Hybrid perovskite (HP) materials: Quantum well design for organic-inorganic electronics

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Main Source:

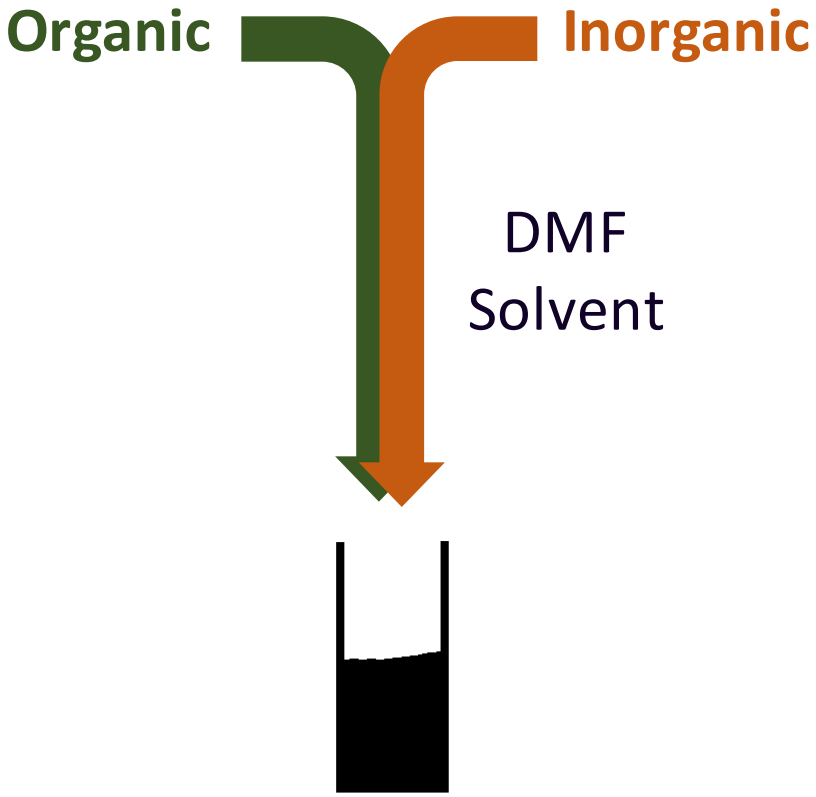
Mitzi, D.; Chondroudis, C.; Kagan, C. *IBM Journal of Research and Development,* **2001,** *45*, 29-45

Organic-inorganic perovskites are an easily processed, versatile class of materials with diverse properties.

Inorganic materials

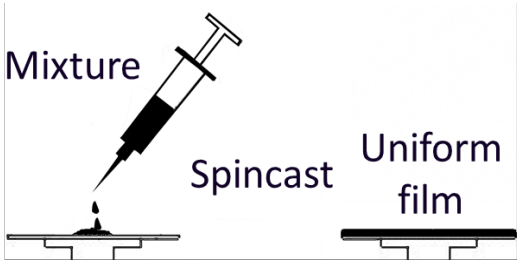
Possess a **range of electronic variation** (insulators, semiconductors, and metals).

They also can posses magnetic dielectric transitions, substational mechanical hardness and high thermal stability.



Organic materials

ease of processing, structural diversity and design



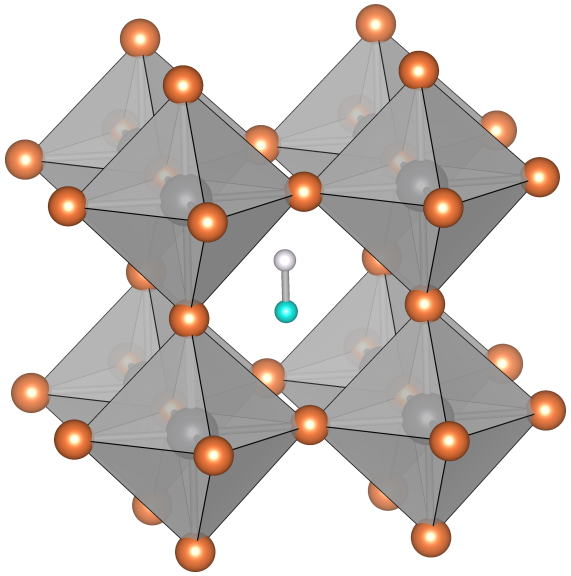
HP's are incredibly diverse, and can be tuned via stoichiometric ratio and type of organic reagents used.

