Supplementary Information

Spectroscopic investigation of the solvated $MAPbI_3$ transition to perovskite crystals: A temperature-dependent Raman study

Abdul Zeeshan Khan[a], Muhammad Shafi[b], Tarek. A. Kandiel [a,c,*], Abdulaziz A. Al-Saadi [a,b,*]

[a]Department of Chemistry, King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, 31261, Saudi Arabia.

[b]Interdisciplinary Research Center for Refining and Advanced Chemicals (IRC-RAC), King Fahd University of Petroleum & Minerals (KFUPM), Dhahran 31261, Saudi Arabia

[c]Interdisciplinary Research Center for Hydrogen Technologies and Carbon Management (IRC-HTCM), King Fahd University of Petroleum & Minerals (KFUPM), Dhahran, 31261, Saudi Arabia.

Email: tarek.kandiel@kfupm.edu.sa; kandiel@science.sohag.edu.eg; asaadi@kfupm.edu.sa

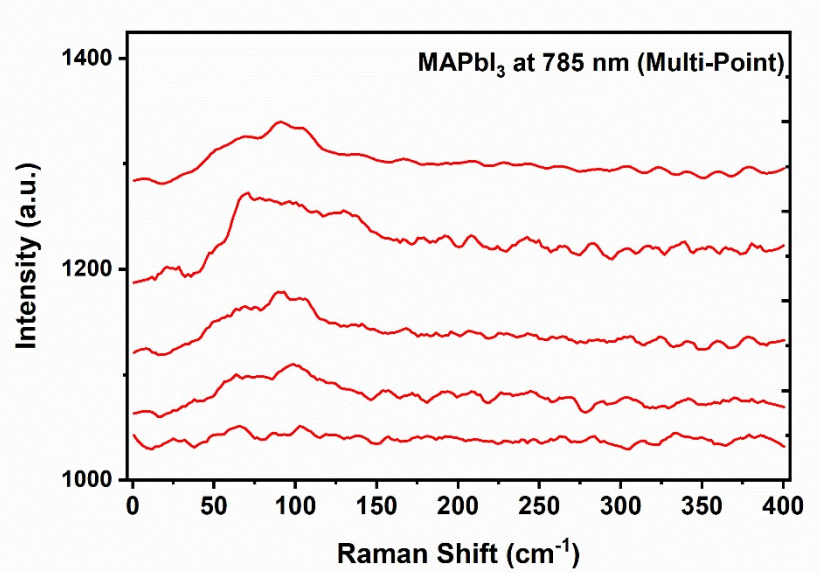

Figure S1. Raman spectra of $MAPbI_3$ crystals recorded at 785 nm excitation from multiple surface point positions, confirming Raman inactivity under non-resonant conditions, with only weak, broad bands (60-110 cm^{-1}) attributed to disorder-activated modes.

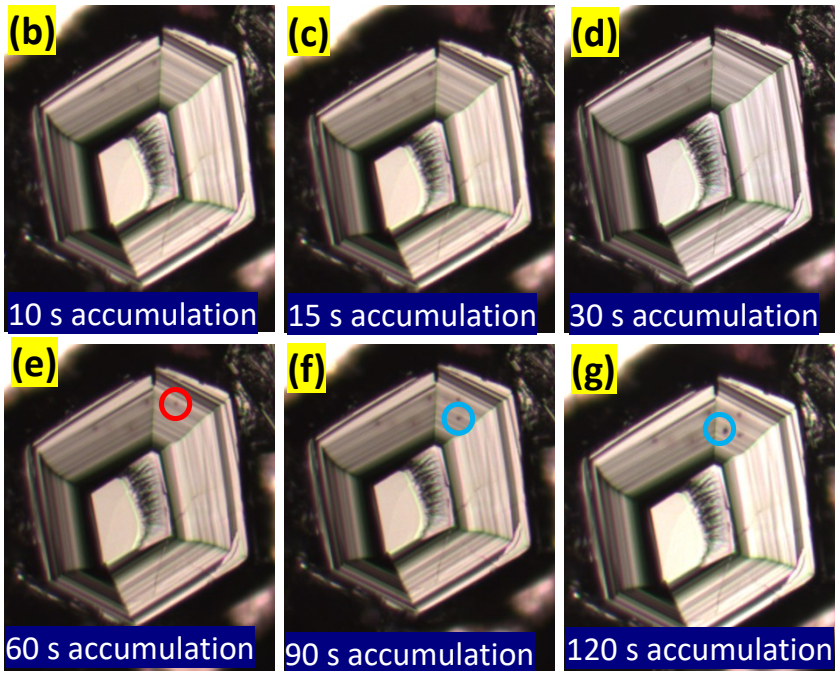

Figure S2. (b-g) Optical microscopic images of $MAPbI_3$ crystals at different acquisition times (10,15, 30, 60, 90, 120 s). Conditions: 600gr/mm grooving,10x focusing, and 532 nm laser excitation source.

