NRL Teams with Smithsonian Institution, Penn State University and Ocean Optics to Study Properties of the Hope Diamond

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Since January, scientists from the Naval Research Laboratory's Chemistry Division have been studying the optical properties of the Hope Diamond, at the invitation of the Smithsonian Institution. In collaboration with the Curator of the National Gem and Mineral Collection at the Smithsonian, Dr. Jeffrey Post, NRL chemist Dr. James Butler, NRL-NRC postdoctoral fellow Dr. Sally Magana, Dr. Roy Walters of Ocean Optics, and Penn State University Professor, Peter Heaney, have conducted spectroscopy tests on the legendary Hope Diamond and other colored diamonds.

The invitation from the Smithsonian presented a rare, hands-on opportunity for Drs. Butler and Magana to study optical defects in natural diamonds with color, and more importantly, the largest known natural blue diamond. Blue diamonds are of particular interest because of their semi-conducting electrical properties as well as the familiar hardness, chemical resistance, thermal, and optical properties. In addition to the Hope Diamond, weighing 45.52 carats, the researchers also studied the Smithsonian's Blue Heart Diamond (30.62 cts) and a suite of 239 colored diamonds, the Aurora Butterfly Collection, on loan to the Smithsonian through July from Alan Bronstein of New York.

While pure diamonds consist of only carbon and are colorless, most natural diamonds contain impurities, usually nitrogen. Color in a natural diamond is definite evidence of an impurity or defect. In the case of the Hope Diamond, the dominant impurity is believed to be boron, whose presence in the lattice can cause the blue color. Dr. Butler, who has been involved in the study and synthesis of diamonds at NRL since the mid-1980s, grows boron-doped and undoped diamonds in the laboratory to research their use as thermal, optical, and electrically semi-conducting materials for such DoD applications as all- electric platforms requiring high-voltage high-current devices, thermal management in electronics, and Micro-electro-mechanical systems (MEMS) for sensors and communications. Since high quality is critical to growing semi-conductor grade diamond materials, learning about the impurities inherent to natural diamonds is an important foundation to understanding the defects observed in synthetic diamond.

The Hope Diamond was known to have an unusual reddish-orange long-lived phosphorescence - i.e. when illuminated with ultraviolet (UV) light and observed in a darkened room, the Hope diamond would glow for many minutes after the light source was turned off, appearing like a hot coal from a fire. While this phosphorescence had been photographed, it had never been studied scientifically. Such phosphorescence, particularly with an intense red color, is a rare phenomena in natural diamonds.

Working after-hours, when the diamonds were not on display at the Smithsonian Museum of Natural History, over several week-long periods, the researchers took equipment to the Smithsonian vaults, where they looked at the spectroscopic characteristics of the Hope and other diamonds. Using highly sensitive spectroscopy equipment belonging to NRL and Ocean Optics, the researchers were able to study optical absorption, Raman spectroscopy, fluorescence, phosphorescence, and particularly the spectral and temporal properties of the phosphorescence.

Little information is currently known about phosphorescence of natural diamonds, however it is known that these properties are brought about by UV-activated defects within the diamond. It is also documented that some synthetic diamonds phosphoresce much more than natural diamonds.

Analysis of the data is underway, assisted by NRL summer intern, Derrick Thiel of NOVA Research. The researchers are now examining similarities between the Hope, the Blue Heart, and the blue/grey and other colored diamonds from the Aurora collection. Although they have not yet tied the fluorescent or phosphorescent properties to any specific defect, all of the blue diamonds have phosphoresce bands centered at 500 and 660 nm wavelengths. Depending on the relative intensities and decay times at these two wavelengths, the phosphorescence might appear aqua, pink, orange, or red.

About the U.S. Naval Research Laboratory

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