Supplemental Document

Atomic Layer Deposition of Lead Halides: $PbBr_2$ and $PbCl_2$

Georgi Popov†, Charlotte Van Dijck†, Laura Junkers†, Goran Bačić‡, Alexander Weiss†, Miika Mattinen†, Anton Vihervaara†, Pasi Jalkanen§, Kenichiro Mizohata§, Jyrki Räisänen§, Marianna Kemell†, Markku Leskelä†, Seán Barry‡, Mikko Ritala†*

† Department of Chemistry, University of Helsinki, P.O. Box 55, FI-00014 Helsinki, Finland

‡ Department of Chemistry, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada

§ Department of Physics, University of Helsinki, P.O. Box 43, FI-00014 Helsinki, Finland

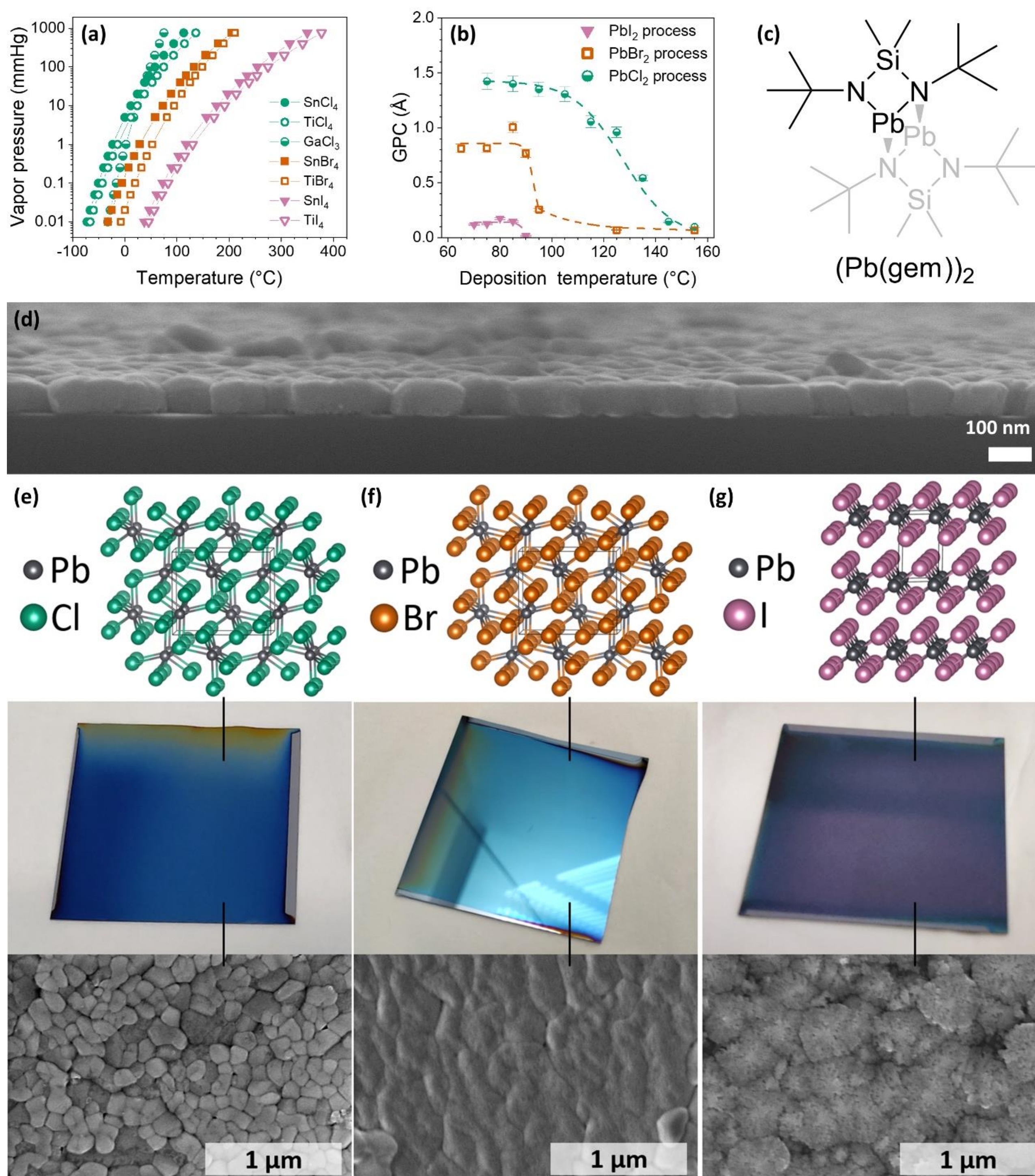

Figure 1. (a) Vapor pressures of $GaCl_3$ (Brunetti et al. *J. Chem. Eng. Data* 2010, 55, 98–102) and volatile tetrahalides of tin and titanium (Perry's Chemical Engineers' Handbook 8[ed]). (b) Growth per cycle values (GPCs) in the lead halide ALD processes as a function of temperature. Lead precursor is $Pb(btsa)_2$ and halide precursors are $GaCl_3$, $TiBr_4$ and SnI_4 respectively. (c) Bis[lead(II) *N,N*'-di-*tert*-butyl-1,1-dimethylsilanediamide] or $(Pb(gem))_2$. (d) Cross-section SEM image of a $PbCl_2$ film deposited at 85 °C. Crystal structures, photographs and SEM images of (e) $PbCl_2$, (f) $PbBr_2$ and (g) PbI_2 films. Films were deposited on 5 x 5 cm Si substrates. $PbBr_2$ and PbI_2 were deposited at 75 °C and $PbCl_2$ at 85 °C. The 2D structure of PbI_2 accounts for smaller GPC in the PbI_2 ALD process compared to $PbBr_2$ and $PbCl_2$ processes.