Effects of band shifting on permittivity of plasmonic material

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1. Introduction

In recent decades, plasmonic devices are widely interested because of the capability of subwavelength confinement. The plasmon phenomena is generated by oscillation of free charges in optical frequency. Hence, the metallic component is general used in plasmonic device. Metal provides large amount of free charges and the negative real part of permittivity, which is the essential property of plasmonic material. However, the loss of metal is critical issue of the devices, which occur from the interband transition in visible and ultra-violet range. Thence, the engineering of permittivity is the important topic for plasmonic devices.

The interband transition of noble metal is known as the electrons transition from occupied d bands to unoccupied states. [1, 2] The concepts of searching materials for low loss alloy is based on the density of state(DOS) structure in the following section.

2. Results and Discussions

From the DOS as shown in Fig. 1, the inhibited states are shown around -4 to -6.3 eV in Pb, and predominated occupied states are located at -2.3 to -6.1 eV in Ag. It is anticipated the lower states are formed as Pb adding in Ag.

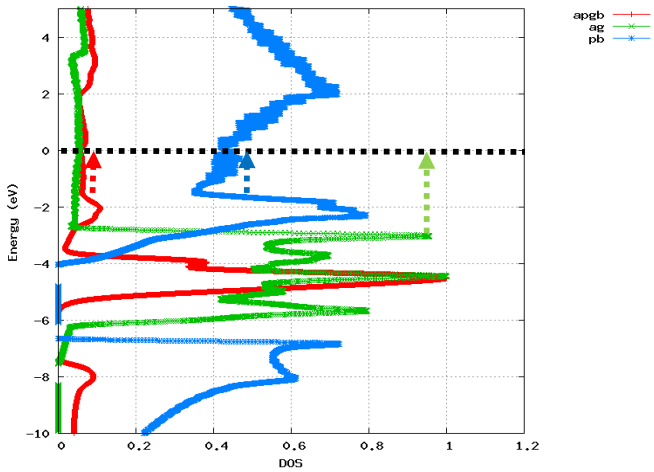

Figure 1. DOS of AgPb (red), Ag (green) and Pb (blue). The Fermi level is plotted in black dotted line. The dotted arrow line denoted onset of the interband transition for three systems.

The imaginary part of dielectric function of three systems are shown in figure 2. The vertical lines denoted the onset of interband transition, which is consisted with energy differences shown as the vertical arrows in DOS simulations in figure 1. From Fig. 1, we can find that the DOS of AgPb alloy is down shifted as comparing to the DOS of pure Ag. However, the original states of Pb around 0 to -4 eV are still existed in AgPb alloy, that make the imaginary part of dielectric function higher than pure Ag in figure 2.

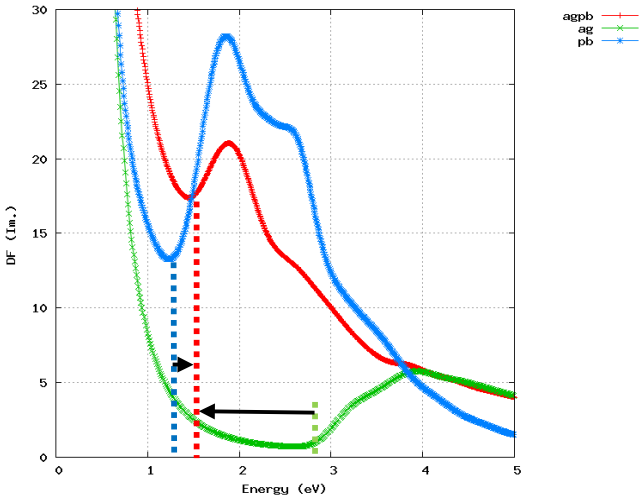

Figure 2. The real (a) and imaginary (b) part of dielectric function of AgPb(red), Ag(green) and Pb(blue).

3. Conclusions

The strategy of band shifting is conducted. The shifting of band is constructed by the inhibited lower energy (-4 ~ -6.3 eV) states of Pb that combined with Ag. On the other hands, the inclusion of higher energy states (0 ~ -4 eV) in Pb increases the imaginary permittivity of alloy.

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References

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[2] Shahcheraghi N., et al., Journal of Physics: Condensed Matter, 28(40): p.405501, 2016