Low Contact Resistivity of PtHf Silicide Utilizing Dopant Segregation Process

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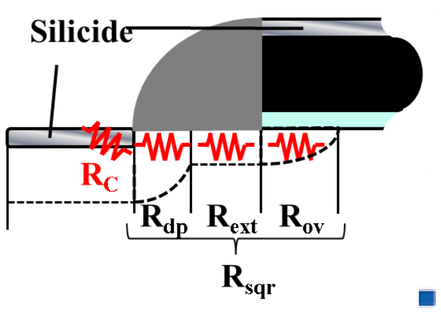
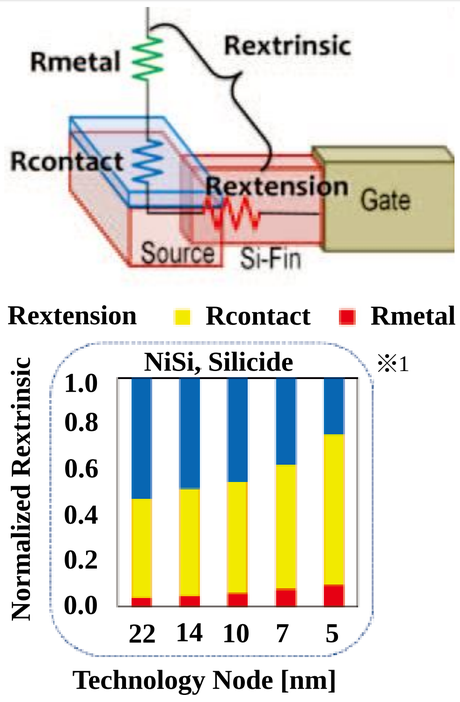
1. Introduction

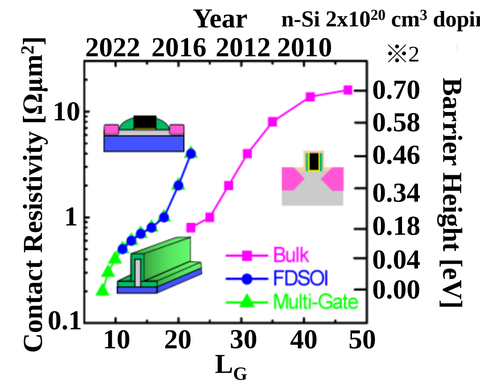
Importance of low contact resistivity for silicide



R_C: contact resistance (Ω)

Contribution of R_C increases

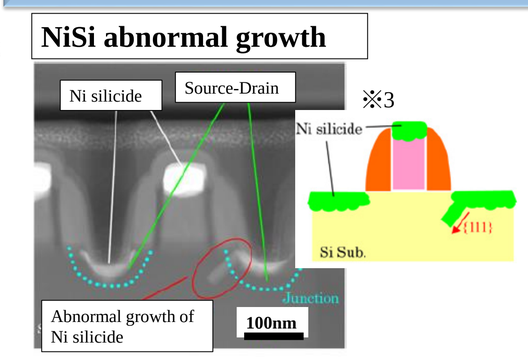


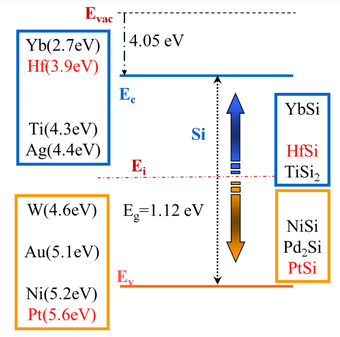


ρ_C: contact resistivity (Ωcm^2)

ρ_C of 10^{-9} Ωcm^2 or below is required

Work function control of PtSi alloying with Hf





	NiSi	PtSi
Resistivity [μΩ·cm]	20	30
Silicidation Temp. [°C]	400	300
Si consumption	0.82	0.66
Barrier height for hole (electron) [eV]	0.45 (0.67)	0.25 (0.87)

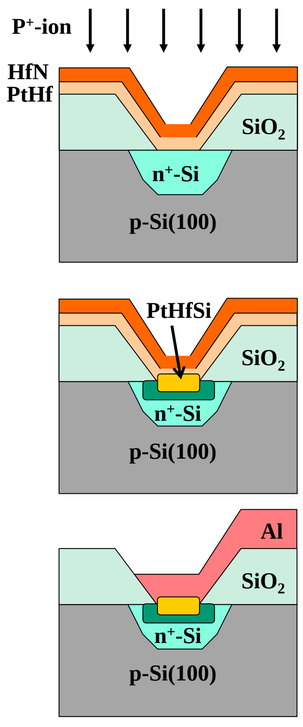
	Crystal system	Lattice constant (nm)		
		a	b	c
PtSi	Orthorhombic	0.59	0.56	0.36
HfSi	Orthorhombic	0.37	0.52	0.69

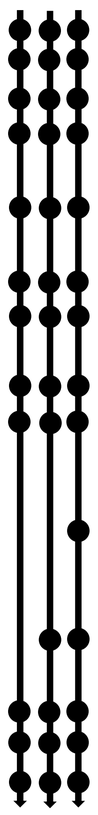
Objective

Reduction of ρ_c for PtHf silicide with dopant segregation process (DS) evaluated by cross-bridge Kelvin resistor (CBKR) method.

