Supporting Information

Atomic Layer Deposition of Ru Nanoclusters on Ba-LaCeO$_x$: A Highly Efficient Catalyst for Ammonia Synthesis under Mild Conditions

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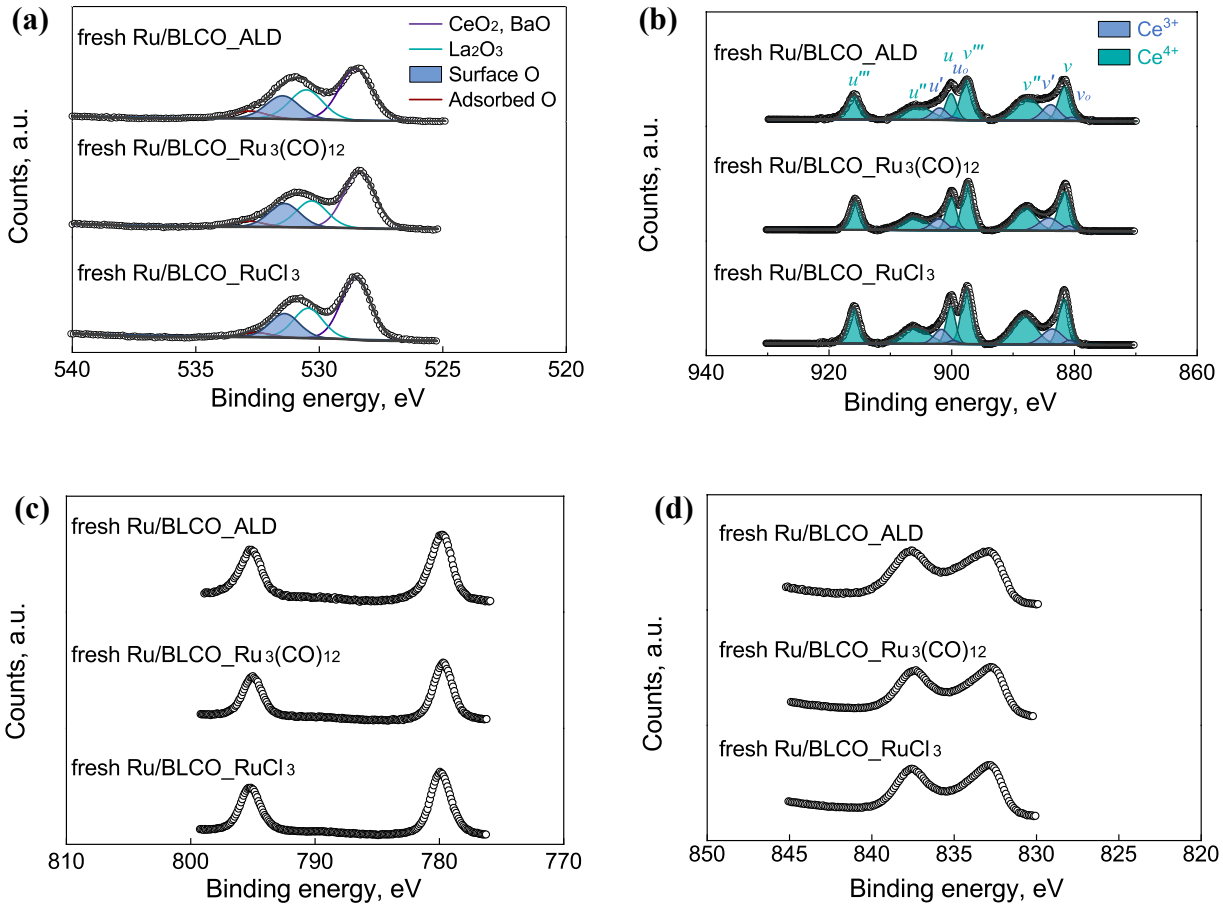

Figure S1. XPS spectra of (a) C1s, (b) Ce 3d, (c) Ba 3d, and (d) La 3d5/2 for the fresh Ru/BLCO_ALD, fresh Ru/BLCO_$Ru_3(CO)_{12}$, and fresh Ru/BLCO_$RuCl_3$ catalysts.

