Supporting Information

Atomic layer deposition of a ruthenium thin film using a precursor with enhanced reactivity

Jung Min Hwang,[a] Seung-Min Han,[a] Hanuel Yang,[a] Seungmin Yeo,[a, b] Seung-Hun Lee,[a] Chan Woo Park,[a] Gun Hwan Kim,[a] Bo Keun Park,[a] Younghun Byun,[c] Taeyong Eom,*[a] and Taek-Mo Chung*[a]

[a]Thin Film Materials Research Center, Korea Research Institute of Chemical Technology, 141 Gajeong-ro, Yuseong-gu, Daejeon 34114, Republic of Korea

[b]School of Electrical and Electronic Engineering, Yonsei University, Seodaemun-gu, Seoul 03722, Republic of Korea

[c]MAPS R&D Center, Advanced Materials Division, Mecaro Co., Ltd., Eumseong-gun, Chungbuk, 27721, Republic of Korea

* To whom correspondence should be addressed. E-mail: eomt@krict.re.kr, tmchung@krict.re.kr

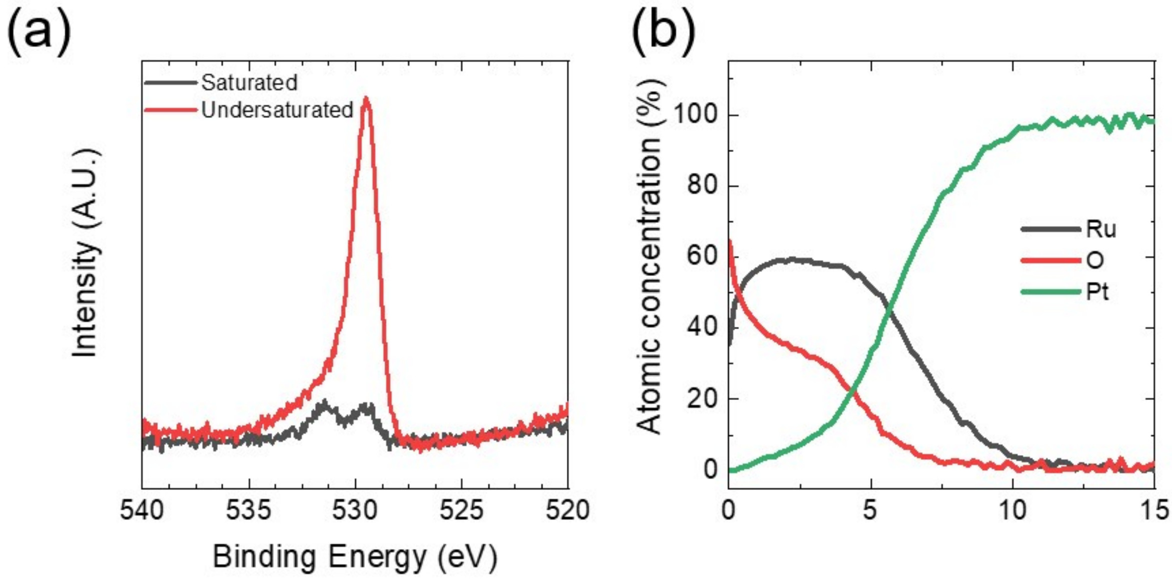

Figure S1. Characterization of Ru thin films deposited at under unsaturated condition (a) Ru 3d XPS spectra (b) AES depth profile

Table S1. List of resistivity and thickness of Ru film at each temperature.

Substrate Temperature (°C)	Resistivity (μΩ·cm)	Layer density (μg·cm^{-2})	Thickness (nm)
150	59.81	6.00	5.04
200	16.45	6.24	5.24
225	6.07	7.18	6.03
250	7.31	7.24	6.08
265	14.17	6.30	5.29
275	9.20	9.63	8.09
300	8.15	9.91	8.33

The thickness of Ru film is converted from layer density according to the density of Ru film measured by XRR. The Ru film thickness was controlled in the 5 to 9 nm range, which is sufficiently thick to measure resistivity regardless of the contribution of the very thin Pt layer (~0.8 nm).

