Optimizing Ti adhesion layer thickness for plasmonic Au films


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Gold thin films are commonly used in industrial applications as surface plasmon resonance (SPR) sensors to monitor chemical and biological processes. Emerging applications such as heat assisted magnetic recording (HAMR) requires these films to operate under higher optical intensities and therefore more extreme local temperatures and temperature gradients. At higher temperatures the films can degrade through a number of processes, including solid state dewetting, delamination, or inter-diffusion. The long-term performance and stability of these films are determined by the film adhesion to the underlying substrate. Metallic adhesion layers such as Ti & Cr have traditionally been used improve adhesion between Au and SiO$_2$ or glass substrates. These films are usually 2 - 5 nm in thickness and result in a significant improvement in stability against effects such as dewetting. These adhesion layers, however, are well known to increase damping of the plasmonic resonance. At elevated temperatures, both Ti & Cr will diffuse into Au causing further degradation.

In this work, we compare a range of different Ti adhesion layer thicknesses used with 50 nm Au thin films. The back-reflected signal of a focused laser heat-source is used to measure the dewetting dynamics of the films. From the obtained degradation curves (see Figure 1(a)), it was found, surprisingly, that the stability of an Au/Ti system is inversely proportional to the thickness of the Ti adhesion layer. A 0.5 nm adhesion layer resulted in the slowest rate of dewetting, whereas the 5 nm layer resulted in the quickest. Further experiments looking at even thinner layers found a decrease in the effectiveness when the Ti thickness is decreases below 0.5 nm. The difference in stability can be seen starkly in SEM images of the irradiated areas (Figure 1(b)). Areas were irradiated for 100 s with 25 mW of absorbed power, in a Gaussian spot of $\sim$1 $\mu$m. Films with thinner adhesion layers were shown to be more resistant to dewetting, in agreement with Figure 1(a). In addition, thinner adhesion layers resulted in less hillocks being formed on the Au surface. Further studies on the plasmonic response of the Au showed as expected a decrease in the plasmonic damping when using thinner adhesion layers. These results show that significant improvement in adhesion and plasmonic properties of Au films can be achieved by using extremely thin adhesion layers (<1 nm).

Figure 1. comparison of the dewetting characteristics for 50 nm Au films with different Ti adhesion layers: (a) degradation curves showing the rate of Au dewetting for different Ti thicknesses, (b) SEM images of irradiated areas in Au/Ti films

References
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