

Photoinduced modulation of polaritons in MoO₃/SiC heterostructures

Juan Luis Garcia-Pomar,^a Rajveer Fandan,^a Fernando Calle,^a and Jorge Pedrós.^a

^a*Instituto de Sistemas Optoelectrónicos y Microtecnología (ISOM) and Departamento de Ingeniería Electrónica, E.T.S.I. de Telecomunicación, Universidad Politécnica de Madrid, Madrid, 28040 Spain*

e-mail: jl.garcia.pomar@upm.es

Keywords: surface phonon polaritons, MoO₃, SiC, doping, canalization; Purcell factor.

AMatS1.- Graphene and other 2D materials.

This study explores the dynamic control of surface phonon polaritons (SPhPs) in a system comprising a van der Waals ultrathin α -MoO₃ layer on a 4H-SiC substrate with tunable carrier density via photoinduction (Fig.1 (a)). Unlike previous static modulation techniques, such as geometric adjustments or chemical intercalation, our method utilizes photoinduced doping in the SiC substrate to achieve real-time tunability of SPhP propagation. This dynamic modulation leads to the formation of a polaritonic band gap in the mid-infrared range, providing a novel on/off switch for SPhPs and enabling precise control over light transport at the nanoscale.

By varying the carrier density in the SiC substrate, we achieve significant enhancements in SPhP canalization, beam confinement, and directionality (Fig.1(b)). Additionally, the ability to generate ultra-slow

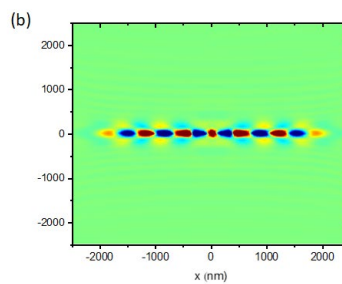
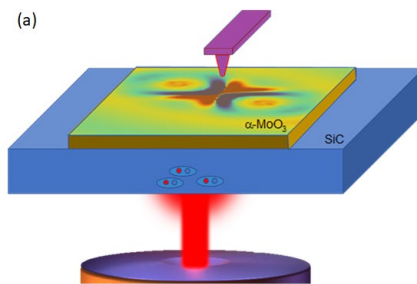


Figure 1 – (a) Geometry of the photonic architecture. (b) SPhPs canalization on α -MoO₃.

light through dynamic doping results in a notable increase in the Purcell factor, which is critical for applications in quantum optics and quantum communications.

Our findings not only increase the understanding of light-matter interaction in polaritonic crystals but also open up new possibilities for the design and operation of tunable nanophotonic devices. The

scalability and compatibility of SiC substrates with existing semiconductor technologies further enhance the practical applicability of our approach. Thus, this work represents a significant step forward in the development of advanced nanophotonic and quantum technologies, demonstrating the potential for innovative applications in tunable optical waveguides, resonators, and enhanced single-photon sources.

Acknowledgments

This work has received funding from the Spanish Ministry of Science and Innovation (MICINN) through project 2D-SAWNICS (PID2020-120433GB-I00) as well as from the Comunidad de Madrid, the Recovery, Transformation and Resilience Plan of the Spanish Government and the European Union - NextGenerationEU (PRTR-C17.11) through projects MAD2D-CM-UPM1 (Complementary Plan for Advanced Materials) and MADQuantum-CM (Complementary Plan for Quantum Communications). J. L. Garcia-Pomar acknowledges the support received from the European Union - NextGenerationEU, the Spanish Ministry of Universities, and the Recovery, Transformation and Resilience Plan, in the framework of the Maria Zambrano program (RD 289/2021) of Universidad Politécnica de Madrid (Contract No. UP2021-035).