※1 S. Datta et al., VLSI Tech. Dig., 174 (2014). ※2 C.-N. Ni et al., VLSI –TSA Tech. Dig. (2013). ※3 S. Kudo et al., IEEE Trans. Semicond. Manuf., **27**, pp. 16-21 (2014).

2. Experimental Procedure





p-Si(100) cleaning (SPM, DHF x 2)
Field oxide: 300 nm/1100°C
Active region patterning
Ion implantation for n$^+$ region formation:
  PH_3, 5x10^{15} cm^{-2}, 15 keV
SiO_2 deposition: RF sputtering
  T_{sub}: 250°C, Ar/O_2: 9/3 sccm, 130 nm
Activation annealing: 900°C/20 min, N_2
Contact hole patterning: (2 x 2) - (16 x 16) μm^2

RF magnetron sputtering:
  PtHf (Pt:Hf=5:2) deposition (20 nm)
    Pre-sputtering: 100 W/5 min or 80 W/3 min
    Depo.: 40 W, RT, Kr, 0.7 Pa
  HfN deposition (10 nm)
    Pre-sputtering: 200 W/10 min
    Depo.: 200 W, RT, Kr/N_2, 0.48 Pa
Ion implantation for dopant segregation:
  PH_3, 1x10^{15} cm^{-2}, 15 keV
Silicidation: 450°C/5-60 min, N_2/4.9%H_2
Selective etching by BHF, Aqua regia
Al electrode

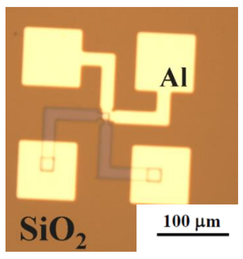
JEOL JEC-SP360R

Evaluation

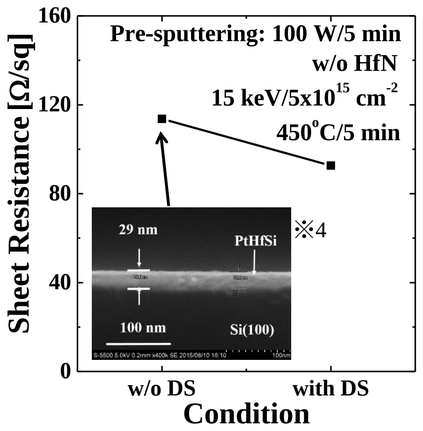
Sheet resistance (R_s), SEM, CBKR

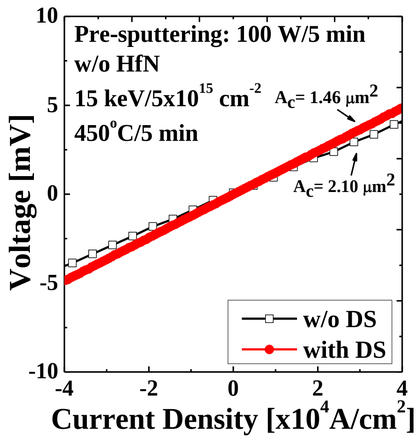
PtHf-alloy target

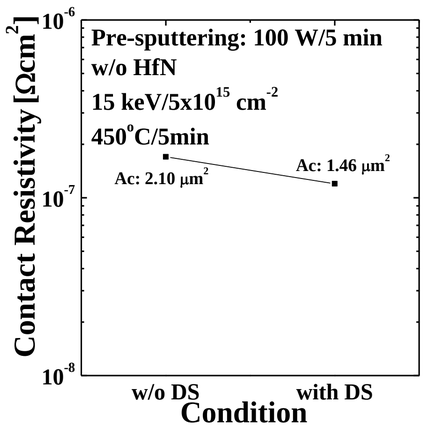
Plane-view of CBKR



3. Effect of dopant segregation process







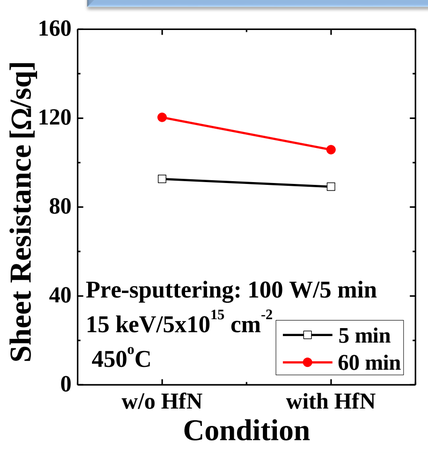
	Sheet resistance [Ω/sq]	Contact resistivity [Ωcm^2]
w/o DS	113.7	1.7x10^{-7}
with DS	92.6	1.2x10^{-7}