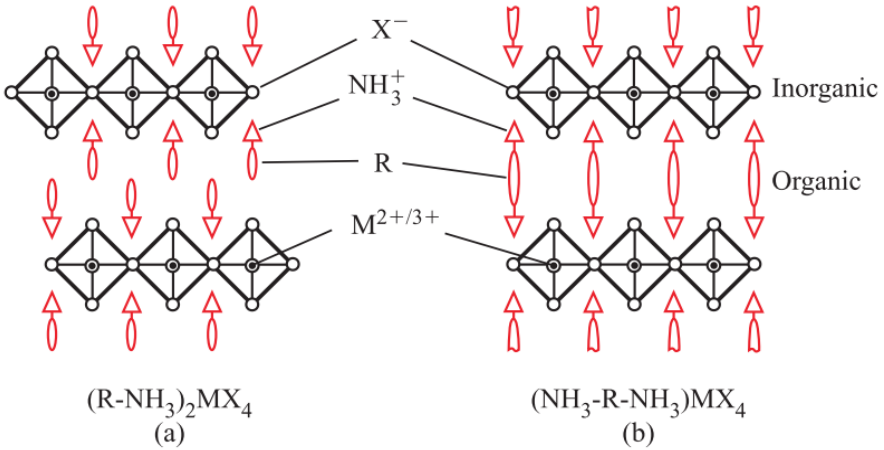
Perovskite formula = ABX_3

HP's divalent B site metal can vary (Cu, Ni, Co, Fe, Mn, Cr, Pd, Cd, Ge, Sn, Pb, Eu, Yb)

The halide can be varied, or even made with a pseudo halide (SCN^-, NCN^-)

