Cathodoluminescence microscopy and spectroscopy and their implication for the laboratory astrophysics

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Cathodoluminescence is a characteristic photon emission in the visible light range of an electromagnetic spectrum caused by the interaction between high-energy electron bombardment and solid. Its implication for the Geosciences has already been described by previous studies, but the application for the Laboratory Astrophysics has not been debated in details, up to date. This overview study is to provide a summary of the preliminary examinations of the cathodoluminescence investigations (as potentials of this technique) in the laboratory analogous materials providing some important information about the possible formation mechanism of forsterite in the Early Solar System and diamonds in the planetary nebula as well as determination of shock wave historry of the fine-grained astromaterials, respectively.

According to Gucsik et al. [1] micro-and nanodiamond samples from various origins such as Chemical Vapor Deposition (CVD), High-Pressure High-Temperature (HPHT), Ultradispersive Detonation Diamonds (UDD) as well as a meteoritic (MD) one were investigated by cathodoluminescence microscopy and spectroscopy at room and liquid nitrogen temperatures. According to the preliminary examinations of these particles, CL intensity of the bands observed in all selected samples tends to increase with a decrease in temperature as temperature quenching effect. This indicates a clear relationship between sample temperature and physical properties of diamond.

Gucsik et al. [2] described CL properties of the experimentally-grown forsterite chondrules in a super cooled melt. They found that the color CL image forsterite exhibits significant blue luminescence in the main branches of the interior structure of lab-chondrule. A new CL band centered at 450–525 nm in blue to green region might be assigned to a microdefect-related center, which is a diagnostic peak for the forsterite that was formed due to the rapid growth. These results can also give new insights to the crystallization processes of the first solid particles in the early Solar System.

Shock metamorphism plays a key role in evolution of the planetary bodies occurred by the impact events, which results irreversible changes of the minerals in the target rocks. Moreover, it is important to know the stages of shock metamorphism and their associated fine-scale shock effects as they could modify the age determination analyses of these samples, for instance. However, the nature and formation mechanism of the shock-induced microdeformations as well as microstructures of astrominerals such as samples form the sample return missions and Interplanetary Dust Particles (IDPs), are controversial. The Scanning Electron Microscope-Cathodoluminescence (SEM-CL) microscopy combined with Micro-Raman spectroscopy provides high-resolution CL imaging at submicron scale not only the Planar Deformation Features (PDFs-as one of the most important mineralogical indicators of shock metamorphism), but also microstructures of the high-pressure polymorphs of minerals [3-9].

Consequently, the SEM-CL instrumentation has been applied successfully to study of the diamond formation in the planetary nebula, crystallization of forsterite in Early Solar System and the fine-scale shock effect determination of astromaterials.

Keywords: Cathodoluminescence, SEM, asteroid, Hayabusa, astromaterials, astrophysics

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