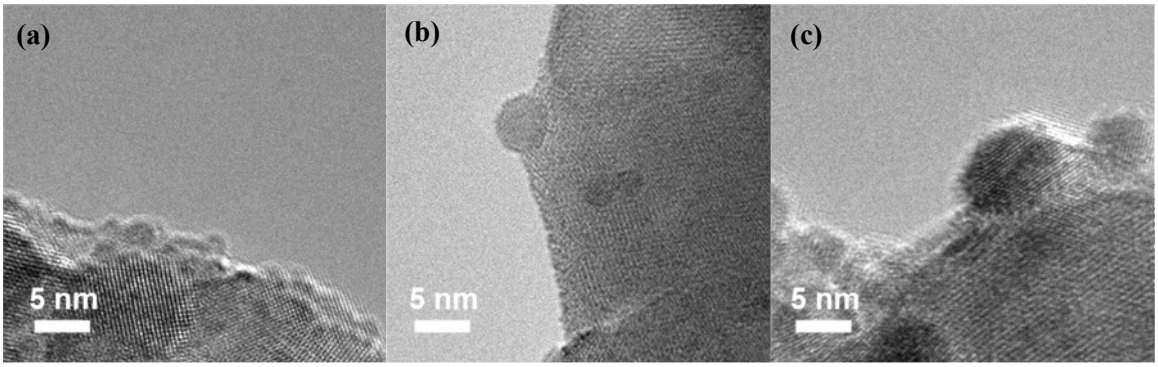

Figure S2. TEM images of (a) reduced Ru/BLCO_ALD, (b) reduced Ru/BLCO_$Ru_3(CO)_{12}$, and (c) reduced Ru/BLCO_$RuCl_3$ catalysts.

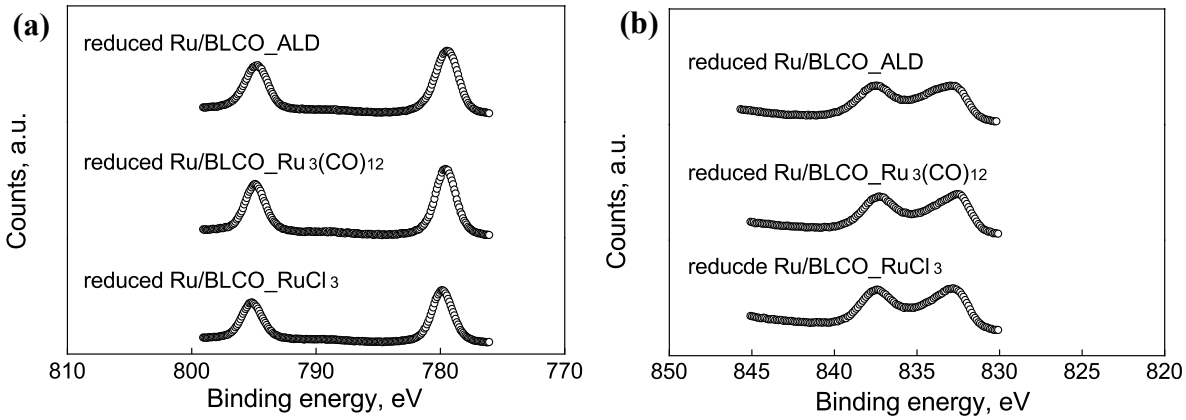

Figure S3. XPS spectra of (a) Ba 3d, and (b) La 3d5/2 for the reduced Ru/BLCO_ALD, reduced Ru/BLCO_$Ru_3(CO)_{12}$, and reduced Ru/BLCO_$RuCl_3$ catalysts.