Organic A site can be monovalent or divalent cation





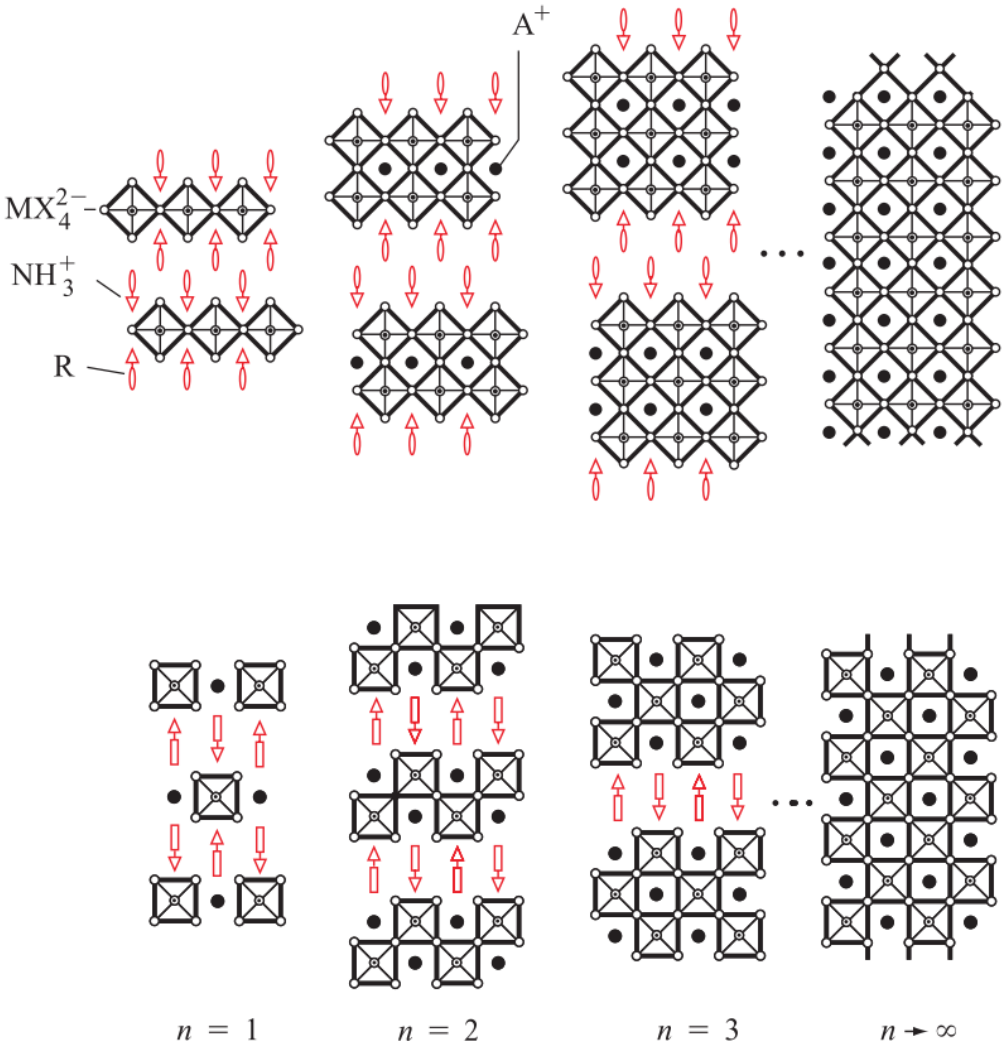
HP's can be tuned even further, selecting for amount of perovskite connectivity as well as crystal orientation

