Growth of ultrathin Pt layers and selenization into $PtSe_2$ by molecular beam epitaxy

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Among the high-mobility two-dimensional transition metal dichalcogenides $PtSe_2$ is of particular interest due to its record high carrier mobility of 1,000 cm^2/Vs, sizeable band gap and air stability to address the current need for low-power, high-performance and ultra-thin body electronics. A scalable fabrication process with highly precise thickness control on ultra-smooth insulating gate oxides however has not been achieved to date. This work is addressing this gap by presenting ultra-thin growth of Pt layers on insulating Al_2O_3 and the subsequent conversion into $PtSe_2$ by direct selenization in molecular beam epitaxy. Due to the chosen growth technique, the approach is scalable and offers precise control over Pt and thus $PtSe_2$ layer thickness. We engineered deposition parameters to fabricate smooth, single crystal Pt films in the mono-/few-layer limit and optimized selenization conditions to convert a maximum amount of Pt into $PtSe_2$. A post selenization anneal in Se proved essential to enhance crystal quality of the $PtSe_2$ layers.