

Excited state in the conduction band of gold nanoparticles

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(Introduction) Nanoscience was triggered by the discovery of catalytic activity of gold nanoparticles (Au NPs) by Haruta *et al.* in 1987 (ref.1). It is well established that defect in NPs is the origin of high catalytic activity. Chemical reactions are controlled by transfer of “hot electrons” and the study of electronic structure is the most important. However, there was no discussion on the electronic structure in defects because of a lack of good diagnostic. In our previous paper (ref.2), we disclosed a novel diagnostic of excited states. In this paper, we report excited state in the conduction band of Au NPs.

(Experiment) A droplet of a colloid of 10 nm diameter Au NPs was dropped on a Si wafer, and baked for one hour in air at 500 deg C. The sample was irradiated by laser pulses of 150 fs pulse duration and the images were observed by photoemission electron microscopy as shown in Fig.1. The brightness of NP images increased with the third power of the laser power as shown in Fig.2. The wavelength dependence of the brightness is shown in Fig.3. By fitting the theoretical curve shown by the solid curve in Fig.3, we get the excitation energy of about 4 eV by assuming the electron affinity, ΔE , of 1.5 eV.

(Electronic structure of gold nanoparticles) Figure 4 shows the calculated electronic structure of gold reported in ref.3. We assign the observed excited state in Fig.3 to the *sd* state lying about 3 eV above the Fermi level and the electron source as the *pd* state located about 1 eV below the Fermi level both at L point.

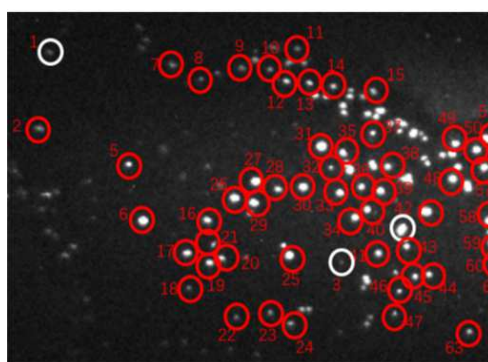


Fig.1: Au NPs observed with PEEM.

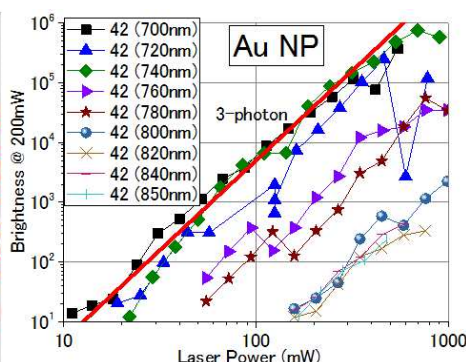


Fig.2: Power dependence of Au NP brightness at various wavelengths.

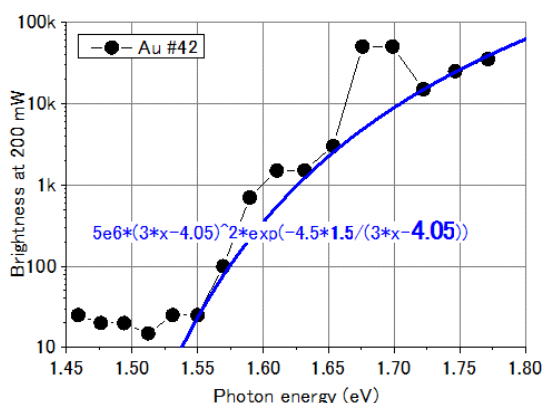


Fig.3: Wavelengths dependence of brightness of #42 Au NP.

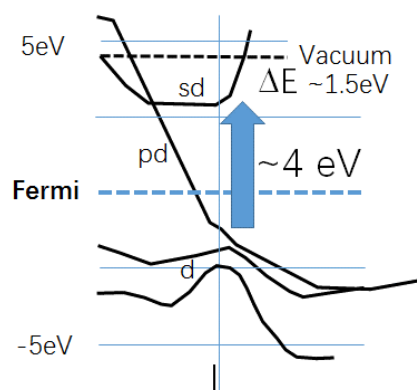


Fig.4: Electronic structure of gold.

References

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