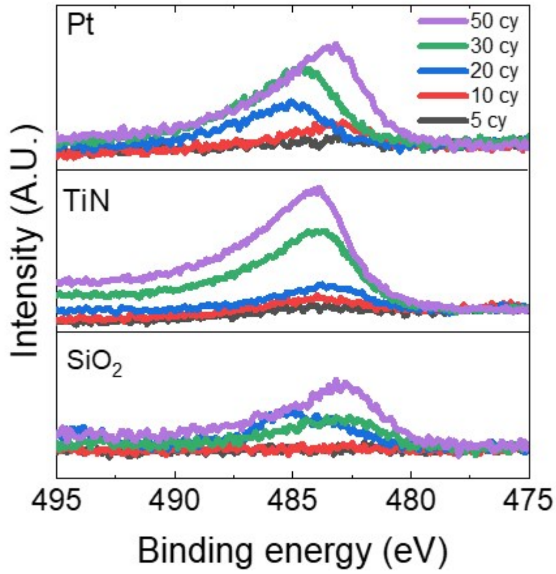

Figure S2. Influence of cycle number in Ru $3p_{1/2}$ XPS spectra of thin Ru films on Pt, TiN, and SiO_2

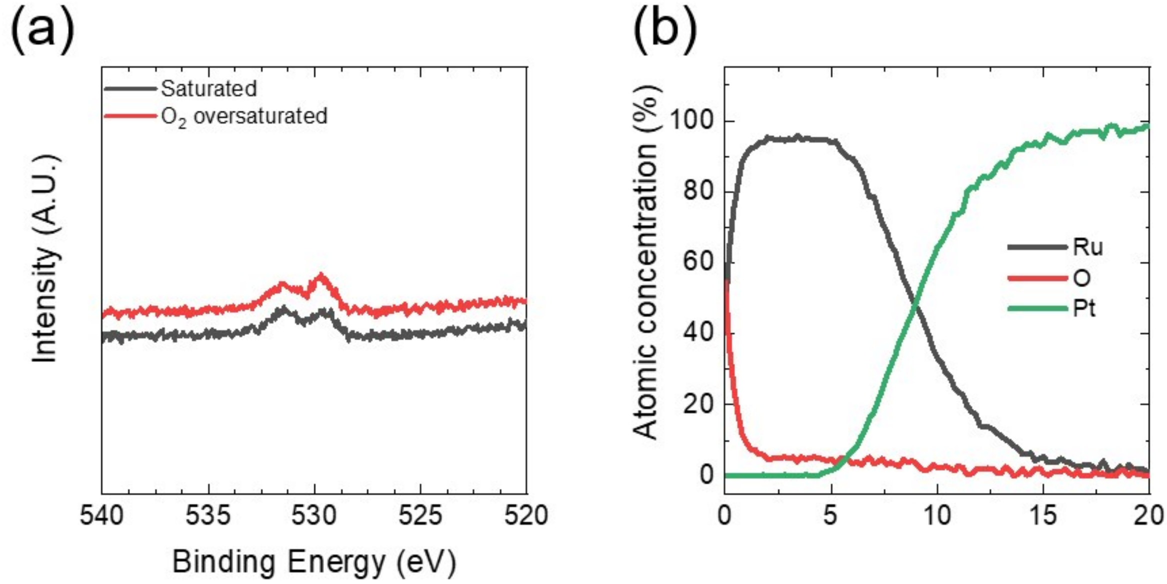

Figure S3. Characterization of Ru thin films deposited at O_2 over-saturated condition (a) Ru 3d XPS spectra (b) AES depth profile

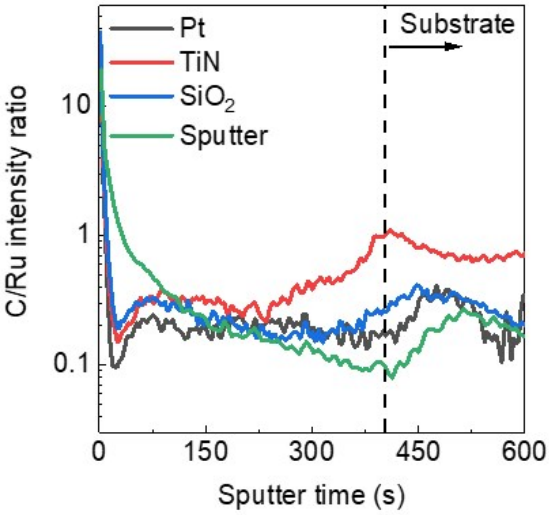

Figure S4. TOF-SIMS depth profile of Ru thin films

To confirm the level of impurity in the film, a Ru thin film was deposited on each substrate by ALD and compared with a film formed by sputter using TOF-SIMS. Here, the intensity of C compared to Ru was displayed in consideration of the matrix effect. The Ru thin film formed by ALD did not show a significant difference in the C impurity level with the sputter-deposited film.