

## Continued Progress in Spectroscopic Characterization of Scintillators with Cation Isoelectronic Impurities

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Scintillators activated by isoelectronic impurities represent an important class of luminescent materials that combine high radiation hardness, fast response, and good thermal stability. Cation isoelectronic impurities (CIIs), are dopant ions that substitute host cations without changing the overall charge state of the lattice. Despite their electrical neutrality, CIIs can strongly perturb the local electronic structure of the host crystal by introducing short-range, non-Coulombic potentials that efficiently localize low-energy excitations such as electrons, holes, or excitons. As a result, CIIs play a crucial role in the formation of luminescence centers in a wide range of insulating and wide-bandgap scintillation materials [1].

Scintillators based on CIIs are particularly attractive for applications in the UV and blue spectral ranges, where conventional activator ions often suffer from thermal quenching or slow decay kinetics. Notable examples include alkali halide compounds doped with monovalent isoelectronic ions, such as CsI:Na [2], as well as complex oxide scintillators with garnet structure, including Sc-doped Y<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> (YAG:Sc) and Lu<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> (LuAG:Sc) [3]. These materials demonstrate high radioluminescence yields, in some cases reaching 30–85% of that of the benchmark NaI:Tl scintillator, while maintaining superior temperature stability and radiation resistance.

A major challenge in the investigation of isoelectronic impurity centers arises from the fact that CIIs typically do not possess internal electronic transitions in the UV–visible spectral range. Consequently, their luminescent behavior cannot be directly probed using conventional absorption or emission spectroscopy. To overcome this limitation, VUV luminescence spectroscopy under excitation by synchrotron radiation (SR) has emerged as a powerful tool. This technique enables direct investigation of excitation processes, exciton localization, and energy transfer mechanisms involving CIIs and related defects, such as antisite defects, which often act as electronic analogues of isoelectronic impurities in complex oxides.

The comprehensive spectroscopic investigations presented in this study, based on cathodoluminescence, X-ray–excited luminescence, tunnel luminescence, and thermally stimulated luminescence measurements performed on CsI:Na and LuAG:Sc crystals, offer deeper insight into charge carrier trapping, detrapping, and recombination processes related to CII-associated centers across a wide temperature range. Understanding these mechanisms is essential for optimizing scintillation efficiency, timing performance, and long-term stability.

Overall, scintillators with CIIs constitute a versatile and promising materials platform for advanced radiation detection applications, including medical imaging, high-energy physics, and beam diagnostics. Continued progress in spectroscopic characterization and defect engineering is expected to further enhance their performance and expand their practical use.

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