<100> oriented family

$[(R\text{-}NH_3)_2A_{n-1}M_nX_{3n-1}]$

<110> oriented family

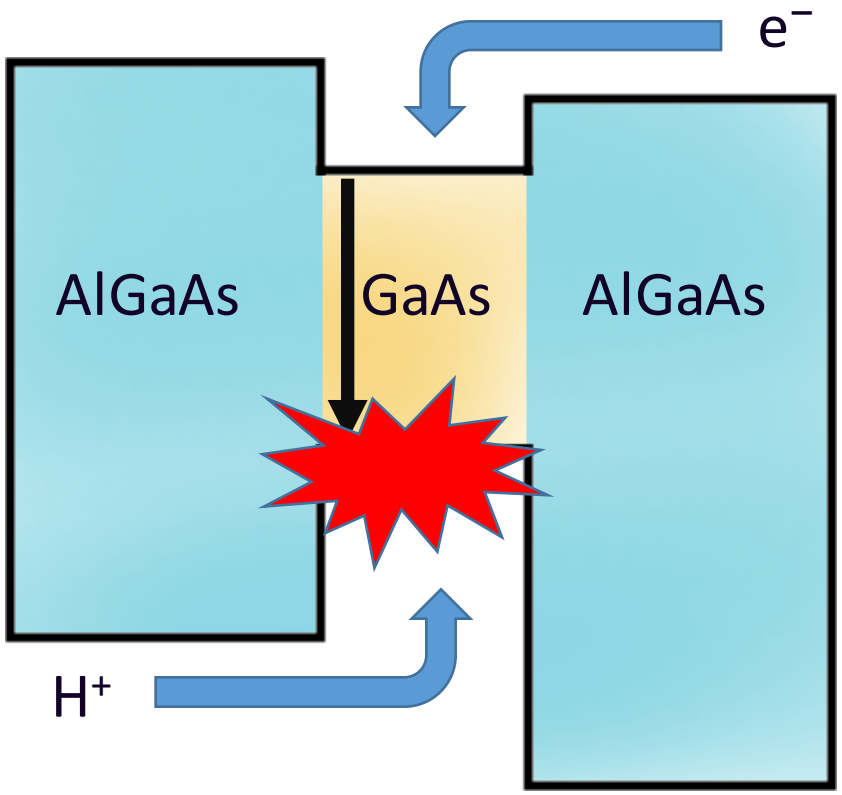
$[(R\text{-}NH_3)_2A_nM_nX_{3n+2}]$



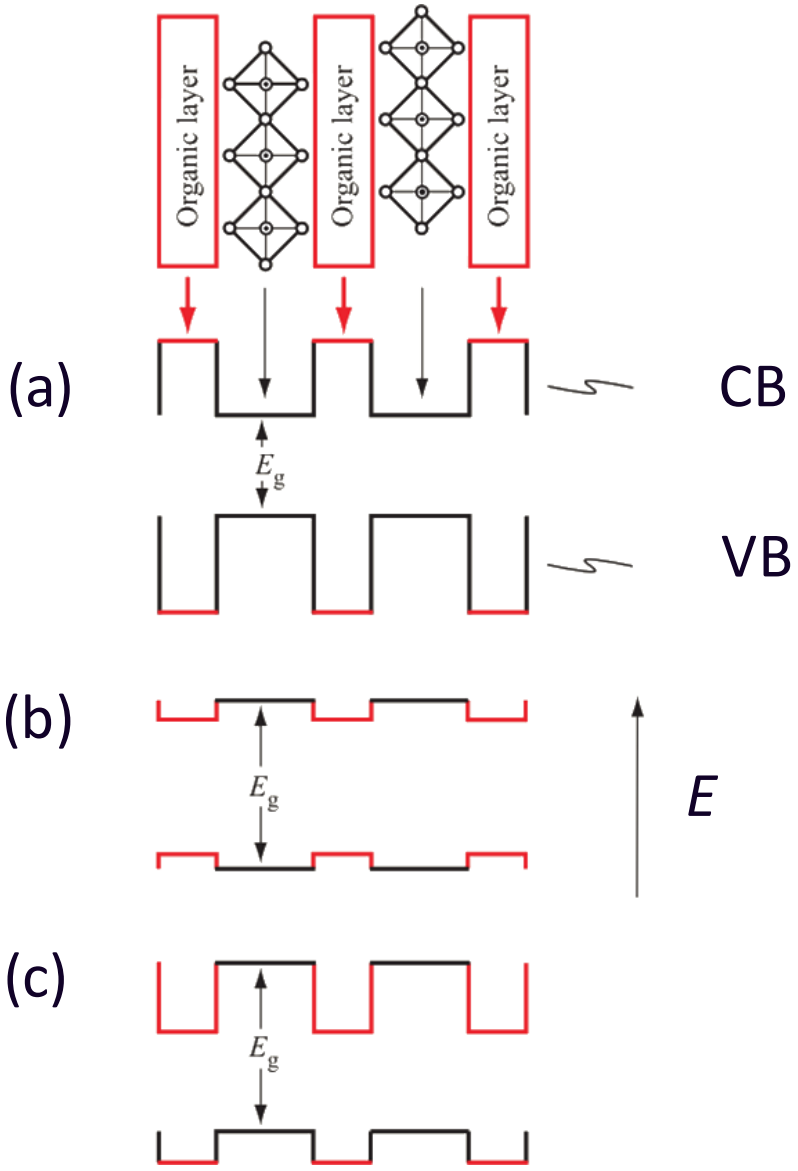
Hybrid perovskite layered materials are analogous to quantum well MBE deposited thin films of inorganic materials.

Because of their quasi-two dimensional nature electrons in quantum wells have a **density of states that has distinct steps** (meaning confined electrons and holes).

