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CHEMICAL VAPOR DEPOSITION OF COBALT ON Si(100)

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ABSTRACT

Cobalt silicide quantum dots and quantum wires have potential applications in nanoelectronics. We report on the deposition of cobalt on Si(100) surfaces and also on the reaction of cobalt to form cobalt silicide. An iimportant advantage of cobalt disilicide is that it has a low lattice mismatch with Si (100) substrates (~1.2%) which should facilitate overgrowth with epitaxial silicon.

In this paper, we explore the CVD growth of cobalt from $Co_2(CO)_8$ on Si(100) and the reaction of cobalt to form cobalt disilicide. Thermal desorption spectroscopy is used to obtain insight into the growth mechanism. RHEED is used to monitor the growth of cobalt on clean Si(100) surfaces and also Si(100) surfaces coated with a thin (2.5 nm) layer of SiO_2. Growth was performed in a system with a base pressure better than 10^{-9} Torr, and the reactant pressure during growth was 1.9×10^{-5} Torr.

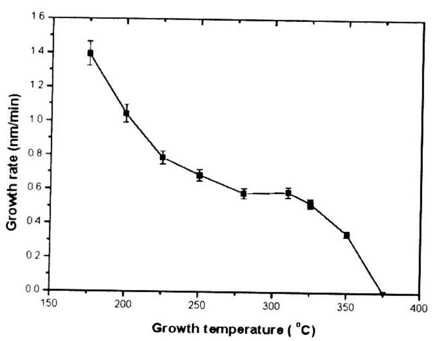

Figure 1. Measured cobalt growth rate as a function of temperature ($Co_2(CO)_8$ pressure = 1.9×10^{-5} Torr).

Figure 1 shows the measured growth rate as a function of temperature. The growth rate decreases monotonically with temperature from 175 to 375 °C. This behavior is similar to that reported by previous researchers who used higher growth pressures (H. S. Rhee and B. T. Ahn, *J. Electrochem. Soc.* **146**, 2720 (1999); M. E. Gross, K. Schnoes Kranz, D. Brasen, and H. Luftman, *J. Vac. Sci. Technol.* **6**, 1548 (1988)). However, due to the absence of gas phase reactions in our system, we can attribute the observed growth rates entirely to the temperature dependence of the surface reactions.

Thermal desorption spectroscopy (TDS) measurements show that the sticking coefficient of $Co_2(CO)_8$ is low (s = 1.5×10^{-3}) at 100 °C and that the CO is desorbed with a peak desorption temperature of approximately 230 °C. From the measured growth rates, we can conclude that the effective sticking coefficient rises between 100 and 175 °C. Possibly sticking of reactant molecules is more likely on a surface which is covered with partially decomposed reactant molecules.

We have also studied the growth on Si(100) and SiO_2-covered surface by RHEED. Figure 2 shows the RHEED patterns after growth of a 2.5 nm SiO_2 layer (left) and after exposure to $Co_2(CO)_8$ at 250 C for 5 min. Cobalt nucleates immediately on the SiO_2-covered surface, indicating that there is no useful selectivity between growth on bare and SiO_2-covered silicon.

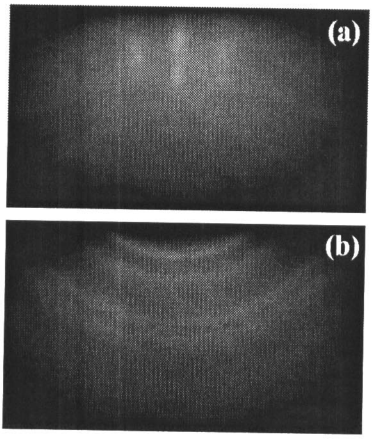

Fig. 2. RHEED patterns for cobalt growth: (a) Si(100) after exposure to O_2 at 800 °C for 20 min; and (b) after growth of Co on SiO_2-covered surface.

In this paper we will report details of the thermal desorption mass spectrocopy measurements and also results of a RHEED study of the reaction to form cobalt disilicide. .

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