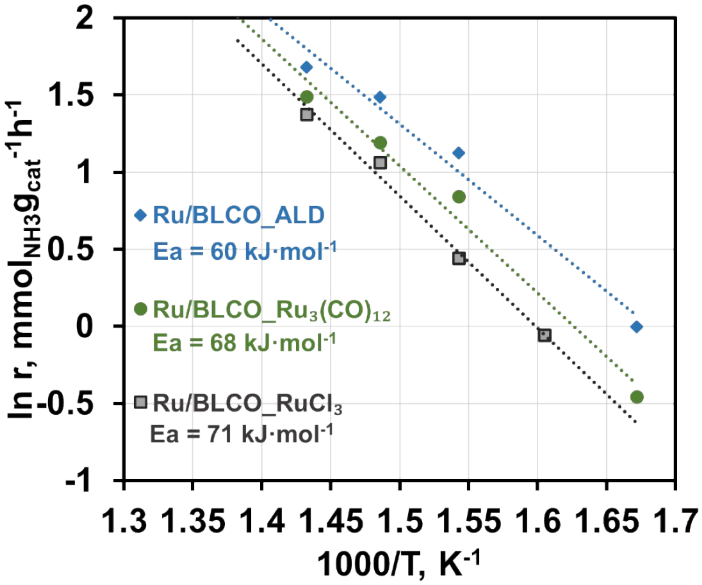

Figure S4. Arrhenius plots for ammonia synthesis reactions at 1.0 MPa and 6,000 mL·g_{cat}^{-1}·h^{-1} over Ru/BLCO_ALD, Ru/BLCO_$Ru_3(CO)_{12}$, and Ru/BLCO_$RuCl_3$ catalysts.

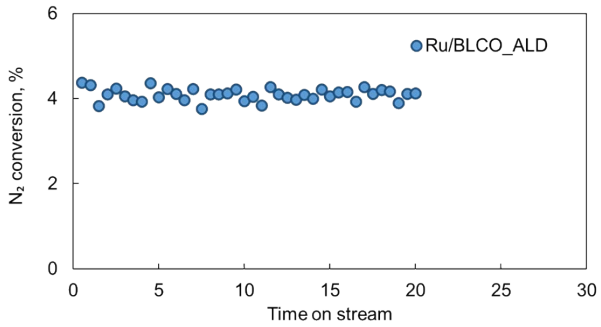

Figure S5. Second cycle stability test of Ru/BLCO_ALD for ammonia synthesis under conditions of 350°C, 4.2 MPa, and 6,000 mL $gcat^{-1}h^{-1}$.

Table S1. Atomic composition results of different catalysts based on XPS.

Catalyst	**Element, atom %**						**Ce/Ru**	**Ba/Ru**
	Ba	**La**	**C**	**Ce**	**Ru**	**O**		
Fresh Ru/BLCO_ALD	3.76	6.60	39.77	4.82	2.27	42.78	2.1	1.66
Reduced Ru/BLCO_ALD	3.96	6.92	40.35	4.97	1.77	42.03	2.8	2.24
Fresh Ru/BLCO_$Ru_3(CO)_{12}$	3.63	6.39	49.56	4.51	1.84	34.07	2.5	1.97
Reduced Ru/BLCO_ $Ru_3(CO)_{12}$	3.87	7.52	31.29	4.88	1.71	50.73	2.9	2.26
Fresh Ru/BLCO_$RuCl_3$	2.84	6.93	37.06	4.63	1.97	46.57	2.4	1.44
Reduced Ru/BLCO_ $RuCl_3$	3.29	5.85	34.94	4.96	1.53	49.43	3.2	2.15

Table S2. Relative atomic concentrations of Ru and RuO_2 based on C1s +Ru3d and Ru3p XPS peak deconvolution.

Catalyst	**Based on C 1s+ Ru 3d**		**Based on Ru 3p**	
	Ru%	**RuO_2%**	**Ru%**	**RuO_2%**
Fresh Ru/BLCO_ALD	72.3	27.7	74.2	24.8
Reduced Ru/BLCO_ALD	76.8	23.2	77.1	22.9
Fresh Ru/BLCO_$Ru_3(CO)_{12}$	-	100	-	100
Reduced Ru/BLCO_ $Ru_3(CO)_{12}$	81.3	18.7	83.5	16.5
Fresh Ru/BLCO_$RuCl_3$	-	100	-	100
Reduced Ru/BLCO_ $RuCl_3$	87.8	12.2	87.1	12.9