Measurement and Validation of Contact Resistance on Nickel-Copper Plated Contacts for c-Si Solar Cells
Joseph Karas$^1$, Lynne Michaelson$^2$, Krystal Munoz$^2$, Tom Tyson$^2$, and Stuart Bowden$^1$

$^1$Arizona State University, Tempe, Arizona, USA
$^2$Technic, Inc., Cranston, Rhode Island, USA

joseph.f.karas@asu.edu

Introduction & Motivation

The commonly-used transmission line method (TLM) is a popular technique for characterizing contact resistivity ($\rho_c$) of c-Si solar cell contacts, and can be performed directly on the fingers of the front grid on finished cells diced into strips. Metal contacts can increasingly be the limiting component of solar cells and new materials and methods of forming contacts are being proposed; therefore it is important that this method of TLM is well-developed and accurate.

Impact of Line Resistance on $\rho_c$

Conventional TLM theory neglects any resistance contribution of the probed fingers, giving the effective contact resistivity as:

$$\rho_c \text{-effective} = R_{LW}$$

The voltage drop $V(x)$ some distance x along a finger with line resistance $R_w$ where current $I$ has been injected:

$$V(x) = \int_0^x \frac{l_0}{2} - \frac{2\pi x^2}{W} R_w \, dx = \frac{l_0}{2} \frac{x^2}{2W} R_w = W \int_0^1 \frac{l_0}{2} - \frac{2\pi x^2}{2W} 2R_w \, dx = \frac{W R_w}{2\pi^2}$$

The corrected effective resistivity is:

$$\rho_c \text{-effective, corrected} = \frac{V(x) - 2V_W}{I_0} = \frac{W}{2\pi^2}$$


For large strip widths W and/or high finger line resistance $R_w$ the line resistance contribution is not negligible. The impact of line resistance is immediately visible for the sample at right, for a sample with $R_w = 370$ mOhm.

Applying the correction method of Guo et al. appears to mitigate this issue, but perhaps overcorrects for wide strips.

Impact of Linewidth on $\rho_c$ Measurement

Same-magnification images of (a) unplated patterned SiN$_x$, (b) 1 um Ni-plated finger, (c) 10 um Ni-Cu plated finger, illustrating different area bases for calculating $\rho_c$.

Emitter and NiSi$_x$ Effects

$\rho_c$ for Ni/Cu contacts on n-type emitters with differing drive-in oxidation. Lower $\rho_c$ is achieved on shallower emitters with shorter drive-in times.

Comparison of Industrial Ni-Cu Plated to Ag Printed Contacts

Sintered Ni-Cu plated samples from two different Ni plating chemistries exhibit lower $\rho_c$ than analogous Ag printed samples.

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