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A—2—5 ON Al-SiO_2 INTERFACES AND OXIDATION TEMPERATURES

M. Av-Ron, M. Shatzkes, T. DiStefano,* and R. Gdula
IBM Data Systems Dvision, East Fishkill
Hopewell Junction, New York 12533

*T. J. Watson Research Center
Yorktown Heights, New York 10598

An examination of conduction through Al-SiO_2-Si (p-type, boron doped, $\rho \simeq 15\ \Omega$-cm) capacitors with dry thermal SiO_2 grown at 1200°C, 1000°C, and 850°C to nominal thicknesses of 36 nm (after chemical etch back), 36 nm, and 25 nm, respectively, showed a tendency of the current to increase with decreasing oxidation temperature, T. This is due to increased effective size of Al-SiO_2 interfacial inhomogeneities at lower T. The barrier height, ϕ_1, associated with the inhomogeneities is 2.43 ± 0.1 eV compared with a ϕ of 3.19 eV for a homogeneous Al-SiO_2 interface.[1] Scanning internal photovoltage experiments show evidence of inhomogeneities at the SiO_2-Si interface. These capacitors, when biased for electron injection from the Al, showed excessively high currents. The presence of inhomogeneities at the Al-SiO_2 interface, and the tendency of their inferred size to increase with decreasing T, may be due to excessive boron flux from the Si into the SiO_2. This flux occurs during oxidation,[2] preferentially along Si crystal irregularities.

We analyzed results in terms of the Murphy-Good tunneling model[3] generalized with a Franz-type dispersion relation.[4] Model parameters appropriate to a homogeneous interface are available from our data, since for sufficiently high fields we ignore the inhomogeneity effect unless its size is very large. This size is extracted from the measured currents by assuming the measured current density, J_c, is a superposition of that associated with the homogeneous regions, J_o, and the inhomogeneous areas, J_1. If α is the fractional area covered by the inhomogeneity, then $J_c = (1 - \alpha)J_o + \alpha J_1$. Figure 1 shows currents for capacitors with oxides grown at 850, 1000, and 1200°C, as well as J_o, as functions of the oxide field, F. For each oxidation temperature, the currents depicted are those that deviated most from J_o and thus had the largest α. For the 1200°C oxide, data points are omitted because current measurements were made at 400°K and, using our model, computationally adjusted to 300°K, at which the other measurements were taken.

Figure 2 shows the distributions of the areas of the inhomogeneities ($\alpha \times 2 \times 10^{-3}$ cm^2, where 2×10^{-3} cm^2 is the electrode area). The ensemble associated with 1200°C can be represented by a Poisson distribution, thus indicating randomness. This is not the case at lower oxidation temperatures. It is clear from Fig. 2. that larger areas of inhomogeneities are found for lower oxidation temperatures.

1. M. Av-Ron, M. Shatzkes, T. H. DiStefano, and I. Cadoff, "On the Nature of Electron Tunneling in SiO_2," Proc. Intl. Topical Conf. on the Physics of SiO_2, March 22-24, 1978, Yorktown, NY. Ed. S. T. Pantelides, Pergamon Press, NY (1978).

2. M. Av-Ron, M. Shatzkes, P. J. Burkhardt, and I. Cadoff, J. Appl. Phys. 47, No. 7, 3159 (1976).

3. E. L. Murphy and R. H. Good, Jr., Phys. Rev. 102, 1446 (1956).

4. W. Franz in Handbuch der Physik, Ed. S. Flugge, 17, 155 (Saringer, Berlin, 1956).

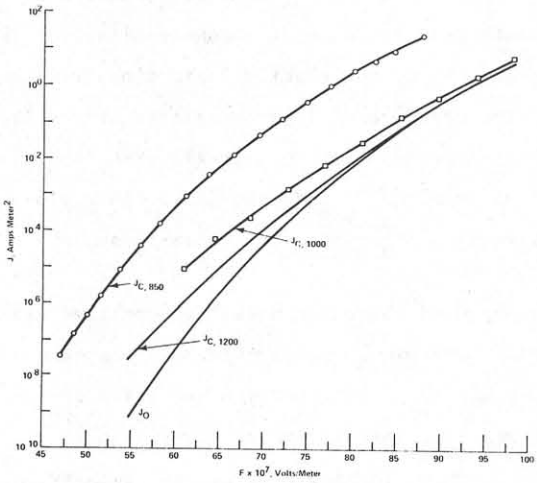

Figure 1. J_o is the current density in an MOS capacitor with a homogeneous Al-SiO_2 interface, as a function of F, computed with a ϕ of 3.19 eV. J_c is given by $(1 - \alpha)J_o + \alpha J_1$, J_1 being J but with a ϕ of 2.43 eV and α is the fractional area of the inhomogeneity. The o's and □'s are experimental results obtained from oxides grown at 850°C and 1000°C, respectively. The experimental results associated with the 1200°C oxide were omitted since the data were obtained at 400°K; the locus $J_{c,1200}$ was, however, calculated for 300°K. For each oxidation temperature, the $J_{c,T}$ depicted are those which deviated most from J_o.

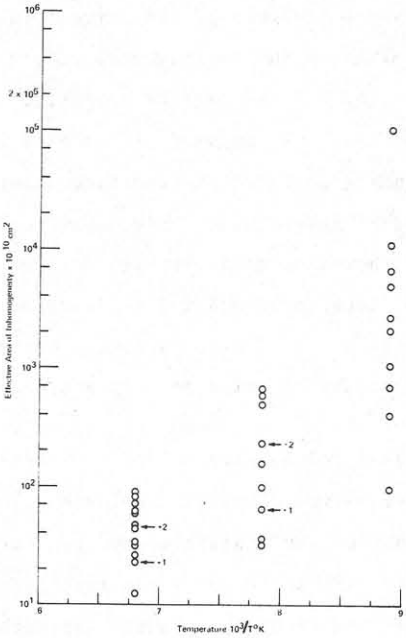

Figure 2. Distribution of the areas of the inhomogeneities, normalized to an electrode area of 2 x 10^{-3} cm^2, and plotted vs the inverse of the oxidation temperature.