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PtSe2 films grown by molecular beam epitaxy for high frequency optoelectronics

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PtSe2 is a promising 2D material for high frequency IR optoelectronics [1], its bandgap varying from 1.2 eV (monolayer) to 0.2 eV (bilayer) [2]. We have grown 2D PtSe2 films on sapphire(0001) substrates by molecular beam epitaxy. In particular, we used sapphire substrates with a 0.25° miscut to generate, after high temperature (1135℃) annealing, stepped structures. Indeed, we demonstrated that a stepped substrate improves the crystalline quality of the films and also increases the charge carrier mobility. We characterized the films using Raman spectroscopy, Grazing Incidence X-ray Diffraction, Transmission Electron Microscopy, Atomic Force Microscopy and their transport properties were evaluated using Van der Pauw experiments.
To fabricate optoelectronic devices, we synthesized a 15 layer thick PtSe2 film on a 2 inches sapphire substrate. In particular, coplanar waveguides integrating a 4x4µm PtSe2 channel were realized to perform high frequency photodetection and optoelectronic mixing. The channel was illuminated with a 1.55µm laser beam modulated in intensity at frequencies varying between 2 and 67 GHz. Our PtSe2 photodetector exhibits a record 3dB bandwidth of 60GHz. These results show that PtSe2 is a highly promising material for high frequency optoelectronics.

References
[1] Y. Wang et al., Appl. Phys. Lett. 116 (2020), 211101.
[2] Y. Wang et al., Nano Lett. 15 (2015) 4013.

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