

The formation of nanoporous noble metal thin films on Si by electrochemical dealloying of $\text{Pt}_x\text{Si}_{1-x}$

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Electrochemical dealloying of bi-metallic alloy mixtures provides a novel way to form nanoporous structures. In the present study we demonstrate the extension of this concept to metal-silicon alloys on silicon platforms for $\text{Pt}_x\text{Si}_{1-x}$. The $\text{Pt}_x\text{Si}_{1-x}$ ($x = 50, 33,$ and 25%) alloys are formed by co-deposition and by thermal reaction of Pt films for PtSi silicide layers. The films (50 to 400 nm thick) are then dealloyed in concentrated HF by an electrochemical process that leaches out the silicon resulting in a local self assembly of Pt into a nanoporous structure. Anodic polarization curves are used to establish the critical concentration and optimum potential for dealloying, for example near + 400 mV (SCE) for $\text{Pt}_{25}\text{Si}_{75}$. Rutherford Backscattering Spectrometry (RBS) depth profiling demonstrates the formation of a pure Pt nanoporous layer on the metal silicide layer as dealloying process progresses and thus provides a direct observation of the dealloying kinetics. The resulting morphology of the nanoporous noble metal structures is determined by field emission scanning electron microscopy and the microstructure by Z contrast and high resolution electron microscopy. Results are presented for various Pt silicon alloys and dealloying conditions. Thermal annealing of the nanoporous films results in a ripening of the pore size with increasing temperature due to surface diffusion, with mean pore diameter growing from ~ 10 nm as dealloyed to ~ 40 nm after annealing to 900°C . These nanoporous metal thin film structures provide high surface area electrodes on Si. This new approach to forming ultra-high surface area noble metal films has the advantage of being compatible with integrated circuit processing. Such nanostructures are expected to have to be useful in emerging applications such as micro-fuel cells, biosensors, and micro-batteries.