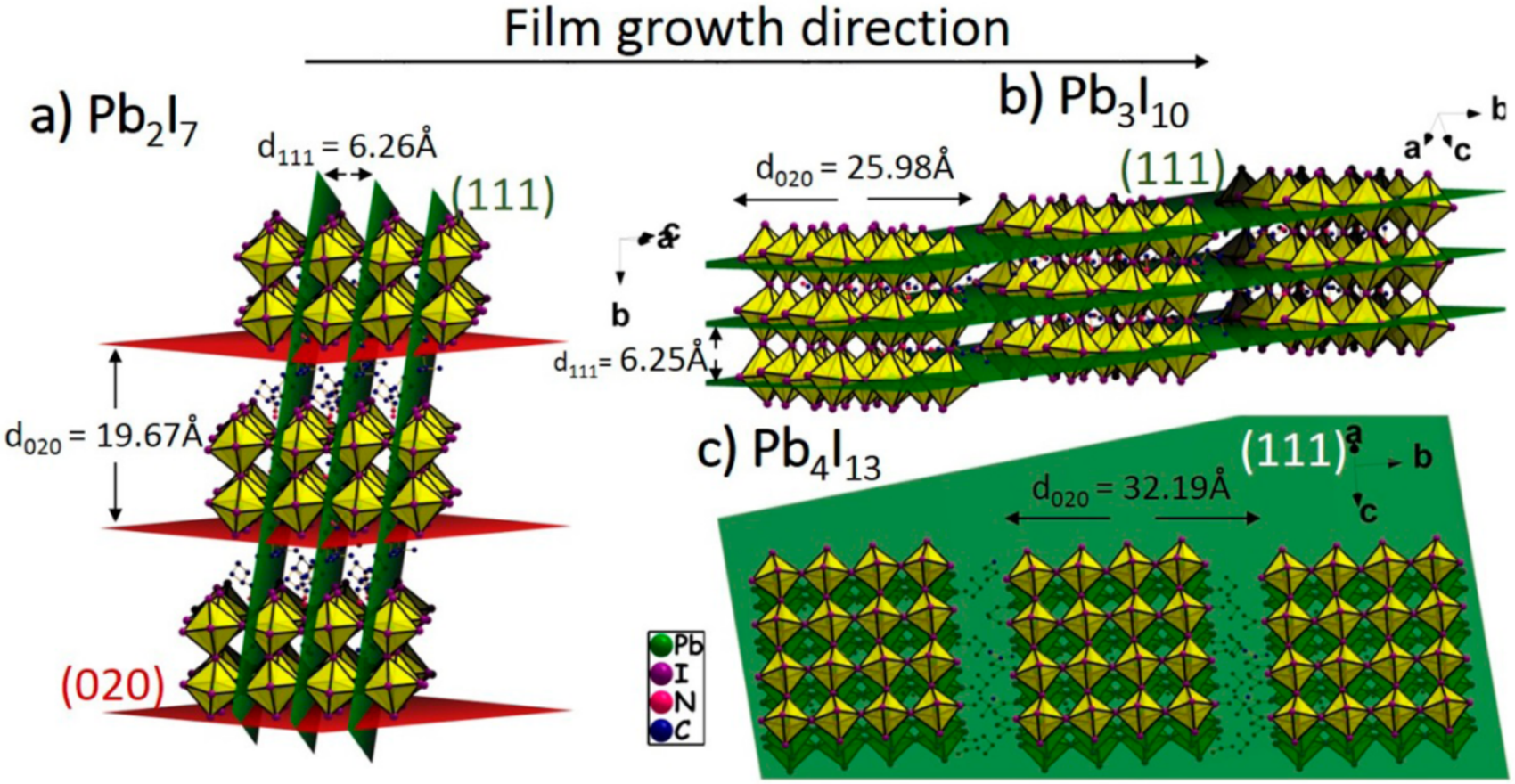
Additionally, the effective mass of holes in the valence band is changed to more closely match that of electrons in the conduction band.



This level of control allows for tuning of quantum wells, especially in systems that contain germanium(II), tin(II), and lead(II).

