(Supplemental)

Oxide film properties using OH radicals generated by water vapor mixed pure ozone gas as ALD oxidant

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Pure ozone generator
(MEIDEN NANOPROCESS
INNOVATIONS, MPOG-X12)

PO-ALD merit items	Memo
High reactivity	Requires multi-step ozone collision reaction with precursor
Long life time	Decreased reaction frequency with O_2 molecules
High active species concentration	High concentrated Ozone gas by liquefaction (>80 vol.%)
High purity	NO_x and heavy metal contaminations free
High growth rate	Highly efficient oxidizing gas diffusion at low pressure in the ALD chamber
Film thickness distribution	
Reduction of O_2 gas consumption	On-demand O_3 gas supply system

Table 1. Pure ozone generator and merits of pure ozone ALD (PO-ALD) .

This work (expected)

Film qualities/ Oxidation sources	Pure ozone $+H_2O$ vapor	O_2 plasma	Pure ozone (PO)	Ozonizer ozone
Electric properties (Ex. dielectric)	**Best**	Best	Good	OK
Step coverage	**Best**	Bad	Best	OK
Productivity (Bach processing)	**Best**	Bad	Best	OK

Table 2. Comparison of film properties using some ALD oxidation sources.

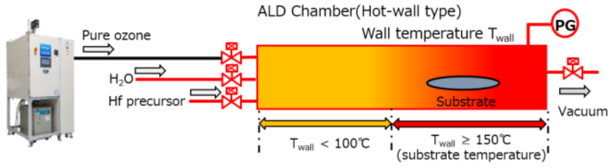

Figure 1. Schematic ALD chamber and gas piping systems.

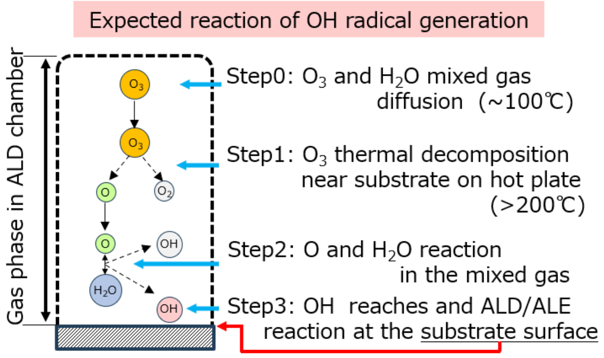

Figure 2. Schematic chemical reaction of OH radical generated reaction in ALD chamber.

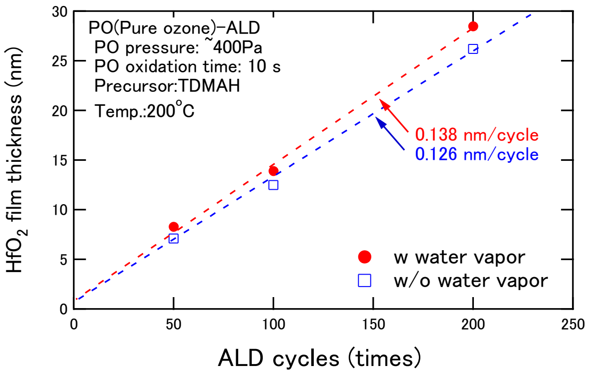

Figure 3. Relation between the number of ALD cycles and HfO_2 film thickness.

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