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Wafer Rotation Effect on Silicon Epitaxial Growth

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Introduction Wafer rotation is one promising way to control boundary layer thickness. Some researchers have carried out experimental silicon epitaxial growth or numerical simulations for a rotating-disk reactor, but the relationships between growth results and theoretical predictions were not very clear. We have examined the dependence of growth rate on growth conditions and compared actual growth results with theoretical predictions.

Theoretical prediction[1] The growth rate in a rotating-disk reactor is expressed as $G.R. = D(C_w - C_\infty)\sqrt{\omega/\nu}\Phi'(0)$, where D is the diffusion coefficient, C is the source gas concentration, ω is the disk rotation speed, ν is the kinematic viscosity, and Φ is the normalized source gas concentration. Under the diffusion limiting condition, the source gas concentration at the wafer, Cw, is negligible; substituting growth condition dependence relations into the growth rate equation, the dependence of growth rate on growth conditions is given as $G.R. \propto \sqrt{P\omega}f/Q$, where P is pressure, f is the source gas feed rate, and Q is the total gas flow rate.

Experiment A reactor diagram is shown in Fig.1. The wafer is rotated at up to 3600rpm and heated by a resistance heater. Wafer temperature is monitored by pyrometers.

Growth conditions were: source gas; SiH_2Cl_2, carrier gas; H_2, pressure; 38-304Torr, rotation speed; 40-3600rpm, total gas flow rate; 10-40l/min at 25℃, 1atm.

Growth results and discussion The dependence of growth rate distribution on rotation speed is plotted in Fig.2. As indicated by the growth rate equation, growth rate increases with rotation speed. Uniformity is obtained at an optimum rotation speed. In this condition, the flow rate discharged by wafer rotation equals the total gas flow rate.

Growth rates are plotted versus the factor $\sqrt{P\omega}f/Q$ in Fig.3. Growth rate is proportional to $\sqrt{P\omega}f/Q$ except under conditions of low rotation speed and large values for this factor. Thus, these growth results show that SiH_2Cl_2 growth is a diffusion-limited process.

Dependence of growth rate on source gas feed rate is plotted in Fig.4. The growth rate increases linearly with source gas feed rate at lower gas feed rates, and shows a tendency to saturate as the rate increases. The saturation value of the growth rate appears to depend on the growth conditions. These results indicate that the growth-rate limiting process changes from source gas diffusion to wafer surface reaction as the source gas flux to the wafer increases.

1)T. Ohmine et al., J. Electronic Materials, Vol.19, p.429(1990)

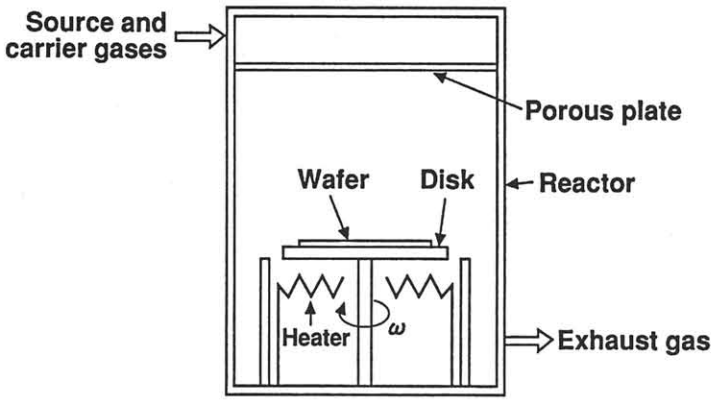

Fig.1 Rotating disk reactor diagram

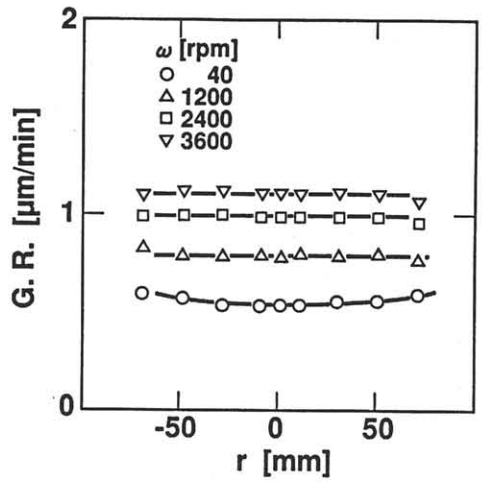

Fig.2 Growth rate distribution dependence on rotation speed

P=38Torr, T=1030℃, Q=30ℓ/min, f=225cc/min

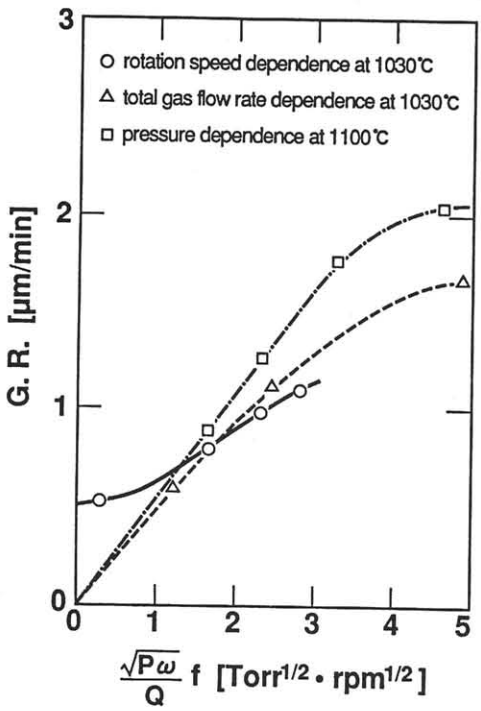

Fig.3 Growth rate dependence on growth conditions

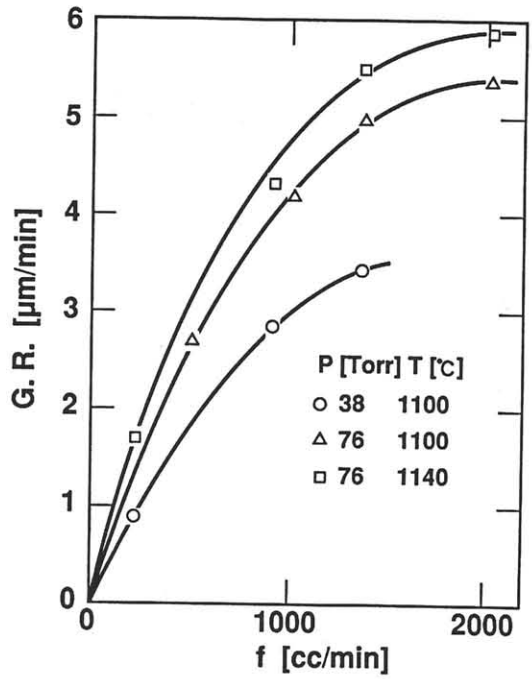

Fig.4 Growth rate dependence on source gas feed rate

ω =1200rpm, Q=30ℓ/min