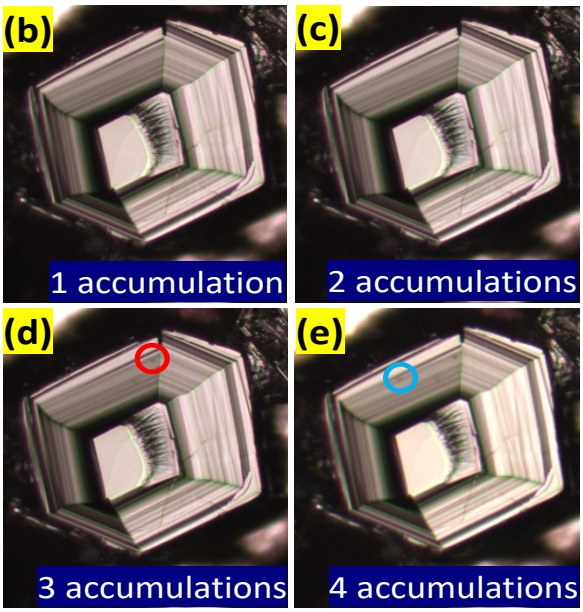

Figure S3. (b-e) Optical microscopic images of $MAPbI_3$ crystal at different accumulation frequencies (1, 2, 3, and 4). Conditions: 15 sec acquisition time, 600gr/mm grooving,10x focusing, and 532 nm laser excitation source.

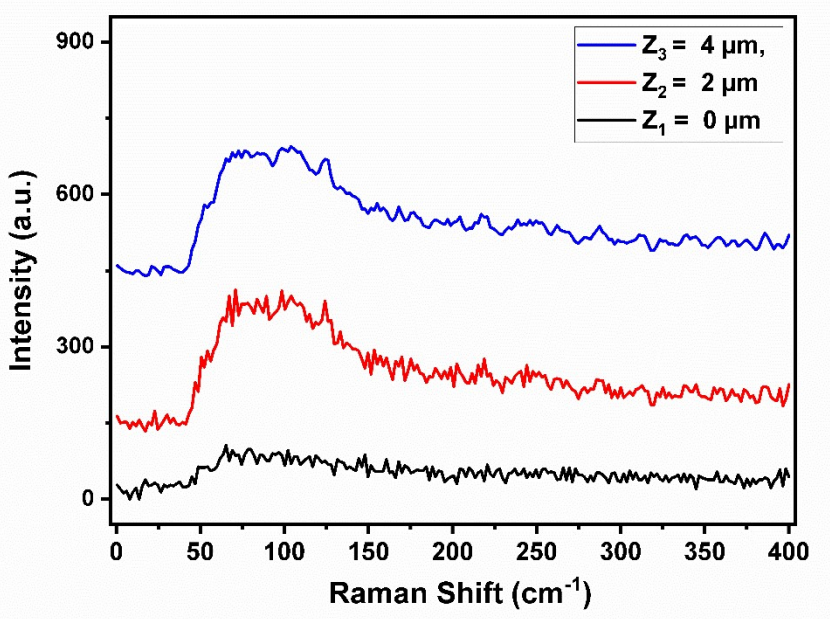

Figure S4. Depth-dependent (z-scan) Raman spectra of $MAPbI_3$ crystals recorded using 785 nm excitation (1.58 eV) at different focal depths (Z_1 = 0 µm, Z_2 = 2 µm, Z_3 = 4 µm)

