A combinatorial approach to the ferroelectric properties in $Hf_xZr_{1-x}O_2$ deposited by atomic layer deposition

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Deposition conditions					
Wafer	Chamber temp.	Precursor temp.	# of pulse cycles	Model	Refractive index
HF treated Si	250°C	**60°C**	100	HfO_2 (Cauchy)	2.07644

Results			
Pulse/Purge time (s)	0.2 / 20	0.1 / 20	0.05 / 20
Legend: 10.00 >; 8.87 - 10.00; 7.75 - 8.87; 6.62 - 7.75; 5.50 - 6.62; 4.37 - 5.50; 3.25 - 4.37; 2.12 - 3.25; 1.00 - 2.12; < 1.00	8.88, 8.94, 8.81, 9.23, 9.01, 8.92, 9.16, 9.22, 9.28, 9.18, 8.83, 9.06, 9.32, 8.68, 8.90, 8.72, 8.73	7.10, 7.91, 7.02, 8.43, 8.29, 7.29, 8.43, 8.59, 8.52, 7.92, 6.83, 8.46, 8.45, 6.74, 8.22, 7.20, 7.65	2.42, 6.18, 2.36, 7.49, 6.76, 2.58, 7.86, 7.91, 7.34, 5.95, 2.62, 7.89, 7.25, 3.81, 7.55, 5.91, 6.41
Avg thickness (nm)	8.99	7.83	5.78
Avg GPC (Å/cy)	0.09	0.08	0.06
Max (nm)	9.32	8.59	7.91
Min (nm)	8.68	6.74	2.36
Max–Min (nm)	0.64	1.85	5.55

Figure 1: A gradient in composition obtained for TDMA-Hf precursor as the precursor temperature and pulse time are reduced below the ALD saturation window. The ALD process temperature is set at 250°C. As the precursor temperature is reduced to 60°C and the pulse time was reduced to 0.1s, a thinness gradient of ~1.6nm was obtained. The arrow indicates the direction of precursor flow into the ALD chamber

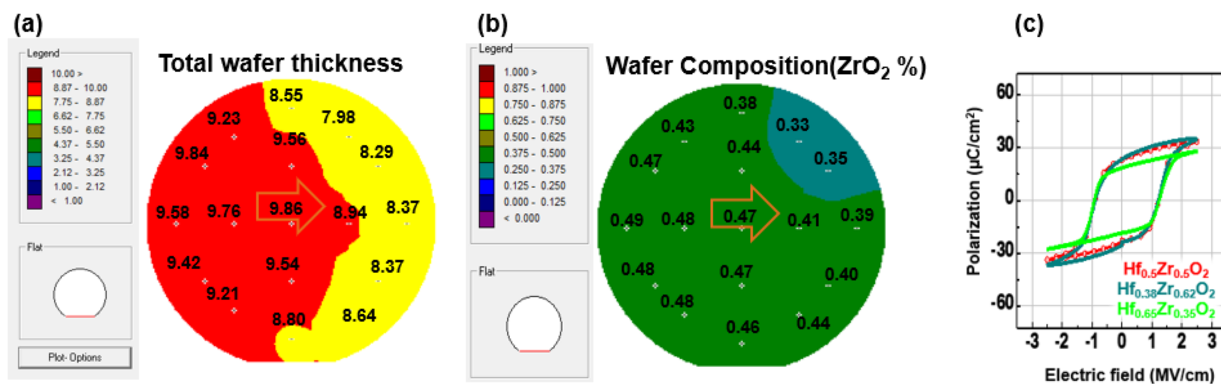

Figure 2: (a, b) shows the total wafer thickness when saturated TDMA-Hf and unsaturated TDMA-Zr precursors are used for the ALD deposition along with the different wafer compositions estimated using sample depositions from spectroscopic ellipsometry. (c) shows a few PE hysteresis loops obtained for three different compositions obtained across different Hf and Zr composition gradient wafers