Sequential and coherent decay of plasmons in solids investigated by (e,2e)

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Synopsis Time correlated electron-electron spectroscopies (e,2e) play a relevant role in establishing mutual relevance of individual and multiple collective excitation to the generation of secondary electrons from solids. In particular, the coupling between spatially delocalized charge density oscillations (plasmons) and localized electron-hole pairs generation is investigated through differential secondary electron yield. A progress report on recent results on Al(100) and HOPG solid surfaces is given by this paper.

Secondary low energy (0-20 eV) electron emission under photons and charged particles bombardment is a phenomenon known from well over a century but the mechanisms responsible for it are not yet fully clarified. In solids, one of the most efficient channel of electron impact energy transfer is the excitation of collective charge density oscillations: the bosons usually termed plasmons. When photoexcited these particles predominantly decay into one single particle excitation [1]. Whether or not this is the case for electron impact and whether or not multiple plasmon excitations will annihilate coherently is still debated.

Electron-electron coincidence experiments, (e,2e), are one of the most complete ways to disentangle plasmon decay mechanisms. The incoming electron scatters inelastically transferring energy and momentum to one or more plasmons that eventually decay generating an electron-hole pair whose energy and angular correlation with the primary one is measured in a coincidence set-up [2]. In competition with this channel, the ejection of a secondary electron due to direct scattering within a medium described by its inverse dielectric function has been proposed [3]. To establish the relative relevance of these two channels and of the sequential versus coherent multiply excited plasmons decay has been our aim in several (e,2e) plasmon assisted experiments on Al [4,5] and Be [6] clean surfaces.

The experiment on Al, performed correlating in time the energy loss suffered by a 2p photoelectron with secondary electrons, proposes an emission mechanism similar to photoemission with the decaying plasmon transferring its full energy and momentum to a single valence electron.

The Be experiment points to plasmon resonant processes as a relevant channel for secondary electron generation.

In both cases, the high degree of correlation existing between the two final (e,2e) electrons (i.e. full conservation of energy and vector momentum) testifies a direct coupling of the plasmon with a single electron-hole pair in the solid. The plasmon resonant channel competes with the direct electron-electron impact process [7].

We present recent results on Al(100) and HOPG that support validity of a single vertex interaction model for generation of secondary electrons and predominance of the sequential decay of multiply excited plasmons, at least in the range 0-20 eV. Experiments performed at constant initial state, show that the plasmon resonant channel dominates over the direct impact one in generating secondary electrons.

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