MoS_2-based ultrathin transistors for flexible electronics

Federico Parenti[1*]
Riccardo Sargeni[1], Elisabetta Dimaggio[1], Tommaso Losi[2], Fabrizio Antonio Viola[2], Arindam Bala[3], Zhenyu Wang[3], Francesco Pieri[1], Andras Kis[3], Mario Caironi[2], Gianluca Fiori[1]

[1]*Dipartimento di Ingegneria dell'Informazione, Università di Pisa, Pisa, Italy*
[2]*Center for Nano Science and Technology @PoliMi, Istituto Italiano di Tecnologia (IIT), Milano, Italy*
[3]*Institute of Electrical and Microengineering, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
[*]federico.parenti@phd.unipi.it

Abstract

Adapting electronics to non-planar and irregular surfaces, such as human skin [1], implies modifying the fabrication methods inherited from the conventional technology on rigid platforms. This determines a shift in focus on processes for reliable fabrication on flexible substrates and based on materials with good electrical properties, but also extremely high mechanical flexibility. These requirements can be easily fulfilled combining bidimensional and ultrathin organic materials with low-temperature and solution-based methodologies [2].

Here, we report a novel approach for the definition of high-performance, ultrathin and conformable electronic devices and circuits, based on the integration of semiconducting transition metal dichalcogenides (TMDCs), e.g., MoS_2, with organic materials, e.g., polyvinyl formal (PVF) through a cost-effective fully bottom-up and solution-based approach. The devices are fabricated by a sequential stacking of ultrathin (nanometres) layers on a few microns thick polyimide substrate, which guarantees the high flexibility mandatory for the targeted applications. On this substrate, the basic transistor topology has been achieved through the wet transferring of a MOCVD-grown MoS_2, and of PVF as gate-dielectric, combined with the ink-jet printing of conductive PEDOT:PSS ink for the source, drain and top-gate contacts. We show the performances of these transistors (Fig. 1a, b), together with some simple circuits, such as digital logic gates, and their performances (Fig. 1b, c, and e) achieved with the same processes. These results unveil an extremely promising scenario for the spreading of electronics beyond the limits imposed by the rigid fabrication paradigm.

References

[1] Yvan Bonnassieux et al. "The 2021 flexible and printed electronics roadmap". In: Flexible and Printed Electronics (2021).
[2] Agata Piacentini et al. "Potential of Transition Metal Dichalcogenide Transistors for Flexible Electronics Applications". In: Advanced Electronic Materials (2023).

Figures

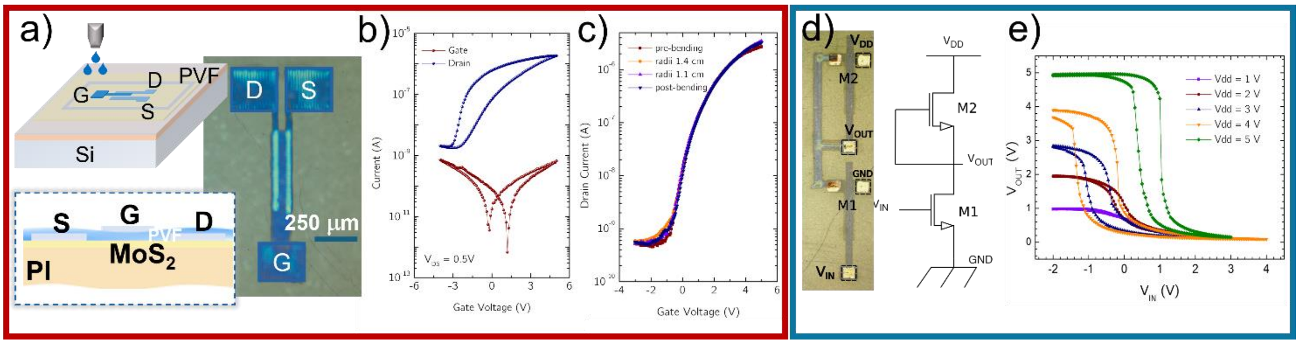

Figure 1 - a) Optical micrograph and section of a transistor. b) Transcharacteristic curve of a transistor and characterization in different bending conditions(c). Optic micrograph and electric scheme of a logic inverter(d) and DC transfer characteristic (e).