics*. 8th ed., New York : John Wiley & Sons, Inc.

Krua-in, C. 2006. *Analysis system for luminescence in solid stimulated by ion beam*, M.S. thesis, Chiang Mai University.

Labphu, T. 2002. *Operational characteristics of a vaporizer ion source of 200 DF-5 Varian implanter*, M.S. thesis, Chiang Mai University.

Lee, J.D. 1991. *Concise inorganic chemistry*. London, the UK : Chapman & Hall.

Lehmann, G., and H. Harder. 1970. Optical spectra of Di- and Trivalent iron in corundum, *Am Mineral.*, **55** : 98–105.

Lever, A.B.P. 1968. *Inorganic electronic spectroscopy*. Amsterdam, the Netherlands : Elsevier Publishing Company.

Limsuwan, P., S. Meejoo, A. Somdee, K. Thamaphat, T. Kittiauchawal, A. Siripinyanond, and J. Krzystek. 2008. Revelation of causes of colour change in beryllium-treated sapphires. *Chin. Phys. Lett.*, **25** : 1976–1979.

University of Guelph. 2003. *Maestro* [computer software], Model A65-B32 UMCBI Kernel Version 6.03., Ontario, Canada.

McClure, D.S. 1962. Optical spectra of transition-metal ions in corundum. *J. Chem. Phys.*, **36** : 2757–2779.

Miessler, G.L., and D.A. Tarr. 2003. *Inorganic Chemistry*. 3rd ed. Minneapolis : Prentice Hall.

Milos, M., S. Kairouani, S. Rabaste, and A. Hauser. 2008. Energy migration within the  $^2E$  state of  $\text{Cr}^{3+}$ . *Coord. Chem. Rev.*, **252** : 2540–2551.

Ministry of Commerce. 2012. International trade statistical of Thailand [Online]. Available: <http://www2.ops3.moc.go.th> [2012, August 16], [In Thai].

Moroño, A., and E.R. Hodgson. 1997. On the origin of the  $\text{F}^+$  centre radioluminescence in sapphire. *J. Nucl. Mater.*, **249** : 128–132.

Motic. n.d. SMZ-168 [Online]. Available: <http://www.motic.com/ProductDetail.aspx?r=Eur&lang=en&cid=&pid=25> [2012, August 11].

Mukhurov, N.I., 2010. Photoluminescence off-centers in films of anodic alumina. *J. Appl. Spectrosc.*, **77** : 549–553.

Nassau, K. 2001. *The physics and chemistry of color*. 2nd ed. New York : John Wiley & Sons, Inc.

Nassau, K. 1978. The origins of color in minerals, *Am Mineral.*, **63** : 220.

Ocean Optics, Inc. 1999. *OOIBASE32* [computer software], Version 2.0.5.3. Florida, the USA.

OriginLab Corporation. 2007. *OriginPro 8* [computer software], Version 8.0724. Northampton, Massachusetts, the USA.

Osipowicz, T., T.S. Tay, I. Orlic, S.M. Tang, and F. Watt. 1995. Nuclear microscopy of rubies: trace elements and inclusions. *Nucl. Instr. and Meth.*, **B104** : 590–594.

Pearce, N.J.G., W.T. Perkins, J.A. Westgate, M.P. Gorton, S.E. Jackson, C.R. Neal, and S.P. Chenery. 1997. A compilation of new and published major and trace element data for NIST SRM610 and NIST SRM612 glass reference materials. *Geostandard Newslett.*, **21** : 137.

Powell, R.C., B. Di Bartolo, B. Birang, and C.S. Naiman. 1967. Fluorescence studies of energy transfer between single and pair Cr<sup>3+</sup> systems in Al<sub>2</sub>O<sub>3</sub>. *Phys. Rev.*, **155** : 296-308.

Profio, A.E. 1979. *Radiation shielding and Dosimetry*. New York : John Wiley & Sons, Inc.

