Pressure-induced 2D-3D conversion in hybrid lead iodide layered perovskite

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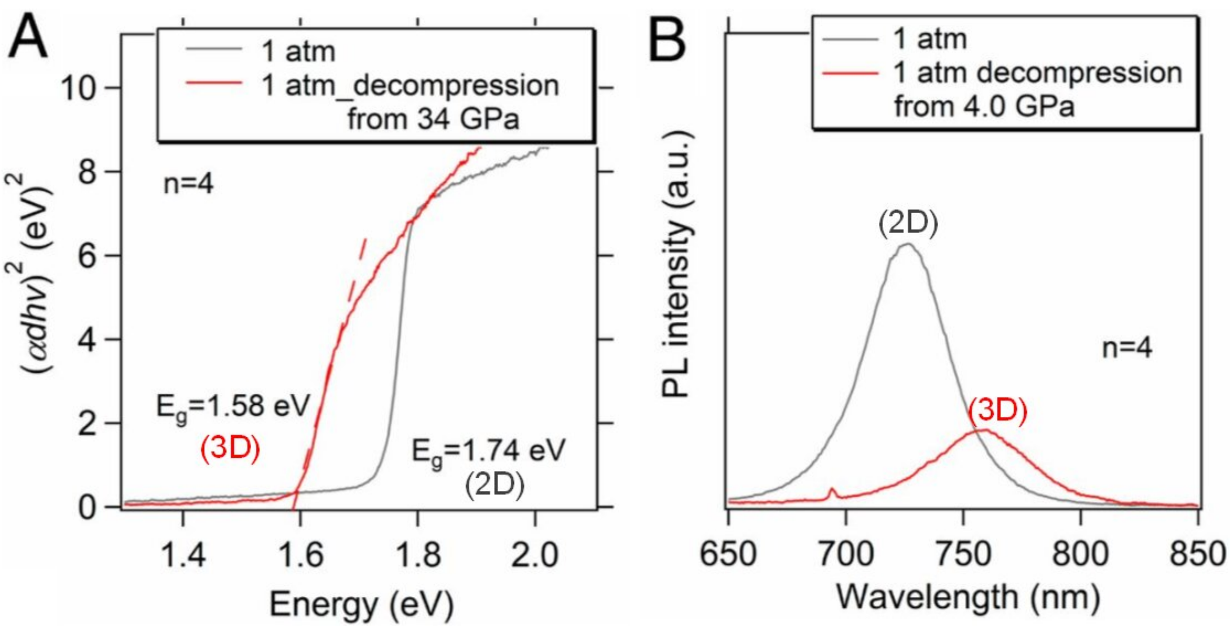

2D-3D transition in hybrid perovskites. Credit: Gang Liu

Hydrostatic pressurization can lead to new and improved material properties. However, most novel material properties are only retainable at high-pressure states, and therefore have no practical applicability at ambient conditions. Recently, a team of international scientists led by Dr. Lingping Kong and Dr. Gang Liu from HPSTAR reported permanent and irreversible transition of 2-D hybrid Dion-Jacobson lead iodide perovskite to 3-D perovskite phase at ambient conditions after pressure treatment. This work suggests the usefulness of high-pressure techniques in preparing materials for real-situation applications. The results, as reported in *PNAS*, marks crucial steps in utilizing pressure for ex-situ and ambient-environment applicability in engineering light-absorbing materials for high-performance optoelectronics and luminescence.

Harnessing pressure-induced properties has been a longstanding effort in the quest of exotic materials in ambient environments. Nevertheless, due to the order-disorder-order and recrystallization behaviors of material structures, desirable properties attainable at high-pressure states tend to be reversed at ambient pressure. Thus, choosing modifiable materials is imperative for a permanent change in properties.

Being a class of 2-D metal halide perovskites, Dion-Jacobson perovskites represent a new material paradigm that is different from the conventional Ruddlesden-Popper perovskite phase, as D-J perovskites do not have the van der Waals gaps observed in R-P counterparts due to the divalent nature of interlayer organics. Their exotic structure ensures a much shortened interlayer distance and greater structural rigidity, two important factors that can enable irreversible structural phase transitions, and thus electronically and atomically resembles the 3-D bulk phase. The scientists observed permanent and notable transition of 2-D D-J phase $(^{3}AMP)(MA)_3Pb_4I_{13}$ to 3-D $MAPbI_3$ after 40 GPa pressure treatment, as proved by X-ray diffraction crystal structure after decompression.

More information: Lingping Kong et al, Highly tunable properties in pressure-treated two-dimensional Dion–Jacobson perovskites, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.2003561117

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