102 Size effects in thin gold films: The end of the road for circuit miniaturization?

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In this work we will discuss measurements regarding the increment of resistivity in thin metallic films induced by electron-surface scattering and by electron-grain boundary scattering. Recent measurements of the resistivity [1] and of the Hall effect [2] performed on thin gold films of different thickness (approximately 50 nm and 100 nm thick), on films made out of grains whose diameter D ranges between 12 nm < D < 160 nm, allow the univocal identification of electron-surface or electron-grain boundary scattering as the electron scattering mechanism mainly responsible for the resistivity observed at 4 K.

It turns out that for films such that D < 12 nm, the resistivity of the film at 4 K is dominated by electron-grain boundary scattering *regardless of the thickness of the films,* and the observed *resistivity at 300 K turns out to be 450% larger than the resistivity of crystalline gold at the same temperature.* In the opposite case, for films made out of columnar grains extending from the top to the bottom surface limiting the film such that D is larger than the film thickness t, then electron-surface scattering dominates the resistivity of the films at 4 K.

The implication is, that the increase in resistivity induced by electron-grain boundary scattering may severely limit the world wide effort of circuit miniaturization, due to the large increment in resistivity observed at 300 K when the interconnects are made out of small grains D < 12 nm, unless a way is found to deposit the metal chosen for building the interconnect onto the trenches of the Si wafer, such that the grains turn out to be long and elongated along the axis of the trenches.

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References

[1] R. Henriquez at al., *Appl. Surf. Scie.* **273** 315 (2013).
[2] R. Henriquez et al., *Appl. Phys. Lett.* **102** 051608 (2013).