Analog Electronics based on a two-dimensional semiconductor

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Although analog electronics may not seem as present in daily life in the 21st century, they are indeed at least as ubiquitous as their digital counterparts since many 'digital devices' actually contain multiple analog parts. While these devices so far are nearly exclusively made from silicon, ever pushing demand regarding integration and diverse applications have (similar to digital electronics) prompted a lot of research for alternative materials. Because of their improved electrostatic control, mechanical flexibility and intrinsic small thickness semiconducting transition-metal-dichalcogenides (TMDs) such as molybdenum-disulfide (MoS_2) show great promise. [1,2]

In our work [3] we demonstrate an essential basic building block of analog electronics - an operational amplifier (OPA) using semiconducting CVD-grown monolayer MoS2 as active material.
The three stage amplifier design is based on locally back-gated n-channel transistors and to our knowledge constitutes the most complex analog circuit using a 2D semiconductor to date. The amplifier provides stable operation with gain as well as sufficient phase margin over a bandwidth of several hundred kHz. We demonstrate our amplifier working in several typical OPA feedback circuits.

References

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[2] S.Wachter, D.K. Polyushkin, O.Bethge & T.Mueller, Nature Communications 8 (2017), 14948
[3] D.K.Polyushkin, S. Wachter, G.Fiori, D.Neumaier & T.Mueller, (in preparation 2019)

Figures

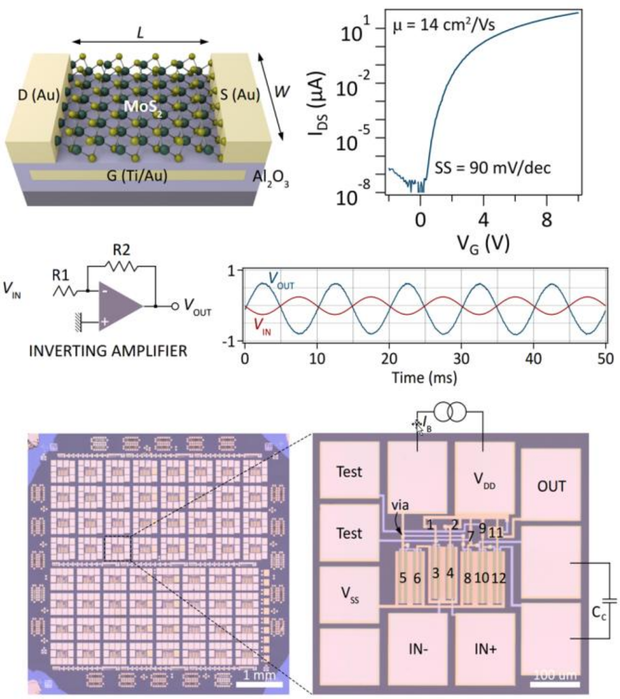

Figure 1: Sketch of individual MoS2 transistor in gate-first technology & transistor transfer characteristics demonstrating high mobility (14 cm^2/Vs) and a subthreshold swing of ~90mV/dec (top). Typical OPA feedback circuit (inverting amplifier) with corresponding input/output voltage (middle). The bottom image shows an optical image of our amplifier.