Supplementary information:

X-ray dose effects and strategies to mitigate beam damage in metal halide perovskites under high brilliance X-ray photon source

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Beam dose calculation

The X-ray dose was calculated by the total energy absorbed (J) by the sample mass (Kg). The unit 1 J/Kg equals 1 Gray (Gy), the SI unit of radiation dose.

The dose is calculated by the formula \( D = \frac{N_E}{m} \), where \( N \) is the number of absorbed photons, \( E \) is the photon energy, and \( m \) is the mass of the sample irradiated by the X-rays.

The \( N \) is calculated by the formula \( N = (1 - e^{-\mu d})I_0t \), where \( d \) is the sample thickness, \( \mu \) is the X-ray attenuation length, \( I_0 \) is the total photon flux incident on the sample, and \( t \) is the exposition time. The mass \( m \) can be calculated by the formula \( m = \rho Ad \), where \( \rho \) is the sample density and \( A \) the X-ray irradiated area.

The dose can be calculated by the following Python code:
**Figure S1:** X-ray fluorescence spectrum obtained with X-ray excitation energy of (a) 10 keV and (b) 14 keV. The spectrum from each pixel was squeezed to obtain the spectrum shown here. The highlighted peak region was used to obtain the nano-XRF maps.

**Figure S2:** Iodine nano-XRF map obtained with the energy of 10 keV and total absorbed dose of 2.9 GGy in two different new regions of the sample.
Figure S3: (a) μ-FTIR maps of the perovskite obtained integrating N-H stretch vibrations (3100-3400 cm$^{-1}$) for different X-ray beam doses in air, and (b) profile of the damaged area. Despite the smaller spatial resolution of the μ-FTIR at resonance 1700 cm$^{-1}$ we chose this one for a more quantitative analysis because the changes in the background in this region are negligible. On the other side, the 3100-3400 cm$^{-1}$ region shows a change in the background, then becomes difficult for a quantitative analysis using these resonances.

Figure S4: Optical microscopy images for different doses (a) 2.9 GGY, (b) 1.9 GGY and (c) 0.7 GGY obtained in air and room temperature.

Figure S5: Effect of different X-ray beam energies with similar absorbed dose rates. The signal corresponds to the iodine XRF emission.
**Figure S6**: Optical microscopy images for environment and temperatures (a) RT-Air, (b) RT-N₂ and (c) Cryo-N₂ obtained with the dose of 2.9 G Gy.

**Table S1: Total absorbed photons for each dose**

<table>
<thead>
<tr>
<th>Energy (KeV)</th>
<th>Area (µm x µm)</th>
<th>Total time (s)</th>
<th>G Gy</th>
<th>Total absorbed photons (x 10²¹ ph/m²)</th>
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<tbody>
<tr>
<td>10</td>
<td>5 x 5</td>
<td>610</td>
<td>2.9</td>
<td>2.53</td>
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<tr>
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<td>410</td>
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<td>1.70</td>
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<td>150</td>
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<tr>
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<td>171</td>
<td>0.0015</td>
<td>0.0013</td>
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<tr>
<td>14</td>
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<td>171</td>
<td>0.013</td>
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