The potential use of single-crystal perovskite $MAPbI_3$ for X-ray detection in radiodiagnostic rooms

The use of X-ray detectors in medical imaging diagnosis is critical since they enable healthcare professionals to visualize the internal structures of the body, such as bones, teeth, the chest, and the abdomen. In a typical X-ray imaging procedure, radiation passes through the patient's body, and a detector captures the attenuated signal. A significant factor contributing to this attenuation is the composition and density of the tissues as well as the properties of the detector itself. According to Fosbinder & Orth (2012), the efficiency of a detector in capturing X-rays is heavily dependent on its photoelectric absorption coefficient, which is directly related to the atomic number (Z) of the detector material. Nowadays, silicone-based detectors are the standard due to their stability, efficiency, and well-established integration into imaging systems. However, their performance has limitations, particularly regarding sensitivity and adaptability to emerging imaging technologies, as well as their relatively low atomic number (Z=14), which limits their sensitivity to X-rays.

To address these challenges, new materials like Perovskites are being explored for their potential to enhance detection capabilities due to their high X-ray absorption and good carrier mobility (Wei et al., 2016). A notable candidate in the perovskite crystal family for X-ray detection is methylammonium lead iodide ($MAPbI_3$). After being developed for use in solar cells, $MAPbI_3$ has rapidly gained attention in the field of radiation detection. Its appeal lies in its unique atomic composition, mainly lead and iodine, which provides a much higher probability of X-ray absorption than silicone due to its heavy atoms like lead (Z=82) and iodine (Z=53), which, due to a physical principle known as photoelectric absorption, increase drastically, combined with an excellent charge transport characteristics, position this crystal as strong potential to replace or enhance traditional silicone-based detectors (Lin et al., 2023).

To explore this material's potential use in medical imaging, we designed and simulated a detection system using Proteus software, simulating both $MAPbI_3$ and Si detectors under the same X-ray exposure conditions. The simulation included the complete circuitry of an X-ray source and modeled how the materials absorb and convert radiation into electrical signals by using electrical equivalent circuits. The results showed that $MAPbI_3$ detectors demonstrated a 45% improvement in detection response compared to their silicone counterparts across the medical imaging energy range (20-140 keV). These results are consistent with previous studies showing that perovskite detectors exhibit greater sensitivity than silicone even at lower X-ray energies, such as those used in crystallography and diffraction (Yakunin et al., 2025). The improved performance of $MAPbI_3$ detectors can be attributed not only to their high atomic number components but also to their efficient charge carrier mobility and low defect density. Additionally, recent research has shown that perovskite-based devices maintain long-term operational stability under exposure to ionizing radiation, an essential factor for clinical deployment (Jošt et al., 2021). As these materials have already demonstrated durability in photovoltaic applications, they are likely to perform well in X-ray detection systems as well.

Our findings suggest that perovskite-based detectors could be a valuable innovation in the field of radiodiagnosis. Even though current medical imaging detectors are almost exclusively based on silicone, perovskites may improve diagnostic outcomes, increase sensitivity, and provide the way for new technologies. It would be interesting to investigate whether this advantage extends to higher energy ranges, such as those used in radiation therapy. In this way, perovskites could not only revolutionize X-ray imaging but also contribute to the detection of high-energy radiation (up to MeV) used in cancer treatment rooms.

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