INTRODUCTION

Our interest in contact resistance was stimulated by the recognition of its importance in our ongoing studies of the Z-pitch, high power microwave generation, triple point junctions, field emitters, and heating photomixing. In learning the subject, we were always referred to the classical reference of Holm [1].

Holm’s a-spot theory gives the electrical contact resistance of a circular constriction between two contacting surfaces. Implicit in the theory of Holm are several assumptions: (A) the a-spot has a zero thickness, i.e., zero axial length in the direction of current flow, (B) the current channel is made of the same material, e.g., the effects of contaminants have been ignored, and (C) the contact members are bulk conductors, whose dimensions transverse to the current flow are infinite.

Here, we present a vast generalization of the conventional theory of bulk contacts [2] and thin film contacts [3], by relaxing assumptions (A), (B) and (C) mentioned above.

BULK CONTACTS

Interface Resistance with Dissimilar Materials

A. Cartesian semi-infinite channel

Laplace’s equation

Boundary conditions

⇒ Potential profile & interface resistance for arbitrary \( a, b, p_1, p_2 \)

Exact Solution

Scaling laws

\[ \frac{\rho}{\pi} \frac{\ln(b/a)}{2} = \sum_{n=1}^{\infty} \left( \frac{1}{\pi} \frac{\ln(b/a)}{2} \right)^n \frac{1}{n} \]  

Interface Resistance of Bulk Contacts

B. Cylindrical semi-infinite channel

Laplace’s equation

Boundary conditions

⇒ Potential profile & interface resistance for arbitrary \( a, b, p_1, p_2 \)

THIN FILM CONTACTS

CONTACT RESISTANCE WITH DISSIMILAR MATERIALS: BULK CONTACTS AND THIN FILM CONTACTS


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CONCLUSIONS

- Simple, accurate analytical scaling laws of contact resistance with dissimilar materials were constructed for both bulk and thin film contacts. They were validated against known limiting cases, experiments, and numerical simulations.
- Interface resistance of bulk contacts depends mainly on the electrical resistivity of the main channel (\( \rho, \rho_b \)), whereas the resistivity of the contact region (\( \rho_c \)) is insensitive to it.
- For fixed \( \rho, \rho_b \), thin film contact resistance primarily depends on \( a, b \), as long as either \( L > a \) or \( L > b \).
- The minimum thin film contact resistance occurs at \( a \to 0 \), regardless of \( \rho_b \) and \( \rho_c \).