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Chemical gradients to control stability and mechanical behavior in nanostructured Pt-Au

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Most heterogeneous nanostructured metals are produced by imposed deformation gradients, such as shot peening or surface mechanical attrition. But microstructural tailoring can also be produced in the absence of severe plastic deformation, by varying deposition conditions or by imparting chemical gradients. Magnetron sputtered Pt-Au with Au concentrations up to 10 at% provides a pedagogical system to study compositional gradients. In the as-deposited condition, Au naturally segregates to the grain boundary and phase separates both in the grain interior and within the grain boundary. The Au stabilizes the grain boundaries against migration both due to thermodynamically lowering the energetic cost of the grain boundaries, and providing kinetic pinning of the boundaries. However, the Au simultaneously embrittles the boundaries and can result in loss of ductility. Under conditions of fatigue loading, the suppression of grain boundary migration leads to substantial increase in fatigue-crack initiation resistance. Ultimately, this fatigue resistance along with the surreptitious formation of tribocatalytic diamond-like carbon from the atmosphere enable this nanostructured Pt-Au alloy to hold the record for wear resistance in a metallic system.

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