Two approaches for enhancing the efficiency of plasmon induced hot electron transfer

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It has been well-established that excitation of plasmons in metal nanostructures can lead to the injection of hot electrons into semiconductors or adsorbed molecules, which can be used to enhance photocatalysis. This novel mechanism suggests that plasmonic nanostructures can potentially function as a new class of widely tunable and robust light harvesting and catalytic materials for solar energy conversion. More importantly, it provides a novel approach to access highly energetic and reactive states of metals that is difficult to access with thermal chemistry. However, plasmon-induced hot electron injections from metal to semiconductor or molecules are still inefficient because of unfavorable initial hot electron distribution and the competing ultrafast hot electron relaxation processes within the metallic domain.

In this talk, we discuss two approaches to enhance the efficiency of plasmon induced hot electron transfer. In the first approach, we explore the possibility of enhancing hot electron distribution by decreasing the size of plasmonic Au particles. Using CdS/Au nanorod heterostuctures, we show that the hot electron injection efficiency increases at smaller Au particle size. We attribute this size dependence to increasing contribution of surface assisted plasmon damping, which generates more hot electrons compared to damping by interband transition. In the second approach, we demonstrate that in CdSe/Au heterostructures with strong metal/semiconductor coupling, the plasmon decays by direct excitation of an electron from the metal to semiconductor, i.e. plasmon induced interfacial charge transfer transition (PICTT). The new plasmon damping pathway can be very efficient because it bypasses the competition with hot electron relaxation within the metal satisfies both the energy and momentum conservation. We will discuss whether PICTT can be a general scheme for efficient hot electron transfer.