Contact Current Distortion Due to Tunnel Effect

Eisuke Takano
1-4-1 Izumigaoka, Izumi-ku, Sendai, Japan

Abstract

The third harmonic distortion ratio of the tunnel current between two electrodes separated by a thin insulating film, is evaluated analyzing the formula derived by Simmons into the Fourier series in this paper. The results show that the theoretical third harmonic distortion ratio is a function of $\mathbf{s}\varphi_o^{1/2}$ (where **s** is the thickness of the film, and φ_o is the work function). The numerical evaluation results in –40 to –80 dB, when **s** is in the practical range of 0.4 ~ 2.0 nm and φ_o is 1 ~ 4 eV. Experimental results produce readings of –50 to –130 dB, when using practical contact materials (95Au-5Ni). The reasons for the discrepancy may involve the effect of the non-homogeneous contact area, which was observed using a scanning tunneling microscope. When the contact resistance of copper with a thin insulating film is measured, the resultant small and negative thermal coefficient of contact resistance proves that tunnel resistance does exist. It is also shown that this tunnel film, a contact deterioration caused by corrosion, can be detected using harmonic measurement.

Key words: Contact current, contact resistance, Fourier expansion, insulating film, third harmonic, tunnel effect.