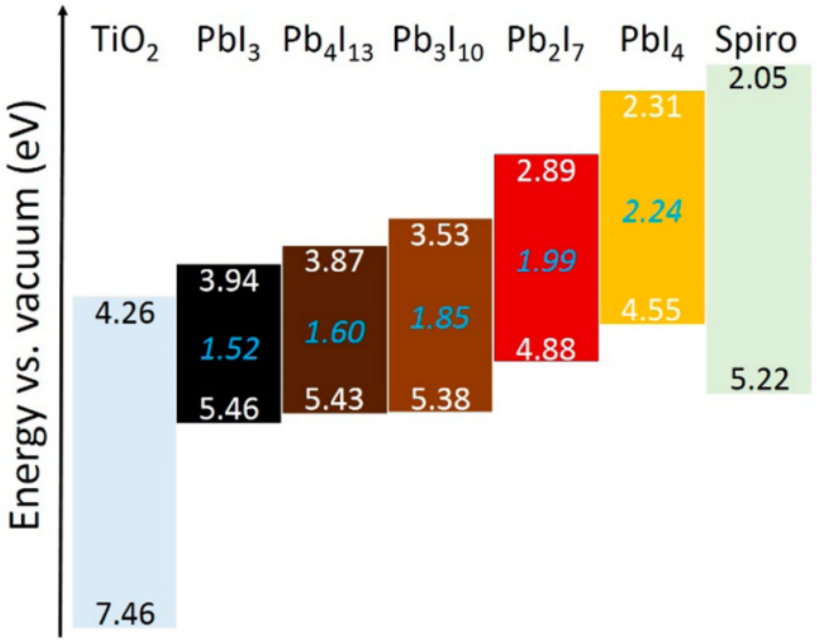


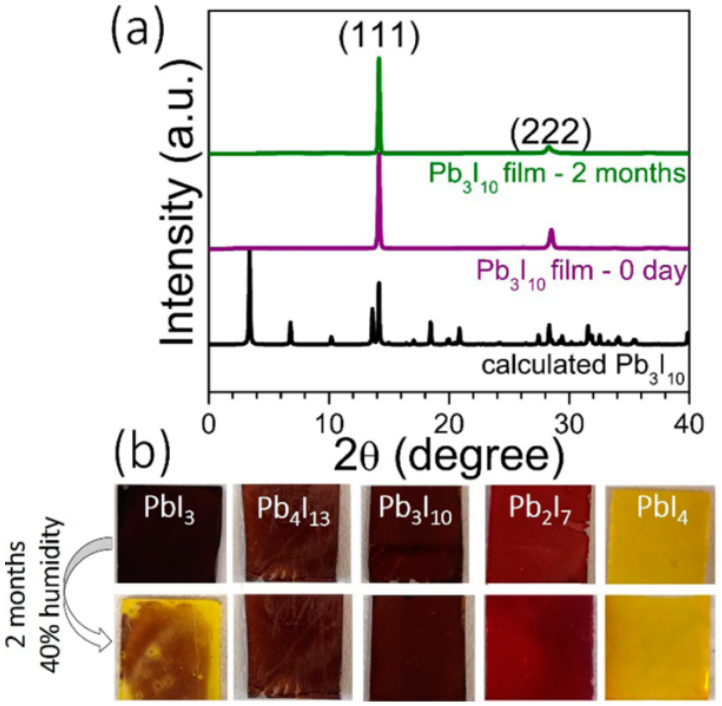
Recent work: creating quantum well HP materials tunes energy gap and increases stability.



Cao, D.; Stoumpos, C. C. ; Farha, O. K. , Hupp, J. T. , Kanatzidis, M. G. *J. Am. Chem. Soc.* **2015,** *2*, 7843 - 7850

Creating quantum well HP materials tunes energy gap and increases stability.





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Take aways

Hybrid perovskite materials can be tuned and processed easily.

They are analogous MBE deposited quantum wells of solely inorganic materials, and can exploit similar quantum phenomena.

Layered perovskite materials have higher stability.