Read, P.G. 2005. *Gemmology*. 3rd ed. Oxford : Elsevier Ltd.

Rothamel, U., J. Heber, and W. Grill. 1983. Vibronic Sidebands in ruby. *J. Phys. Condens. Matter.*, **50** : 297.

Sanchez, J.L., T. Osipowicz, S.M. Tang, T.S. Tay, and T.T. Win. 1997. Micro-PIXE analysis of trace element concentrations of natural rubies from different locations in Myanmar. *Nucl. Instr. and Meth.*, **B130** : 682.

- Somsorn, S. 2008. *Instruction manual of RBS, RBS/Channeling, PIXE and IL analysis techniques*. Chiang Mai University. [In Thai.].
- Spinolo, G., V. Palanza, A. LeDonne, and A. Paleari. 2009. Absorption and emission spectroscopy in natural and synthetic corundum. *Geophys. Res. Lett.*, **11** : 1299–1301.
- Srisupawatana, S. 2011. Srinakharintheawiroj University, Personal communication.
- Sun, T.T., U.T. Hlaing, W. Atichart, W.W. Thar, and S.M. Tang. 2001. A preliminary study of sapphire from Myanmar (Burma). *Proc. 28<sup>th</sup> Int. Gemmological Conf.*, 90–93.
- Sutherland, F.L., D. Schwarz, E.A. Jobbins, R.R. Coenraads, and G. Webb. 1998. Distinctive gem corundum suites from discrete basalt fields: a comparative study of Barrington, Australia, and West Pailin, Cambodia, gemfields. *J. Gemmol.*, **26** : 65–85.
- Tang, S.M., S.H. Tang, K.F. Mok, A.T. Retty, and T.S. Tay. 1989. Study of natural and synthetic rubies by PIXE. *Appl. Spectr.*, **43** : 222.
- Tang, S.M., S.H. Tang, T.S. Tay, and A.T. Retty. 1988. Analysis of Burmese and Thai rubies by PIXE. *Appl. Spectr.*, **42** : 44–48.
- Teo, E.J., A.A. Bettoli, T. Osipowicz, A. Hao, S.J. Chua, and Y.Y. Liu. 2004. Depth resolved luminescence imaging of epitaxial lateral overgrown GaN using ionoluminescence. *J. Cryst. Growth.*, **268** : 494–498.
- Themelis, T. 1992. *The heat treatment of ruby and sapphire*. the USA. : Gemlab Inc.

Townsend, P.D., P.J. Chandler, and L. Zhang. 1994. *Optical effects on ion implantation*, 2nd ed., New York : Cambridge University Press.

Turner, J.E. 1995. *Atoms, radiation, and radiation protection*. 2nd ed., New York : John Wiley & Son, Inc.

Ueda, J., and S. Tanabe. 2010. Preparation of glass ceramics containing ruby crystals. *J. Am. Ceram. Soc.*, **93** : 3084–3087.

University of Leipzig. 2010. Ion beam analytical methods [Online]. Available: [http://www.uni-leipzig.de/~nfp/Research/Methods/body\\_methods.html](http://www.uni-leipzig.de/~nfp/Research/Methods/body_methods.html) [2011, August 16].

Varian/Extrion Division. 1980. *Model 200-DF4/DF5 Production ion implanter maintenance manual*. Blackburn Industrial park Gloucester, Massachussettes, the USA.

Vij, D.R. 1998. *Luminescence of solid*. New York : Plenum Press.

Vincent, A. 2001. *Molecular symmetry and group theory*. 2nd ed. New York : John Wiley & Sons.

Yu, L.D. 1997. *Ion implantation and materials modification*. Fast neutron research facility, Department of Physics, Faculty of Science, Chiang Mai University.

Ziegler, J.F., M.D. Ziegler, and J.P. Biersack. 2008. SRIM [computer software], Version SRIM-2008.04. [Online] Available: <http://www.srim.org> [2011, March 3].