Multi-photon luminescence measurement of natural and treated diamonds

*Shoko Odake[1], Hiroaki Ito[2], Hiroshi Takahashi[3], Shingo Ono[2]

1. GIA Tokyo Godokaisha, 2. Nagoya Institute of Technology, 3. Gemological Institute of America

Treatments are widely used to modify diamond’ s body color to improve it's value as a gem. Typical examples of treatments are annealing in high-temperature and high-pressure (HPHT) environment to remove brownish color from diamonds and irradiation with an electron beam to add bluish color. To distinguish between natural and treated diamonds, spectroscopic measurements are used. The spectroscopic measurements currently used are limited to the surface and the area near the surface of the diamond. In order to accurately and quickly distinguish between natural and treated diamonds, a method for evaluating the defect distribution inside the diamond is needed. In this study, distribution of defects in natural and treated diamonds were evaluated three-dimensionally by using multi-photon luminescence measurements.
The measurements were performed on natural untreated, HPHT treated (type I and type IIa), and electron beam irradiated diamonds. The measurement of multi-photon luminescence is widely used for biological research, and is a method capable of measuring three-dimensional defects inside a sample with nondestructive and high spatial resolution. A multi-photon laser-scanning microscope (Olympus, FV1200MPE) was used for the measurement. In a multi-photon laser-scanning microscope, excitation light from a femtosecond laser is reflected by a mirror and focused and irradiated to a sample using an objective lens. By using a galvanometer mirror, excitation light is moved in the XY direction, and the objective lens is moved in the optical axis direction, and scanning is performed in the Z direction, thereby enabling three-dimensional scanning. The multi-photon luminescence generated from the samples were collected using the objective lens, and the multi-photon luminescence intensity was measured using a photomultiplier tube. Band pass filters were used to isolate defects in specific wavelength ranges.
As a result, in natural diamonds the differences of the color center in different growth planes were visualized three-dimensionally. In treated diamonds, distribution of 1-micron size defects in HPHT were visualized. In irradiated diamonds, irradiation-related defects were observed only in the surface area. In this presentation, we will discuss details about differences between conventional methods and multi-photon luminescence measurements.

Keywords: Diamond, Multi-photon luminescence, Treatment

