Four-point TLM measurement for specific contact resistance assessment

In a metal-semiconductor specific contact resistance measurement, there are several different resistances, as shown in Fig. 1 (a). Similar with the four-point probe sheet resistance measurement, there is also a probe resistance R_p, a probe-to-metal contact resistance, R_{cp}, a semiconductor sheet resistance R_s, and a metal-to-semiconductor contact resistance R_{cs}.

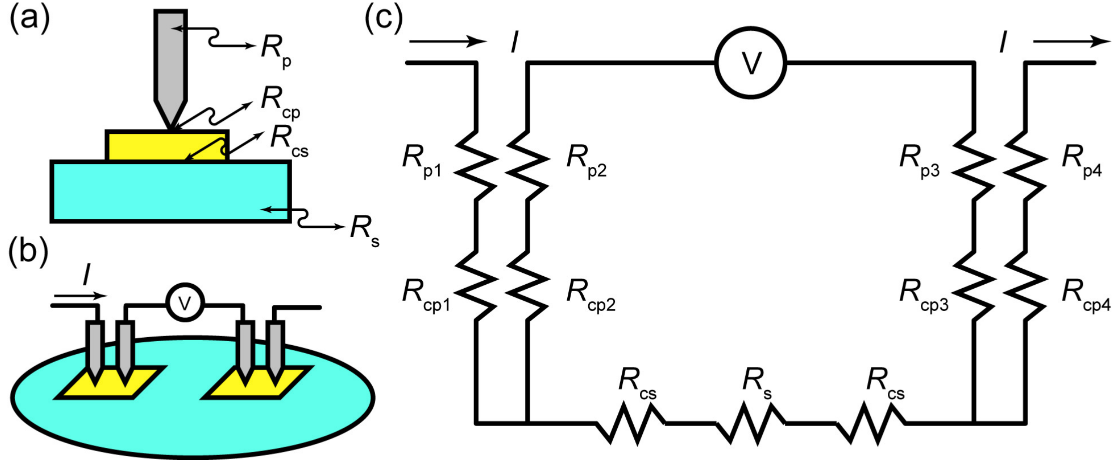

Figure 1: Four-point measurement of metal-semiconductor specific contact resistance.

The equivalent circuit for the measurement of metal-semiconductor contact resistance by using four-point transmission line method (TLM) is shown in Fig. 1 (c). Because the resistance of the voltmeter is very large (ideally infinitely large) compared to the probe resistance and probe-to-metal contact resistance, R_p and R_{cp} can be neglected. Therefore, we can calculate the total resistance R_T:

$$R_T = 2R_{cs} + R_s = \frac{V}{I},$$

where V is the voltage reading from the voltmeter and I is the current carried by the two current-carrying probes.

The advantage of using the four-point method is that it can eliminate the parasitic resistance introduced by the probes. If the metal-to-semiconductor contact resistance is very small (*e.g.* comparable to the probe resistance), one should use four-point instead of two-point for the measurement. This is important when the specific contact resistance is less than about 10^{-4} Ω cm^2.

Fig. 2 shows the TLM data measured on the same sample by using two-point and four-point method. The specific contact resistance measured by four-point method is smaller than the contact resistance measured by the two-point method. This is because the four-point method does not suffer from the parasitic resistances introduced by the probes.

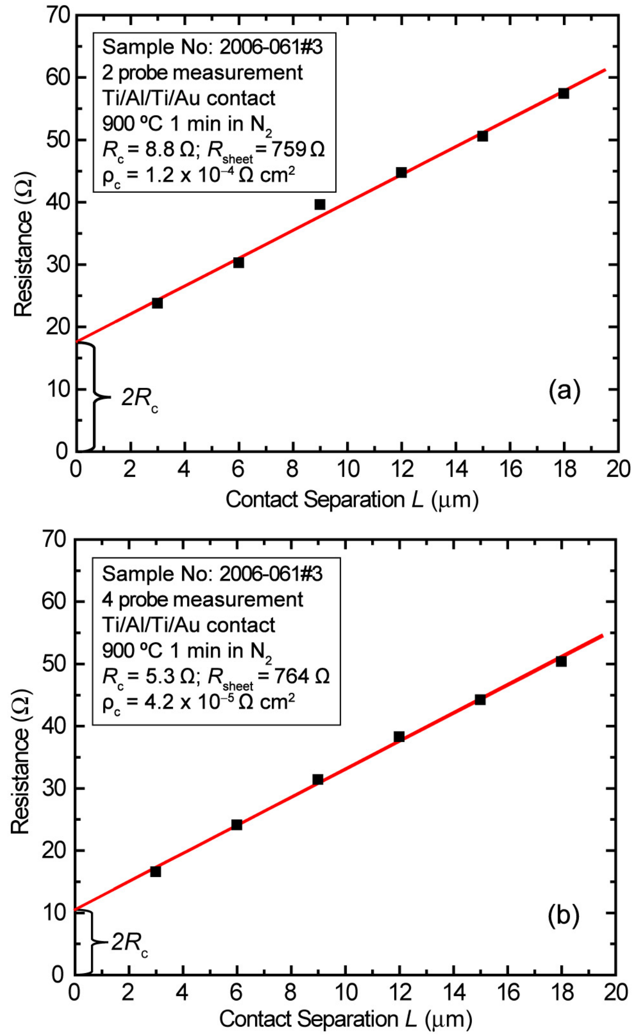

Figure 2: TLM data measured by (a) two-point and (b) four-point method.