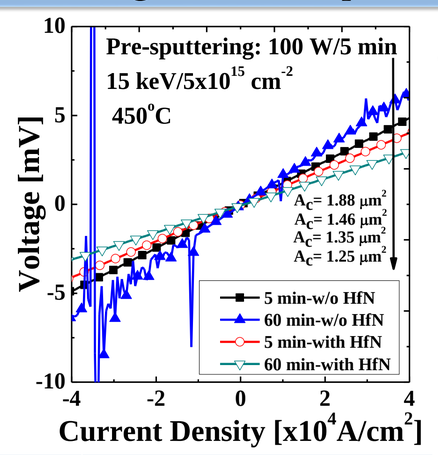
- Excellent Ohmic property at small contact area (1.46 μm^2).
- Reduction of ρ_c and R_s with DS.

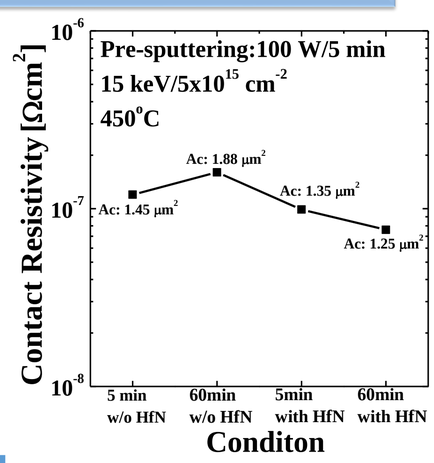
※4 S. Ohmi et al., IEICE Trans. Electron., **E99-C**, pp. 510-515 (2016).

4. Optimization of dopant segregation process

Annealing duration dependence







	Sheet resistance [Ω/sq]	Contact resistivity [Ωcm^2]
5 min w/o HfN	92.6	1.2x10^{-7}
60 min w/o HfN	102.3	1.6x10^{-7}
5 min with HfN	89.1	9.9x10^{-8}
60 min with HfN	105.8	7.6x10^{-8}

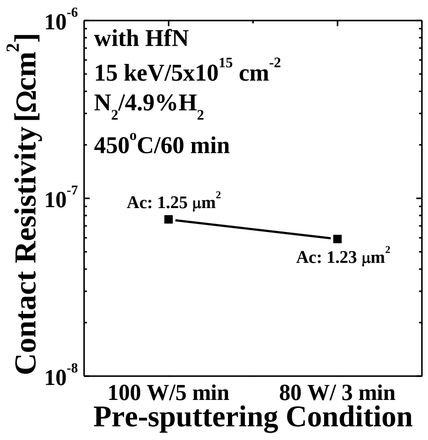
- Reduction of ρ_c with HfN capping layer.

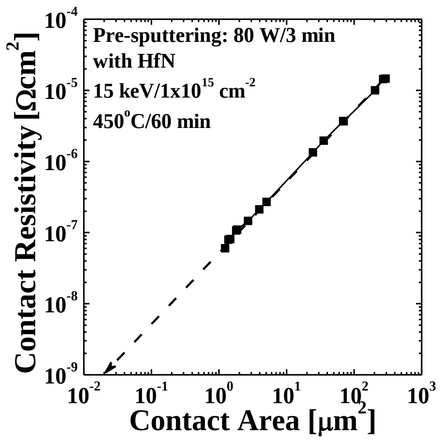
Improvement of pre-sputtering process

Hydrophobicity of Si wafer after pre-sputtering

100 W/5 min

80 W/3 min





	Sheet resistance [Ω/sq]	Contact resistivity [Ωcm^2]
100 W/5 min	105.8	7.6x10^{-8}
80 W/3 min	134.1	5.9x10^{-8}

- Reduction of pre-sputtering power improves hydrophobicity of Si wafer.
- ρ_c of 5.9x10^{-8} Ωcm^2 was obtained.
- ρ_c of 10^{-9} Ωcm^2 by scaling of contact area.

5. Conclusions

Reduction of contact resistivity for PtHf silicide utilizing dopant segregation was investigated.

- Dopant segregation process reduced ρ_c and R_s of PtHf silicide.
- Excellent Ohmic property was achieved even at the small contact area of 1.23 μm^2.
- HfN capping layer was found to be effective to reduce ρ_c.
- ρ_c of 5.9x10^{-8} Ωcm^2 was obtained with optimized dopant segregation process.

In conclusion, a contact resistivity of 10^{-9} Ωcm^2 is expected to be achieved with scaling.

Acknowledgement

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