4th International Gemological symposium, San Diego

New Technologies Used to Identify Colored Stone Treatments

George R. Rossman

The detection of treatments in gem materials involves the application of a variety of complimentary analytical methods that range from careful observation at low magnification to expensive and involved analyses with elaborate instruments. The need for the latter is driven by the increasing sophistication of treatment technology.

Significant advances have been made in the chemical analysis of minerals with the introduction of a variety of highly sensitive methods for elemental analysis. For example, researchers are scrutinizing several new instruments for their possible application to the detection of beryllium diffusion in corundum. Like laser ablation−inductively coupled plasma−mass spectroscopy (LA-ICP-MS), laser-induced breakdown spectroscopy (LIBS) provides rapid and comparatively inexpensive analysis of a wide range of elements, with many detected in the parts-per-million range. It is a rapidly evolving technology that can give results within minutes from the time the sample is introduced into the instrument. Secondary ion mass spectroscopy (SIMS) likewise can determine a wide range of elements, with many in the parts-per-billion range. However, SIMS requires considerable sample and instrument preparation time, and the cost of the analysis is significantly higher than with LA-ICP-MS and especially LIBS. The application of these methods to gemological analysis has been reviewed by Ahmadjan and Kitawaki (2006). If properly calibrated, SIMS can also determine the isotopic composition of major and minor components in solids. To date, this application has been primarily directed at origin studies, but it may be useful in the future for the detection of treatments, coatings, and synthetics.

Electron paramagnetic resonance (EPR) spectroscopy has existed for more than 50 years but has not found widespread application in gemology. A sample is placed in a high–frequency microwave field and subjected to an intense, variable magnetic field. Ions containing unpaired electrons will produce strong absorption of the microwaves at characteristic magnetic field strengths. EPR it is an exquisitely sensitive technique for detecting certain components, such as those produced when ultrahigh-temperature treatments are applied to gem minerals. The single-negative charged O^- ion that forms in beryllium-diffused corundum is an example (figure). Beryllium-diffused corundum, in particular, could motivate improvements in the sample-size limitations (~3 mm) of many current instruments.

Advances in electron microscopes have also allowed improved detection of coatings and fillings. Resolutions in the 0.01 μm range are now routinely attained. Currently, such instruments are providing spectacular insight into such treatments as well as greatly improved imaging of natural inclusions and defects in stones.

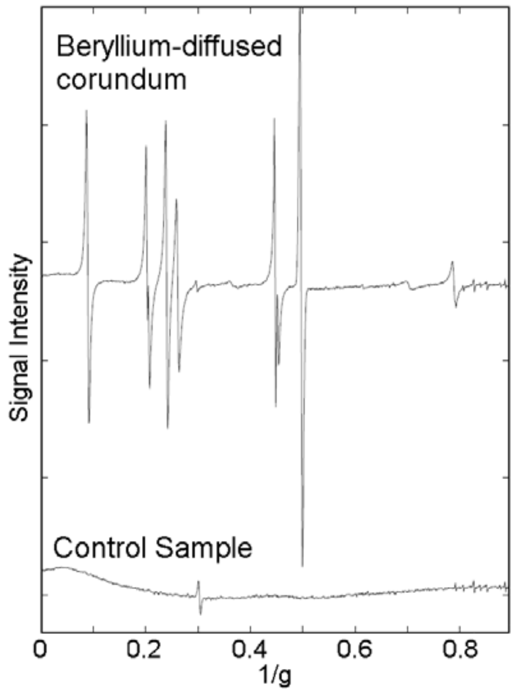

Figure. The EPR spectrum of a natural corundum that was Be diffused at high temperature (top) is significantly different from that of an untreated (control) sample of synthetic corundum. The term “g” is a calculated physical property that is proportional to the applied magnetic field strength. The graph plots the absorption caused by resonating electrons in paramagnetic centers as the magnetic field is varied.

Dr. Rossman is professor of mineralogy at the California Institute of Technology in Pasadena, California. grr@gps.caltech.edu

Reference:

Ahmadjan A, and Kitawaki H (2006) Applications of Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) to Gemology. Gems & Gemology 42(2), 98-118.