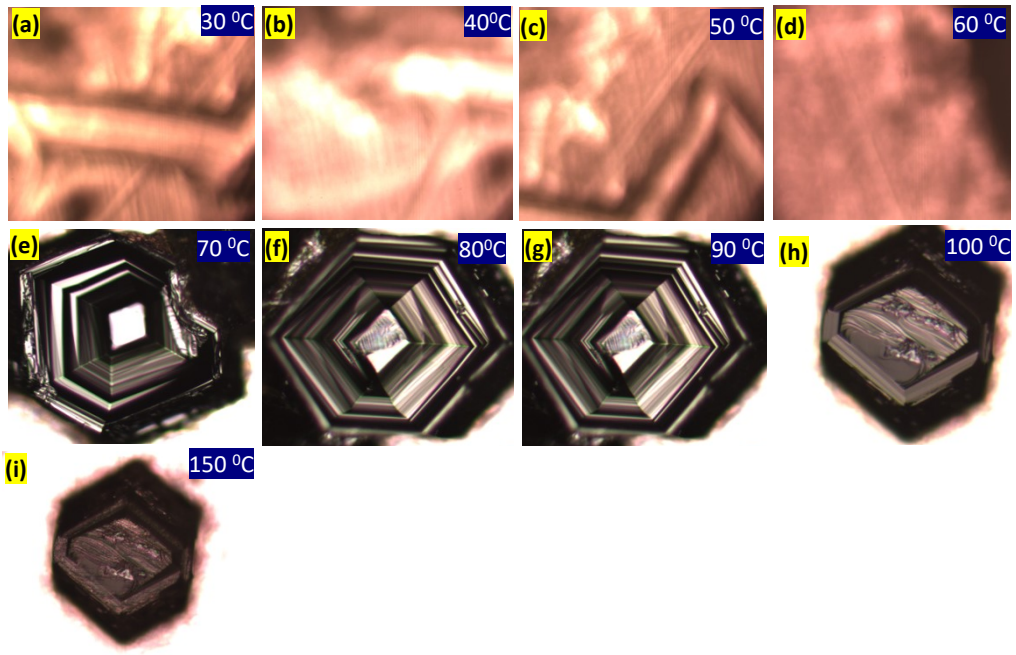

Figure S5: (a-h) Optical microscopic images taken while collecting the temperature-based Raman spectra of solvated $MAPbI_3$ were measured in an N_2 environment and are presented in Fig. 5.

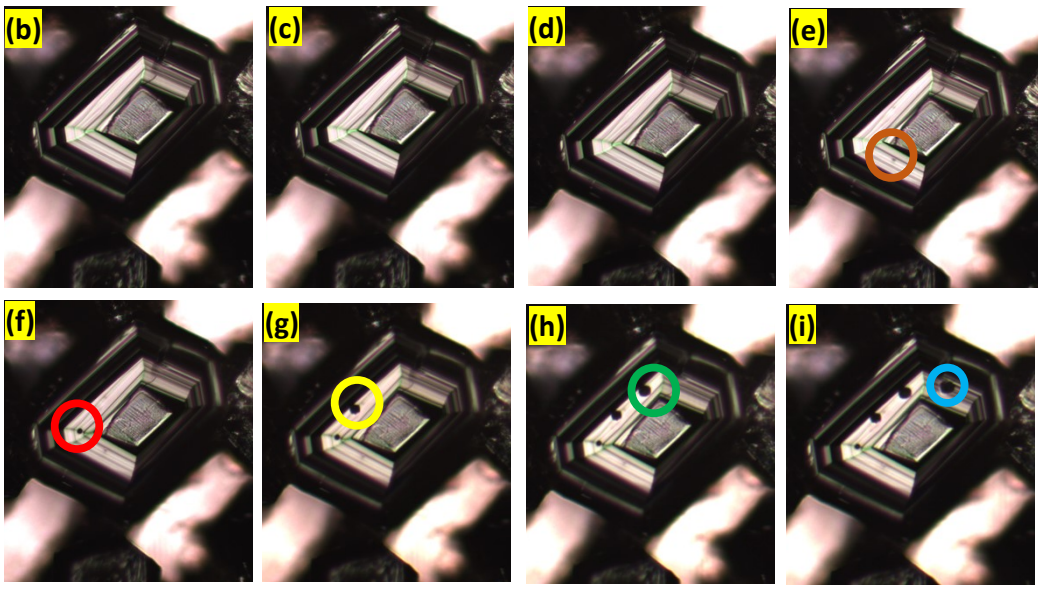

Figure S6. (b-i) Optical microscopic images of $MAPbI_3$ crystals at different laser power adjusted using different neutral density filters (ND 0.1 to 100 %) and a 10x lens. Conditions: 15 sec with 2-time acquisition, 600gr/mm grooving, 532 nm laser excitation source.

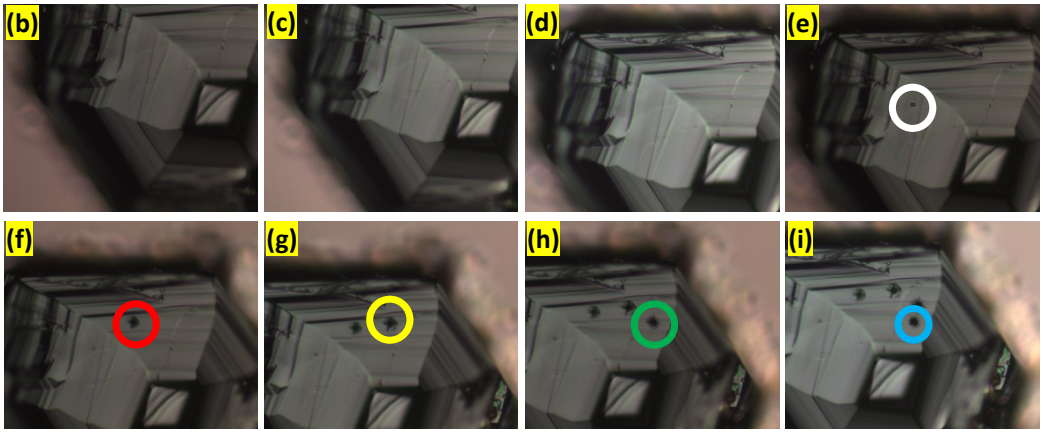

Figure S7. (b-i) optical microscopic images of $MAPbI_3$ crystals at different laser power adjusted using different neutral density filters (ND 0.1 to 100 %) and 50x lens, Conditions: 15 sec with 2-time acquisition, 600gr/mm grooving, 532 nm laser excitation source.