Piezo-Tunnel effect in Al/Al2O3/Al junctions elaborated by Atomic Layer Deposition

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Purpose/Aim

This work is an experimental study of Al_2O_3-based tunnel junctions under mechanical stress. The Fowler-Nordheim current passing through the junction is affected by the strain, and this piezoresistive property can be exploited to make a sensor.

According to our research, the effect of strain on tunneling current have mainly been investigated in transistor gate oxide as the cause for leakage current [1][2]. Only two groups have exploited this effect to create strain gauge [3][4]. Both groups obtained gauge factor around 20 when typical monocrystalline Si transducer can reach 80 to 100.

Experimental/Modeling methods

$Al/Al_2O_3/Al$ junctions are realized on oxidized Si wafers. Al electrodes are deposited by electron beam assisted evaporation while the middle alumina layer is made by ALD at 200°C. The Si substrate is then cut into centimetric beams and a flection test bench (Fig 1b) is used to impose a transversal strain in the junction while the current is measured (I(t) and I(V)).

Results/discussion

Fig 1c shows the current response of a Al/Al_2O_3(10nm)/Al junction at 4.4V under a beam deflection varying from 0 to 800µm. A transversal gauge factor of 35 is measured that cannot be explained only by a geometrical variation. The influence of physical parameters of the junction is discussed, and numerical simulation shows that strain sensitivity derives not only from mechanical deformations, but also from the variation under strain of material properties (barrier height, effective masse).

Conclusions

This new type of transducer seems promising for MEMS sensors. The low temperature process may enable the integration onto flexible substrates.

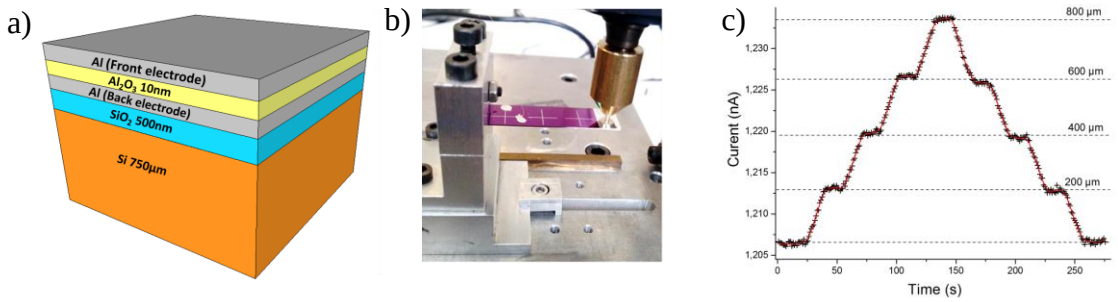

Figure 1: *a) Stacked Al/Al2O3/Al tunnel junction ; b) Photograph of the experimental set-up; c) Current response of the piezo-tunneling gauge under transversal strain*

References

[1] Y.S. Choi & al., Journal of Applied Physics, 103, 064510 (2008)
[2] X. Yang & al., Appl. Phys. Lett., 88, 052108 P. (2006)
[3] A.P. Friedrich & al., Transducers'97, 133-136 (1997)
[4] L. Zhu & S. McNamara, J. Microelectromech. S., 24, 755-762 (2015)